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Information Technology in Dentisry: A Review

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Abstract

Technology in dentistry is a novel science and it will continue to grow in future. The research field that study dentistry from a technical perspective is dental informatics. A simple but congent definition of dental informatics is "The application of computer and information science to improve dental practice, research, education and management". Dental informatics is beginning to exhibit the characteristics of a discipline: core literature, trained specialists and educational programs. Over the past two decades, there have been significant achievements in oral health in India, but, it still remains a challenge to achieve the establishment of a database for monitoring and surveillance. Most dentists are unaware of what dental informatics is, what its goals are? What it has achieved and how they can get involved in it. Dental informatics presents possible solutions to many longstanding problems in dentistry, but it also faces significant obstacles and challenges. Its maturation will depend as much on the efforts of people as on the collective efforts of the profession.

Keywords: Information Technology, Teledentistry, Dental Informatics, Digital Radiography

Introduction

Information technology has developed very rapidly in a short span of 40 years and touched almost every aspect of the society. According to Merriam Webster it is defined as ―the technology involving the development, maintenance, and use of computer systems, software, and networks for the processing and distribution of data. [1] Information technology, or IT, has transformed society and will continue to do so in the future. The way in which children grow up, companies do business, people shop and communities socialize has changed significantly since the beginning of the information revolution. That revolution also has made its mark in the dental profession. Almost 80 percent of dentists have computers in their offices in USA, almost 30 percent have access to the Internet, and an increasing number use a variety of other technologies, including digital intraoral cameras and paperless patient records.[2] According to 1997 survey by ADA, almost 80 percent of dentists have computers in their offices, 30 percent have access to the internet, and an increasing number use a variety of other technologies, including digital intraoral cameras and paperless patient records.[3] Dental informatics combines dentistry and several research disciplines, such as computer science, information science, cognitive science, and telecommunication.[4] Dental informatics is a young discipline. It has seen many developments since early computers were first exploited to address problems in dental practice, research and education. [5]

History and Evolution of Dental Informatics

Dental informatics has developed significantly since the 1960s, when the first uses of informatics approach to address dental issues were documented. In the 1960s, the National Library of Medicine (NLM) in the USA began to accumulate in a computer the bibliographic citations of the more than 3000biomedical journals stored and indexed by the NLM. By 1971, these references were available in MEDLINE, the first interactive online medical bibliographic database. Since 1979, MEDLINE has included all references contained in the index to Dental Literature and is the most comprehensive bibliographic database of the published dental literature. [6,7] In the early 1990s, some professional organizations—such as the International Medical Informatics Association, the American Medical Informatics Association, and the American Dental Education Association—began to organize interest groups in dental informatics. A key development was the initiation of funding for dental informatics training by the National Institute of Dental and Craniofacial Research (NIDCR) in 1996, which for the first time recognized the need for a formal education of dental informatics. (The National Library of Medicine [NLM] had been funding similar

training in medical informatics since 1972 [Braude, 1991]). [5] The evolution of Dental Informatics in India has been a new-comer. The vast strides made by the country in the field of Information Technology have helped popularize the use of computers in Dentistry. Several dental software programs have been indigenously developed for clinical care, patient education, for practice management last but not the least for data analysis. [8].

Application of Dental Informatics

1. Clinical care

As the patterns of oral diseases are continuously changing, dental care has now become more complex and informatics is an effective science to rely on. A new paradigm for clinical care, embracing informatics includes: development and maintenance of computer-based patient records, full use of expert systems and artificial intelligence in diagnosis, treatment and prevention of oral diseases, and improved communication between various professional elements based on electronic links

2. Computer-based patient records

The most important improvement offered by IT application to dental decision-making is the ability to make the different parts of the patientrecord immediately accessible in a synoptic, comprehensible, and easily managed way. As with many other types of data, the ideal method for data capture is at the source, with notime lag and without any intermediaries. The electronic patient record system exclusively uses the graphical user interface (GUI). Basically, this interface relies on graphic images, or icons, rather than on words to identify each component of the record and when identified the user can explore the information depicted by the icon by clicking on the icon in question [9].

3. Telecommunication

In this age of information explosion, dentists face overwhelming levels of new dental information every day. To stay ahead, continuous professional development is a must for the dental profession. In this respect, telecommunication helps in three ways [9].

1. Dental distance learning.
2. Dental information searches.
3. Teledentistry.

1. Dental distance learning

Continuous Dental Education is the most obvious way for the dentist to get value added to his/her career life. However, studies performed by national dental associations have found that the available postgraduate training programs do not attract interest from a considerable group of dentists. There might be many reasons for that. One reason could be that the geographic distances are considerable and the available communication systems bad. Socio-economic factors may be an issue. Another reason for not participating in postgraduate educational programs might be that the dentist feels uncertain and shy in relation to his/her colleagues and does not want to be confronted bywell trained colleagues. [9]

2. Dental information searches

The internet is a dental information treasure island. By using a powerful search engine such as Google, the dentist can acquire most current and useful clinical information from different dental specialties online [9]

3. Teledentistry

Teledentistry is the provision of dental care where the patient and provider are not physically located in the same place. Teledentistry can extend care to under-served patient populations, such as those in rural areas, at a reasonable cost. It also provides an opportunity to supplement traditional teaching methods in dental education, and will provide new opportunities for dental students and dentists [9]

Use of Expert Systems and Artificial Intelligence in Diagnosis, Treatment, and Prevention of Oral Diseases

Artificial Intelligence (AI) is the field of computer science that seeks to implement computer-based technology that can simulate the characteristics of human intelligence 10. This broad scope includes computer vision, expert systems, game playing, general problem solving, machine learning, natural language, pattern recognition, robotics, speech recognition and synthesis, and theorem proving. Large amounts of specialized factual and empirical knowledge provide best solutions for the AI systems in diagnosis [11]. .

The most common means of data analysis used in decision-support systems to link patient information to the store of medical knowledge are: Algorithmic Systems, Statistical Systems, Rule-based Systems and Neural networks [11].

Research

Recent scientific and technological advances have combined with new information technologies to reveal the needs of dental research and patient care.

During the past decade, advances in information technology have increased the computer speed.[13] These accelerating advances in information technology are having a parallel impact on the technologies used to conduct dental research, and consequently, on the methods and materials used to provide oral healthcare to patients. The impact on dental research has helped increase our knowledge of dental caries, oral candidiasis, periodontal disease, and other oral health diseases, in addition to helping map the human genome. [15, 16]

Besides, traditional dental research, biomedical informatics is also advancing educational and clinical research. Biomedical informatics supports educational research through simulations of biological systems to improve the understanding of the roles and interactions of biological systems for students and practitioners [14]. Biomedical informaticians help in creating databases and knowledge bases by means of working on diagnostic codes and assessing outcome data for patients. There also exist challenges to use information technology in research, which require different approaches to simplify the complexity of research by using IT support. [17]

Education

Computers and the Internet are revolutionizing the process of education at all levels. Besides, being a key tool in the educational process, computers are also making education available in places and at times in which it was previously inaccessible. Students in the health profession now dissect cadavers on the computer screen, prepare teeth with real time feedback from a computer, and practice surgical procedures on simulators [18].

The trends of dental informatics, which can reshape dental education and continuing education, have been explored in previous reports [19].

Continuing dental education on the World Wide Web

Continuing dental education (CDE) is a requirement for dental practitioners and dental hygienists. These requirements can be fulfilled in various ways, including attending lectures, reading journal articles, listening to an audiotape, viewing a videotape, and completing a course on the World Wide Web [20]. An important pioneering application in dental education is the emergence of E-textbooks. As biomedical and dental literature is inevitably generated and stored digitally, the move towards e-textbooks has become unavoidable. Many other technologies, such as intelligent tutoring applications, student response systems, and lecture recording and broadcasting have reshaped the dental education landscape already and will continue to do so. [21, 22].

The limitations in implementing informatics in oral healthcare profession are several, which may best be perceived as challenges to overcome in the near future. Both, technological and ethical concerns of using information technology in dentistry are to be addressed for effective implementation in areas of education, research, and clinical care. [23, 24]

Computerized Diagnostic Devices

These devices offer in-depth diagnostic information previously unavailable.

A. Periodontal probe

Enhances probing examinations by improving the resolution, repeatability, and accuracy of measurements. This probe was designed to use electronics to probe using controlled-force conditions relative to the cemento-enamel junction, thereby providing measurements of both probing depth and attachment level. The Florida probe is a controlled-force depth gauge. It uses a personal computer and one of its strengths is the ability to store each examination on disk allowing it to flag the parts of the examination that have changed from time to time [9].

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B. Electromyography for mandibular motion analysis

Electromyography assessment is a reliable method for differentiating between types of neuromuscular imbalance. Several authors have reported that neuromuscularly dysfunctional craniomandibular disorder (CMD) patients have higher resting levels of facial EMG activity than do non-CMD patients. Glaros et al concluded that facial EMGs have a positive predictive value for determining muscular dysfunction [9]

C. RadioVisio Graphy

RadioVisioGraphy (Trophy Radiology, Vincennes, France) was developed by Frances Mouyen to provide instant dental radiographic images. There are three basic components to RVG. ‘Radio’ part is a conventional X-ray generator with a precise microprocessor timer for very short exposure times plus an electronic sensor. ‘Visio’component stores the incoming signals during exposure and converts them pixel by pixel into 256 discrete grey levels. The image is produced in real time, with the magnification dependent on the size of the monitor employed. ‘Graphy’component is the storage unit. A reduction in radiation of over 94% with RVG compared with Ultra speed film [9].

D. Digi - Graph

Digi - Graph is a synthesis of video imaging, Computer technology and sonic digitizing. It enables the clinician to perform noninvasive andnon-radiographic cephalometric analysis. The system allows cephalometric evaluation and treatment progress as often as necessary without radiation exposure. The Digi Graph allows all patients' radiographs tracings. Cephalograms, photos and models to be stored on the computer hard disk [9]

E. Digital subtraction radiography

Digital subtraction radiography is a technique used to obtain additional information from radiographic images. Two radiographs made at two different times are compared and all unchanging structures are subtracted, leaving the areas of change displayed against a neutral, usually grey background. The computer can be used to isolate areas of change using what is called the 'morphologic technique'. [9].

F. Digital intraoral and extra oral camera

The potential uses for intraoral and extra oral cameras are: patient education, dentist education, and documentation. Use of intraoral or extra oral cameras allows patients to see magnified images of their conditions. Dentists can educate themselves by observing their own dental service both initially and over a period of time 11.

G. Bone densitometer

Bone densitometer is an electronic device to measure bone density and very useful to find out the bone fracture risk in a patient. The device after examination gives the result within few seconds and is of great use in the patients undergoing implant surgeries of teeth [9].

H. Dental Imaging

Dental imaging is a solution wherein a small intraoral camera is interfaced to the computer so that the user has to just focus the camera to capture the image on the monitor click and the image can be saved as a part of a picture album for each patient in the computer itself. These images can be viewed, edited, transformed into slides and printed [9].

I. Computerized Cephalometric Systems

Computerized Cephalometry provides, in addition to reliability, the advantage of speed. It can be performed in 10% of the time of a normal manual registration - and calculation [25].

J. Cad - Cam in Dentistry-

CAD stands for Computer Aided Design while CAM stands for Computer Aided Manufacturing. CAD is the ability to get a design on the computer. CAM on the other hand helps in manufacturing a product or prosthesis or an appliance using the computer aided design. CAD - CAM technology was first introduced to dentistry in 1971 by Duret. Heitlinger in 1979 used CAD - CAM to mill stone study models which was used to fabricate crowns, inlays and bridges. The advantage of these CAD - CAM dental systems is the ability to construct the restorations or prosthesis in a single appointment without the needfor impressions or fabrication of temporaryprosthesis. The system designs the restorations electronically and then mills it from a block of porcelain or any other material [25].

K. Oral CDX

Method for screening oral lesions that involves a brush biopsy and computerized analysis of histologic slides allows for screening of more patients for premalignant and malignant lesion earlier [2].

L. Tuned Aperture Computed Tomography

Is an Example of a three dimensional imaging modality? Applications include primary caries detection, and assessing bone defects at implant sites [2].

M. Computerized Syringe Device

The Wand local anesthesia system (Milestone Scientific) was developed to improve pain control during local anesthesia delivery. The device is a computer-controlled system that maintains constant pressure and volume ratios, delivering local anesthetic solutions at a constant rate regardless of tissue resistance [26].

N. Optical Methods in Dentistry

Optical methods for treatment include the well-known curing of polymeric materials, photodynamic therapy of tumors and potentially, laser fusion of enamel and dentin [27].

O. Dental Holography

Optical measuring techniques- such as holography, contouring, moire, and speckle- offer new nondestructive possibilities for bridging the gap between in vitro and in vivo measurements in dentistry, and thus increase the possibility of achieving more accurate and sometimes more objective diagnosis and therapy [28].

P. Scanning Acoustic Microscope

It can be used to obtain images of caries lesions in longitudinal sections of human enamel. Contrast in the acoustic images is unique in that it arises from changes in the elastic properties across the surface of a specimen. Comparison of an acoustic micrograph, a polarized light micrograph, and a microradiograph of a caries lesion reveals that the elastic properties of enamel are strongly dependent on the level of mineralization within the tissue [29].

Q. Telemetric Methods

The use of telemetric methods for obtaining data from the human oral cavity has increased dramatically over the last two decades. Measurement of intra-oral pH from plaque or saliva has been the most common application of ion-specific telemetry in dental research 2.

R. DNA Probes in Dental Diagnosis and Therapy

Recombinant DNA technology now allows for the development of genetic probes specific for a growing large number of etiologic disease agents, including those suspected pathogens in the oral environment. The use of probe technology potentially offers a much more facile, accurate, and less time-consuming mechanism for the identification of fastidious micro-organisms from the oral cavity, many of which are laborious and difficult to cultivate [29].

S. Controlled-Release Therapeutic Systems

Controlled-release therapeutic systems are designed to deliver a pre-determined amount of drug to a specific anatomical site for an extended period of time. A system for fluoride has reduced experimental dental caries in rats by over 50% and has significantly elevated salivary fluoride concentrations during a six-month trial in adolescents [30].

Conclusion

The slow emergence of dental informatics is primarily a failure of academic dentistry. Investing in dental informatics requires money and resources for qualified faculty, academic departments and/or centers, and research projects. The current age of financial scarcity for dental schools requires sound allocation of resources. Developing dental informatics is not an option, but a necessity.

Improved quality of oral health information systems worldwide may help to strengthen health systems and operational research may assist in translating sound knowledge about prevention program and health promotion for the benefit of the poor and disadvantaged population groups. Putting the theories and concepts of informatics into practice requires significant effort and investment. Many projects on this road will fail. Dentistry, however, should learn from the failures as much as it does from the successes. Only then will we realize the promise of informatics.

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