Lessons Learned: Lots of Internet-of-Things Do Not Make a 21st Century Health System. But What Does?

The Future of the Professions by Richard and Daniel Susskind paints a picture of how the digital revolution unforgivingly alters the service work of all kinds of professionals. The driving force behind the changing roles of human experts comes from the fact that the “professional currency”—the application of knowledge to problems—can be rendered by machines, particularly when those machines exceed the performance of humans when presented with hugely complex problems. With the work of many professionals changing at an accelerated pace, the question needs to be posed: Where is oral health, and the practice of dentistry, in understanding its professional future? Will current investments be sufficient to pave the road for the next generation of oral health professionals toward a societally meaningful role in the emerging, massive health enterprise system?

EMERGING HEALTH SYSTEMS SOLUTIONS

Fundamental to any health system is a common and enabling communication platform, with the electronic health record (EHR) at its core. While dental practice guidelines have traditionally targeted a single condition in an environment of siloed care, the increasingly higher levels of comorbid chronic health issues in the US population, notably in dental patients in need of major prosthodontic services, demand care coordination beyond single professional domains. Acknowledging the existing health complexities in dental patients and the mounting societal pressures to achieve better health outcomes and safety for those patients, interdisciplinary and interprofessional team efforts are required.

Co-location with other health professionals remains a challenge for dentistry because of prohibitively high start-up costs to deliver those dental services. However, the COVID-19 pandemic has catapulted enterprise health systems into the virtual space, offering unprecedented opportunities to clinicians and patients with respect to collaborative care and telehealth. These developments have opened the door to train the future dental workforce in an environment where physical co-location, working side-by-side in collaborative practice, is no longer required. The oral health profession cannot miss the chance to build upon these newly established virtual linkages, especially when it comes to building bridges with primary care, behavioral health, social work, and public health.

INTERNET-OF-THINGS TECHNOLOGIES IN DENTISTRY

Dentistry is in its very early infancy from a technologic point of view with respect to the now prevailing health system thinking. Integration of dental processes and workflows into emerging collaborative practices under the umbrella of overarching health enterprise system solutions cannot be found anywhere. Dental internet-of-things (IoT) technologies suggest professional advances comparable to other medical fields when this is in fact far from being the case. While current dental IoT technologies trigger a false sense of professional progress and unquestionably boost sales of dental equipment manufacturers, permitting dental markets to hang on in these challenging times, it needs to be emphasized that lots of these technologic things do not bring dentistry into the “One Health” solution.
Dental technologies typically accommodate stand-alone or relatively small-scale dental service operations in contrast to today's health enterprise systems that administer well-being to millions. In fact, proprietary dental systems and IoT gadgets fail horribly when merged into massive health enterprise solutions because they were never designed to live in the operational complexity of today's health enterprise networks. Not only is their presence a source of frustration due to interoperability and security issues, but the frustration of enterprise managers becomes yours to address when trying to push the horizon beyond small-scale installations. Do not expect help from your dental equipment manufacturers, as the scale of their research and development (R&D) is miniscule compared to the intellectual horsepower and sophistication required to play in the sandbox of today's medical health care organizations. Without friends in the right places who are willing to work with you when bringing a rowdy dental software package or an unruly piece of radiographic equipment into the system network fold, you are finished. You do not want to explain to a thoracic surgeon at another Ivy League institution why your dental software is aggressively popping up on other software.

**PROPRIETARY PRODUCTS, R&D, AND DIGITAL TECHNOLOGY MARKETS**

"Vendor lock-in," the situation in which an oral health provider is dependent on a single vendor, has emerged as the dominant business model in the digital dental marketplace. Because of significant start-up investments in hardware and software, switching to another vendor for products and services cannot happen without experiencing major losses due to closed architecture designs, proprietary standards, licensing restrictions, and/or lack of interoperability of software programs. Vendors navigate the landscape with the intent to increase their market share while minimizing losses in their "locked-in" customer base. Once a digital workflow is adopted, the vendor attains monopoly power while the dental practitioner loses the bargaining edge.

Current R&D efforts are focusing on enticing new customers to enter into the digital arena or disrupting the customer base of the competition via notable additions and/or improvements to product lines. Product upgrades are attractively packaged to stimulate sales for existing, "locked-in" customers. Recognition of the competitive edge of hardware and software over the competitor, consideration of switching costs for locked-in customers, and offering deep discounts or loyalty rewards are ways by which proprietary vendors establish their pricing schedules to defend or grow their market share. While this business model has become the dominant, if not only, way to advance the integration of digital workflows into the daily practice of dentistry, it detracts and excludes the oral health profession from engaging in the bigger overarching initiatives that shape emerging health systems.

Depending on whether you are a solo practitioner or an academician in an institution of higher education, the digital transformation has different meanings—eg, the adoption of a digital workflow vs reinventing the profession to maximize its contribution in a world altered by the digital revolution, while also training students in the very same processes that transform the workflow in the daily practice of dentistry. It is unfortunate that very little R&D is devoted to what Susskind and Susskind capture in the *The Future of the Professions*. Too few dental programs and faculties engage in data science, and, if so, with minimal collaboration from their dental trade partners. Digital transformation is not just about implementing new digital processes in daily dental practice (eg, the adoption of CAD/CAM), it is about the rebirth of the dental profession in a world of big data, machine learning, natural language processing, open-source software, and the development of a competent workforce capable of maneuvering in a vendor-neutral space.

**ORAL HEALTH IS HEALTH**

Growing emphasis on both individual and population health is placed on preventive oral health care to achieve improvements in overall health and well-being by reducing the inflammatory burden linked to oral disease. On the other hand, advanced cases of oral disease with loss of teeth are significantly associated with a host of chronic diseases, including a statistically increased risk of mortality. Enabled by the digital revolution and with comprehensive health information at a clinician's fingertips, the restoration of oral health and function following tooth loss will increasingly have to be viewed as a value contribution in the concurrent management of a patient’s comorbid health conditions.

Health enterprise solutions increasingly capitalize on actionable opportunities made available by digital technologies, and crises trigger accelerated changes in advancing such opportunities. Regarding the management of patients, technology solutions emerged in the medical space due to constraints imposed by the COVID-19 pandemic and the widespread availability of smartphones and broadband. Patient portals that access an electronic personal health record (ePHR) tethered to an institutional EHR emerged as a safe and effective way to communicate between a patient and the treating clinician, or even multiple care providers in the same context. It is reasonable to assume that due to positive experiences of this nature and the perceived convenience of interacting with otherwise hard-to-reach care providers, this type of communication
interface will gain further traction. Consumer expectations enabled through access to the ePHR will call for a growing number of professionals to adopt the applicable technology solutions. With compromised oral health rarely occurring as an isolated health condition, notably in those patients in need of treatment solutions that fall into the scope of a prosthodontist, patients may sooner rather than later want to see the prosthodontist registered as a member of their caregiver team who is accessible through the patient portal. Care coordination requires that all care providers have access to the same information and share a common goal.

BIG DATA ANALYTICS AND MEDICAL-DENTAL INTEGRATION

Big data analytics allow health industries to analyze immense volumes of data to generate data-derived novel ideas and to enable decision-making and actionable insight to influence and transform business practices in support of better care at a lower cost. To date, the oral health community, given its siloed existence, has not embraced data science to the degree that other health sectors have, having strategically positioned themselves to monetize the predictive insight derived from massive amounts of structured and unstructured data. According to the “Study on Big Data in Public Health, Telemedicine and Healthcare” of the European Commission, big data analytics can identify early signals of disease that could lead to novel treatments, recognize previously unknown risk factors, improve pharmacovigilance and patient safety, and improve the prediction of individual health outcomes.²

Most dental health records in current use do not lend themselves to be bidirectionally linked to an enterprise health information system, which challenges the operationalization of oral health being health. Electronic dental records are also designed for fee-for-service operations without provision to reward fee for value or to learn from past mistakes. Deep changes of the dental profession in the sense of Susskind and Susskind¹ will likely be imposed on the oral health community by parties employing predictive capabilities from big data that recognize value in medical-dental integration. Although a few shared health information platforms that enable medical-dental integration have been launched, no primitive examples of proactive learning from mistakes exists today.

TRAINING THE NEXT ORAL HEALTH WORKFORCE

Building a pipeline of oral health professionals requires an understanding of the working knowledge and skill sets demanded of the workplace. However, the workplace within which the future oral health professionals operate is better understood by parties outside the profession than within the academic community charged with the education. Health system thinking is woefully underdeveloped and overshadowed by considerations of the digital workflow using IoT technologies in daily dental practice. Few demonstrative projects explore value-based incentives for professional services rendered, and even fewer exhibit an overarching health focus for populations that consist of more elderly individuals than ever and require more caring than curing. Dental accreditation standards produce overcrowded curricula and freeze the dental profession in a historical context, creating a false sense of comfort for educators.

Faced with the challenge of producing a workforce that requires more than the skills mandated by current accreditation standards, educators need to create the emerging environment for learning the skills to support the unavoidable professional evolution. Although boxed in a packed curriculum, learning from and interacting with data scientists and wrestling with the extraction of value from big data by means of deep learning and artificial intelligence while implementing the most promising open-source workflow solutions in delivering care is what educators need to provide to students. However, if only workflow solutions applicable to the daily practice of dentistry are shaping the curriculum, the oral health profession will unquestionably jeopardize its membership in higher education. The standing of the dental profession will suffer the consequences.

HEALTH ENTERPRISE SYSTEMS HARVEST AND LEARN FROM ENCOUNTERS

A past-century science foundation and “drill-fill-bill” competencies will no longer be sufficient to guarantee a seat for the dental profession at the table of “One Health.” Parity of oral health with health brings with it the need to accept the intellectual challenges that have to be met by all the other health disciplines, including an unwavering commitment to precision medicine. Emerging smart health systems generate knowledge by learning from mistakes that occur in daily practice and thereby continually improve care to achieve better health at a lower cost. Managing complexity and uncertainty is at the core of both quality and safety of precision medicine. Improved health and health outcomes will increasingly be obtained from knowledge derived from accumulated massive data that offer actionable, predictive guidance to clinicians for disease prevention and precision care. The “one size fits all” approach is incompatible with unique gene variants, different lifestyles, and particular environmental factors contributing to individual response differences regarding health in general, specifically oral health and its comorbid conditions.
SUMMARY

Although these developments will take time, medical-dental integration is a critical first step to align the dental profession with the transformative pressures influencing the future of health care and population health. Alignment with medicine and public health will provide dental educators with the environmental stimuli that inspire the necessary curricular innovation in support of the next generation of professionals to lead the way into the future. One lesson that we at Columbia have learned from being at the technology forefront to bring the “mouth back into the body” is that dental faculties are better served by their counterparts in engineering and data science than from their dental equipment manufacturers. The lift into the future is just too heavy and time-sensitive in order to accomplish the professional transformation from within dental education and the affiliated dental equipment manufacturers.

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REFERENCES