



Primary care dentistry: Past, present and future

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ABSTRACT

This article examines the past, present and future of primary care dentistry. It provides a historical background of primary care dentistry and describes stages of its evolution. It further reviews the purpose and mission of contemporary primary care dentistry and outlines a vision for the development of primary care dentistry in the future. The type and extent of innovations and technological advances that have impacted – and improved – primary care dentistry revolutionising clinical activities, ranging from early computerised tomography to modern digital systems and workflows are summarised. A discussion of current scientific evidence base pertinent to primary care dentistry highlighting the need for 'effectiveness' rather than 'efficacy' studies is included in order to provide research data pertinent to the primary care dentistry setting where most dental patients receive most of their care most of the time.

1. Introduction

Primary care dentistry, often referred to simply as general dentistry, is essentially a primary care discipline insofar as the vast majority of dental patient care takes place in the general dental practice settings and is provided predominantly by 'generalists' who in the main hold, or aspire to hold, a long-term relationship with their patients [1]. Whilst most of dentistry is provided by generalists, occasionally patients are referred to specialists working in primary care or in the hospital setting for advanced or specialist care. This paper will focus on primary care dentistry and will provide an overview of the past, present and future of primary care dentistry, without claiming to be exhaustive.

2. Primary care dentistry – the past

The history of primary care dentistry traces back thousands of years, with evidence of early dental practices found in ancient civilizations such as the Mayans, Egyptians, Greeks, and Romans. However, the formalisation of primary care dentistry as a distinct profession and field of study began to take shape much later in history. An overview of key milestones in the history of primary care dentistry is shown below:

1. Ancient Times - Middle Ages: Ancient civilizations developed rudimentary dental practices focusing mainly on tooth extraction to alleviate pain and dental prosthetics. Early dental tools and

techniques were often primitive using dentures made from human or animal teeth held together with metal bands, and materials like carved seashells, stones, and metals to replace missing teeth. During the Middle Ages, dental care was often provided by individuals such as barbers, blacksmiths, healers, or general physicians who had little training in managing dental ailment. Remedies for dental ailments in the Middle Ages often included herbal treatments and charms.

- 2. 16th - 17th Centuries:** In Europe, the Renaissance period marked the beginning of dentistry evolving as a distinct branch of health care separate from medicine and surgery. The first dental textbook, 'The Little Medicinal Book for All Kinds of Diseases and Infirmities of the Teeth' by German physician Artzney Buchlein was the first book solely written on dentistry, published in 1530. It included topics such as oral hygiene gold fillings and tooth extraction, and it helped educate the public about teeth. In 1563 Bartholomew Eustachius published the first accurate book on dental anatomy, *Libellus de dentibus*. The first dental book written in English, *The Operator for the teeth* by Charles Allen was published in 1685.
- 3. 18th and 19th Centuries:** In Europe, dentistry began to separate from medicine and surgery during the Renaissance period and it began to emerge as a distinct profession. Innovations such as the development of dental instruments and the discovery of anaesthesia (ether and chloroform) led to more sophisticated dental procedures. Pierre Fauchard, a French physician often referred to as the 'Father of Modern Dentistry,' published one of the earliest comprehensive

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dental textbooks, *"Le Chirurgien dentiste"* in 1728. The first lectures on the teeth at the Royal College of Surgeons, Edinburgh by James Rae were in 1764 and John Hunter published *"The natural history of human teeth"* in 1771 giving a scientific basis to dental anatomy. In 1780, William Addis manufactured the first modern toothbrush.

In 1831, James Snell designed the first reclining dental chair and in 1870, Greene Vardiman Black (1836–1915) invented the Cord driven foot engine with a foot motor. The foot pedal was pushed up and down to power a dental drill that was used to remove areas of tooth decay. G.V. Black has made numerous other contributions to dentistry, including the development of dental drills, standardised rules of cavity preparation for the management of dental caries (G.V. Black's "extension for prevention"), standardised the formula of amalgam which had been used almost unchanged for over a century, provided a classification of dental caries and standardised dental terminologies, and he published several dentistry textbooks, including books on dental anatomy and operative dentistry. He is also known as the father of operative dentistry.

4. **Founding of Dental Schools (19th Century):** The 19th century witnessed significant advancements in dental education and the establishment of dental schools. The Baltimore College of Dental Surgery, founded in 1840, is widely recognised as the first dental school in the world. Other early dental schools, such as the Harvard School of Dental Medicine (1867) and the University of Pennsylvania School of Dental Medicine (1878), followed suit, laying the groundwork for modern dental education and training. The Dental Hospital of London, the first clinical training establishment for dentists in Britain opened in 1858 and first licences in dental surgery awarded by the Royal College of Surgeons of England were bestowed in 1860. Dentistry gradually gained recognition as a distinct field, with the establishment of dental societies and the development of dental education with the opening of other dental schools in Europe and North America
5. **Expansion of Dental Services (20th Century):** The 20th century saw the expansion of dental services and the integration of dentistry into primary healthcare systems. Dental professionals began to emphasise preventive care, early intervention, and community-based dentistry to improve oral health outcomes. Public health initiatives, such as water fluoridation and community dental clinics, played a crucial role in promoting oral health on a population level.

An international World Health Organization (WHO) conference on Primary Health Care with the participation of representatives from 134 countries and 67 international organizations, was held in Alma-Ata (now Almaty), Kazakhstan in 1978. The 1978 WHO (aka Alma-Ata) declaration emphasised the importance of primary healthcare (PHC) as an essential component of health systems worldwide. The key principles and goals outlined in the declaration are: Universal Access, Equity, Community Participation, Intersectoral Collaboration, Comprehensive Care, and Primary Healthcare as Central (positioning primary healthcare as the cornerstone of health systems). In the spirit of the Alma Ata Declaration, the US delegate Michael Loupe was tasked by US stakeholders to provide a definition of primary dental care. He and his working group came up with the following definition [2]: *"Primary dental care is continuing management and coordination of health services provided by a dental care provider system of first contact for maintenance of health, prevention of disease and injury, and restoration of health. It includes appropriate assessment of general and oral health status; provision of oral diagnostic, preventive, educational, and therapeutic services; and referral and coordination of episodic specialty care."* The Alma-Ata Declaration had a profound impact on global health policy, inspiring efforts to strengthen primary healthcare systems and promote health equity worldwide. While progress has been made since 1978, challenges remain in achieving the vision outlined in the declaration, including resource constraints, political commitment, and the need for sustained community engagement. Nevertheless, the principles

articulated in the Alma-Ata Declaration continue to guide efforts to improve healthcare delivery, including primary care dentistry, and advance the goal of health for all.

In the latter part of the 20th Century new technologies emerged, starting with computer tomography in the 1970s. In 1983, the prototype and it in the same year the CEREC 1 unit (Sirona Dental Systems GmbH, Bensheim, Germany) was developed for the chair-side computer aided design - computer aided manufacturing (CAD-CAM) fabrication of ceramic restorations, specifically to enable primary care dentists to complete one or multiple ceramic restorations in a single appointment.

6. **Development of Comprehensive Primary Care Dentistry (21st Century):** Research in the early 21st century has shown that oral and dental diseases have strong associations with systemic diseases, and poor oral health can worsen the impact of systemic diseases. In addition, an increasingly aging population, particularly in the developed world, and an increase in use of polypharmacy have led to people living longer with chronic and complex medical conditions. These transformations required an improved understanding of the complex interactions of oral/dental diseases and systemic chronic diseases that can complicate treatment of affected individuals. The growing recognition of the interconnectedness of oral/dental health with systemic health resulted in growing emphasis on interdisciplinary collaboration between primary care dentistry providers and other medical healthcare providers to address the holistic needs of patients; thus, increasingly practising comprehensive primary care dentistry promoting overall health and well-being.

In recent decades, we have witnessed the advancement of digital technology and its integration into primary care dentistry, often at a remarkable pace. The evolution of digital technology in the oral health care arena had three foci: CAD-CAM systems, imaging, and practice/patient software management systems. As a result, digitization has gradually taken root in primary care dentistry, which evolved further with the adoption of digital technology, i.e., direct digital radiography, computerised radiography, cone-beam computerised tomography with intuitive software systems, digital workflows, and newer biomaterials.

Overall, the history of primary care dentistry reflects the evolution of dental practices from ancient times to the present day, with significant advancements in education, training, technology, and service delivery contributing to improved oral health outcomes, comfort and aesthetics for individuals, families, and communities worldwide.

3. Primary care dentistry – the present

Primary care dentistry has emerged as a distinctive entity characterised by a unique body of scientific knowledge applied in practice. Practitioners in primary care dentistry can undertake courses and programmes that are relevant to their practice. Not only are most of these courses and programmes well researched and evidence-based with relevance to primary care dentistry but they also provide opportunities for dental practitioners and the wider dental team to share knowledge, understanding and most importantly, best practice. Nowadays, primary care dentistry encompasses a wide range of services aimed at promoting oral health, preventing dental diseases, and maintaining, improving, or restoring oral function, aesthetics and oral health related quality of life.

In the UK, the primary care dentistry team, comprising of dentists and dental care professionals (DCPs), (e.g., dental hygienists, dental therapists, clinical dental technicians and dental nurses), plays a crucial role in primary care settings working alongside medical doctors and other healthcare professionals to provide comprehensive services and care to patients of all ages. The goal of contemporary primary care dentistry is to promote good oral hygiene habits, detect dental and oral soft tissue diseases early, and provide necessary diagnostics and treatments in the primary care setting i.e., check-ups, dental radiographs, fluoride treatments, fissure sealants; direct and indirect restorations,

endodontic treatment, dental extractions, and tooth replacement to prevent more serious problems from developing. It forms the foundation of oral health care and is essential for maintaining a healthy mouth and overall well-being.

3.1. Minimal intervention dentistry

Minimal intervention (or minimally invasive) dentistry (MID) is a concept for the maximal preservation of healthy tooth structures whilst reducing detrimental effects on the dental pulp from (excessive) intervention. It has evolved as a consequence of our increased understanding of the caries process and the development of improved adhesive restorative materials [3]. It is widely recognised that demineralised but non cavitated enamel and dentine can be 'healed', and that the surgical approach to the treatment of a caries lesion along with 'extension for prevention' as proposed by G.V. Black is no longer tenable [3]. The evidence for the minimally invasive operative caries removal strategy using a range of clinical methods (e.g., mechanical hand instruments, chemomechanical agents such as Caridex™ and Carisolv™ gel) in appropriately selected patients exists [4].

The concept of MID has been extended to the management of direct dental restorations with localised defects. The repair of such a restoration is a minimally interventive means of extending the longevity of the restoration without unnecessarily sacrificing healthy tooth structure [5]. Contrary to total removal of the defective restoration, repair procedures do not result in progressive cavity enlargement and consequential weakening of the tooth, let alone repeated insults to the pulp [6,7]. Thus, unlike total restoration replacement, repair is not going to accelerate the restorative cycle of the tooth [8]. Longitudinal clinical studies have shown that restoration repairs in permanent teeth are able to significantly increase the lifetime of restorations and the restored tooth unit [9,10] and come with reduced treatment time, lower costs and lower risks of complications than total replacements [11].

3.2. Digital dentistry

We are witnessing an increasing trend towards the use of computerised systems and digital workflows in primary care dentistry moving away from conventional, analogue impressions and traditional impression materials, which are often associated with time and handling limitations. The exponential advances in digital dentistry reflecting increasing demands for optimal aesthetic results, high quality precision, shorter treatment time, reduced number of appointments, and treatment decisions based on predictable outcomes using highly aesthetic restorations with the latest biomaterials and technologies have created exciting opportunities for improving patient comfort and experience and have transformed modern primary care dentistry.

These days, the scope of digital systems is immense. We now have technologies available that allow us to digitise almost any type of information that can be readily acquired, stored, retrieved, shared, and analysed [12]. In addition, new user-friendly and patient-friendly versatile digital systems, including the development of interactive software to allow for digital smile design and 3D virtual treatment planning, such as computer assisted rehabilitation in implant dentistry [13] have made a key impact in modern primary care dentistry.

In some countries the professional body of primary care dentistry is represented through various dental organisations supporting the professional development of the primary care team and providing assorted benefits for their members. In the UK, the newly formed College of General Dentistry (CGDent), is the professional body for primary care dentistry complementing professional body support for members of the primary care dentistry team. The purpose and mission of CGDent spans fostering excellence in oral healthcare, setting standards to further enhance quality of primary care dentistry. In addition to promoting standards in fields such as leadership, management, law and ethics and information technologies in everyday oral healthcare, CGDent is

implementing aspects of continued and further evidence based dental education and a structured career pathway for general dental practitioners and DCPs enhancing their career potential at every step.

3.3. Evidence-based practice in primary care dentistry

A central question to ask is what is evidence-based best practice in primary care dentistry and from where is it derived? While universities are an important source for research, they are not the only source. Many practitioners in primary care dentistry would argue that university research is not applicable to their work when compared to other more invaluable sources that may be more pertinent to primary care dentistry. This is largely because university based research is commonly carried out under ideal and standardised conditions by calibrated operators on well controlled patients resulting in a lack of generalisability and external validity [14] inhibiting clinicians' decision-making abilities [15]. In contrast, research in primary care dentistry makes dental practice an area of fundamental importance in the assessment of new techniques, devices and materials, as success of a technique, device or material could be considered to be its performance in everyday use in primary care dentistry, which may be considered to differ from the controlled academic environment of assessments carried out in a dental hospital or school [16].

Indeed, the assessment of the performance of dental restorations, techniques and devices carried out in a dental hospital or school environment may be considered to represent 'efficacy', the performance of the material under ideal circumstances, while their performance in dental practice may be considered to represent 'effectiveness', or, how something performs in the 'real world' [16]. Since the majority of treatment, worldwide, is carried out in the real world of general dental practice, it cannot be overemphasised that when formulating an evidence-base for primary care dentistry, this must take place in terms of 'effectiveness' that is pertinent to real world dentistry practiced in primary care, rather than in terms of 'efficacy' stemming from assessments in 'ideal' environments with 'ideal' conditions.

3.4. Practice-based research in primary care dentistry

The importance of practice-based research has been emphasised by Mandel [17], who considered that 'research is not only the silent partner in dental practice, it is the very scaffolding on which we build and sustain a practice'. In this respect, a UK-based group of practice-based researchers known as the PREP (Product Research and Evaluation by Practitioners) Panel, and a US-based group of practice-based researchers known as the National Dental Practice-based Research Network (PBRN) were formed researching a wide variety of research projects that may be considered to be appropriate to provide the required evidence-base for primary care dentistry. These include [18]:

- Assessment of materials and techniques
- Clinical trials of materials
- Assessment of treatment trends and treatment of disease
- Assessment of behaviour and attitudes (of dentists as well as patients)
- Evaluation of disease incidence
- Patient satisfaction.

Practice based research involving a group of dental practitioners is particularly important as the performance of a material or device by one operator is necessarily subjective, but when practitioners band together to form a group in order to evaluate new materials in dental practice, the results are likely to be more objective and generalisable [16]. All of this is possible when practitioner-based research groups are teamed with the expertise available in academic institutions allowing for the translation of generalisable 'research findings into primary care dentistry.

4. Primary care dentistry – the future

Taking a glance to the future, the transformation in primary care dentistry resulting from technological advances is likely to continue to grow. The continual advancement of technology and its integration into dentistry has enormous potential to further transform the field of primary care dentistry. Thus, as new technologies are developed, we can expect more innovative applications of digital systems in primary care dentistry that will improve patient outcomes while reducing costs and increasing efficiency. In addition, new technologies are likely to provide solutions to problems encountered in primary care dentistry that were previously thought as unapproachable.

4.1. Digital technologies

Although the digitisation of dentistry through the application of digital technologies has certainly begun, when looking ahead, future generations will see the 2020s as being only the beginning. Continual exponential advances in digital dentistry using improved technologies and newer materials will unquestionably lead to a transformation in oral healthcare and primary care dentistry where additive manufacturing technology in terms of three dimensional printing is going to become commonplace. This author conjectures that intraoral scanning, CAD-CAM restorations using newly developed hybrid materials, and 3D printing will become the norm in the provision of primary care dentistry, particularly in developed countries. It will be both challenging and exciting to witness new digital innovations and watch how we shape the digital transformation directed at improving oral health care and dental rehabilitation of patients to a restored state of function, appearance, and comfort.

4.2. Teledentistry

The expanding utilisation and adoption of teledentistry, a branch of telemedicine that has rapidly advanced in the last few years is likely to continue flourishing in the future. The Covid-19 pandemic has increased the adoption of all digital health technologies and teledentistry is no exception. Teledentistry is a combination of telecommunications and dentistry involving the exchange of clinical information and images over remote distances for dental consultation and treatment planning using the Internet. Continual improvements in information and communication technologies (ICT) utilised by teledentistry to deliver dental services over long distances are likely to result in teledentistry improving access to patients who do not have prompt and immediate access to primary care dentistry services and is likely to gain popularity for sharing digital information and distant consultations at lower costs to patients. It also has the potential to eliminate the disparities in oral health care between rural and urban communities.

4.3. Artificial intelligence

Artificial intelligence (AI) is a subdiscipline of computer science that has been making waves in various industries, and dentistry is no exception owing to its tremendous potentials and equally substantial challenges. AI refers to the idea of building machines that can perform tasks that are normally performed by humans. Machine learning (ML) is a subfield of AI, in which algorithms are applied to learn the intrinsic statistical patterns and structures in data, which allows for predictions of unseen data, automated interpretation of dental imaging, predicting future disease and treatment outcomes [19,20].

In recent years, AI has been increasingly used in dental education, diagnostics, treatment planning, patient communication, and treatment workflows to improve patient outcomes and streamline dental procedures. One of the most significant advantages of AI in dentistry is its ability to analyse vast amounts of data quickly and accurately, providing primary care dentists with valuable insights to enhance their diagnostic

and clinical decision-making processes [21]. However, looking ahead future generations are likely to harness AI to revolutionize dentistry and, with it, primary care dentistry. To this effect, primary care dentistry is likely to increasingly integrate AI to help transform and improve the current state of clinical dental practice. Examples might include AI assisted diagnostic and virtual treatment planning, AI based clinical decision making, and robotics becoming integral to primary care dentistry. For this to be achieved, however, it is essential that current challenges, such as data privacy (AI requires access to sensitive patient information such as medical records and imaging data) will be overcome. A growing body of AI research, particularly on how ML algorithms can be trained on diverse datasets to ensure unbiased decision-making in dentistry may pave the way for a wider application of AI in primary care dentistry in the future.

5. Conclusion

Primary care dentistry has come a long way since it has emerged as a distinctive entity within dentistry. It is the first point of contact in a care process for most dental patients and it aims to provide continuing or longitudinal care with a health maintenance role centred on the individual rather than specific diseases or conditions. The generalists working in the primary care dentistry setting also have a gatekeeper and co-ordinator role in relation to specialist services when referral to specialist services in primary care or dental hospital services is indicated.

Although primary care dentistry has evolved much over the past 50 years with the introduction of new materials, concepts, techniques, and technologies it is still a developing field with a promising and exciting future, last but not least owing to the many more technological innovations and developments to come. A much needed development, however, is developing an evidence base in terms of 'effectiveness' studies that will drive up standards of prevention and treatment, and help strengthening the foundations of primary care dentistry to the benefit of patients, dental professionals, and the wider society.

CRediT authorship contribution statement

Igor R. Blum: Conceptualization, Data curation, Writing – original draft.

Declaration of competing interest

The author declares that there is no conflict of interest of any kind.

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