Review Article

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Evolution of Dental Informatics: A Cornerstone of Dental Practice

Mohit Dadu*, Aruna D.S., Dimple Arora***, Richa Arora*****

Abstract

Information technology or IT, has transformed society and will continue to do so in the future. A simple, but cogent, definition of dental informatics is "the application of computer and information science to improve dental practice, research, education and management," Dental informatics (DI) is a relatively new field that has significant potential for supporting clinical care. It is a young scientific discipline that is undergoing continual maturation. Its main purpose was to develop strategies for how bio medical informatics can most productively contribute to the resolution of dental research problems. Most dentists are unaware of what dental informatics is, what its goals are, what it has ach ieved and how they can get involved in it. It is mainly concerned with collecting, storing, and retrieving data from large databases. This article attempts to review the evolution and progress of dental informatics as a specialty and its applications in dental practice. This review delineates informatics from information technology and explains the types of scientific questions that dental and other informaticians typically explore. Scientific investigation in informatics centres primarily on model formulation, system development, system implementation, and the study of effects. Informatics draws its scientific methods mainly from information science, computer science, cognitive science, and telecommunications. Dental informatics has lead to numerous applications that improve dental practice, research and management. DI shares many types of research questions and methods with its parent discipline, biomedical informatics and Tele-dentistry. However, there are indications that certain research questions in dental informatics require novel solutions that have not yet been developed in other informatics fields.

Keywords: Bioinformatics; Databases; Dental informatics; Oral pathology.

Introduction

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.[1-7] That revolution also has made its mark in the dental profession. Almost 80 percent of dentists have computers in their offices, 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.[8] Dental management experience have led to a number of unexpected opportunities, which are coming together into a Comprehensive System to help our profession learn about and use technology. This includes Seminars, User groups, Newsletters, Books and Articles, Internet groups, Consulting, Training, Technology references, Hardware, Room Design and more. Training and developing the people in the office, including the dentist, to use advanced technology effectively is at least as important as the hardware and software components.[9] According to Merriam-Webster's Collegiate Dictionary, informatics is derived from the term "information science," which is the collection, classification, storage, retrieval and dissemination of recorded knowledge treated both as a pure and applied science.[10] In 1946 the world's 1st electronic computer viz. Electronic Numerical Integrator And Calculator (ENIAC) was developed. This has

Author's Affilation: *Post Graduate student, **Professor and HOD, ***Post Graduate student, Department of Public Health Dentistry I.T.S–Dental College Muradnagar, Ghaziabad.

Reprints Requests: Dr. Dimple Arora, H. No. – 399, Sector 21 - C, Faridabad – 121001, Haryana, India.

E-mail: dimple.dimplearora90@gmail.com

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undergone various changes to become a present day microcomputers which are far more powerful and cost very little. The advances in computer technology are usually talked in terms of generations. The 1st generation computer started in 1945 contained 18,000 small bottle sized valves which constituted its CPU. This machine did not have facility to store and is complicated. The 2nd generation computers found the way for development with the invention of the transistor in 1947. Such computers appear in market in the early 60s. They are much smaller and more reliable. The 3rd generation computers followed the invention of integrated circuit (IC) in 1959. They appeared in the market in the 2nd half of the 60s. The 4th generation computers owe their birth to the advent of the microprocessor in 1972. This device has enabled the development of microcomputer, personal computer and portable computers. The 5th generation computers which are in developing stage may use switch like high electron mobility transistor and will be 50 times faster than the present day superfast machines.

A common misconception is that informatics is the same as IT. Informatics is focused primarily on research, development and evaluation of information models and computing applications. IT, on the other hand, is concerned with the implementation and application of computer technology and telecommunications. Despite the larger conceptual division, limited areas of overlap between informatics and IT exist, such as custom development of software and evaluation of implemented systems.[11]

The practical applications of computer systems in clinical dental practice include office management, digital imaging, radiography, and teleconsultation. The emerging discipline of dental informatics is derived from such applications, and is sure to tremendously affect the practice & development of dentistry.

Application of computers in epidemiological data[12]

The problem of analysis of dental epidemiological data is the amount of data which has to be collected to make any study worthwhile. After collecting a data it has to be looked under various ways and to be compared them with the results of the previous studies. If such a study is to be undertaken by hand several months are required to obtain the results and the analysis is abandoned simply because of the time factor. In the last few years, almost every published reports of the dental epidemiological work indicate that computer facilities have been used for the analysis.

Preparation of epidemiological data for the computer[12]

One of the methods of entering the data is in the form of punch cards but the data collected in a dental survey cannot be recorded by punch cards so it is necessary to decide how the information should be recorded. All the qualitative information (male or female, good, fair or poor) to be collected in a survey has to be coded in a numerical or alphabetical characters (male=0/m, female=1/f, good=g/1, fair=f/2, poor=p/3). Quantitative data are already numerical so do not need to be coded. In addition to the coding it is necessary to decide the position at which each item of information is to be punched on to the card. Some items will require only a single column e.g. sex, while some such as DMF scores will require more than one. The total number of columns designated for each item is known as a field. It is necessary that each field is always in the same position in every card and care must be taken during the preparation of the data. Ones the position and code for each field have been determined details should be fully documented. The field length and the details of the coding should be arranged to suit the user's requirements and the computer programme accordingly. The preparation of the data consists of the 3 phases – the collection, coding, & punching. Dental data are normally recorded on a chart in a diagrammatic form which has to be coded and to ensure accuracy at the punching stage this coding is usually recorded on the second form. At the clinical examination, the examiner calls out his

findings in code rather than in the usual manner. After the collection of data they are punched as previously described. The cards are passed through a verifier in which a similar sequence of events takes place to ensure that the holes are in correct place. Any errors detected are corrected before the analysis begins. Using this method of collecting data it is possible for a skilled punch operator to prepare the data for computation at about the same rate as it is collected.

Analysis of dental data[12]

The dental data collected on punch card is analysed in two steps: 1. The abstraction of the data according to the various epidemiological indices. 2. The analysis of the results of the groups of individuals using these indices. The Abstract programmes are arranged so that they may abstract details from the fill mouth, or from any named quadrant or quadrants, teeth or tooth groups. In this way the programmes are very flexible and can be used for partial as well as complete analysis. The output of the analysis is usually in the form of tables giving detailed results for each group. When required the necessary statistical test between groups can be undertaken. It is also possible to produce bar charts giving details of the DMF of each group. Many analysers have reported that this system was easy to use and many have indicated that in the absence of the computer they would not have considered starting their surveys.

How can you get involved in dental informatics?

Getting involved in and staying up to date on dental informatics is not as easy as joining a professional society and subscribing to its journal. There are, however, a few options for articles on dental informatics in major dental journals. Journals in which articles about dental informatics appear periodically include JADA, Journal of Dental Education, Quintessence International and the Journal of Computerized Dentistry. The Journal of the American Medical Informatics Association, MD Computing, and the Journal of the American Medical Association and the British Medical Journal are good sources for keeping up with general medical informatics developments.

What are dental informatics' practical goals?[13-15]

The main goal of dental informatics is to improve patient outcomes. Thus, the discipline must support and improve diagnosis, treatment and prevention of disease and traumatic injury; relieve pain; and preserve and improve oral health. A secondary goal is to make the delivery of dental care more efficient; for example, by maintaining or improving cost-benefit ratios. Dental informatics also must support Research and Education, and improvement in these areas should, and often do, translate into improved patient care. Informatics is the key in helping practitioners solve clinical problems and keep current. Most educational programs still subscribe to the philosophy that everything dentists need to know can be learned in dental school. The trend toward problem-based learning and the development of critical-thinking skills tells a different story.

Bioinformatics[16]

Bioinformatics is a relatively new field of science that incorporates the principles of biology and computer science. It is mainly concerned with collecting, storing, and retrieving data from large databases. Ever since the successful completion of the Human Genome Project, there has been an exponential growth in the volumes of biological data that is being generated worldwide. The evolution of bioinformatics has made it possible to access these databases and apply the information for better research. One discipline that has been benefitted from the advent of bioinformatics is oral pathology. Oral pathology is a branch of dentistry which deals with the diseases of the head and neck region. Remarkable progress has been made in the diagnosis and treatment of diseases with the aid of bioinformatics. This article attempts to review the evolution and progress of dental

informatics as a specialty and its applications in oral pathology.

Biomedical informatics[17]

Biomedical informatics involves a core set of methodologies that can provide a foundation for crossing the "translational barriers" associated with translational medicine. To this end, the fundamental aspects of biomedical informatics (e.g., bioinformatics, imaging informatics, clinical informatics, and public health informatics) may be essential in helping improve the ability to bring basic research findings to the bedside, evaluate the efficacy of intervention across communities, and enable the assessment of the eventual impact of translational medicine innovations o health policies. Here, a brief description is provided for a selection of key biomedical informatics topics (Decision Support, Natural Language Processing, Standards, Information Retrieval, and Electronic Health Records) and their relevance to translational medicine. Based on contributions and advancements in each of these topic areas, Biomedical informatics practitioners ("biomedical informaticians") can be essential members of translational medicine teams.

Dental informatics and its relationship to biomedical Informatics

How exactly nursing informatics, dental informatics, pathology informatics and other disciplines are related to biomedical informatics is subject to an ongoing debate.[18] On one hand, it is understandable that established professions such as dentistry and nursing would like to claim informatics as part of their domain. On the other hand, an excessive number of boundaries have the danger of balkanizing biomedical informatics as a whole. It is obvious that the spectrum of research questions ranging from the cellular and molecular level to public health is similar in most clinical disciplines. It is also intuitive that most informatics methods are more or less broadly applicable across this range of research questions. The differences seem to cluster in

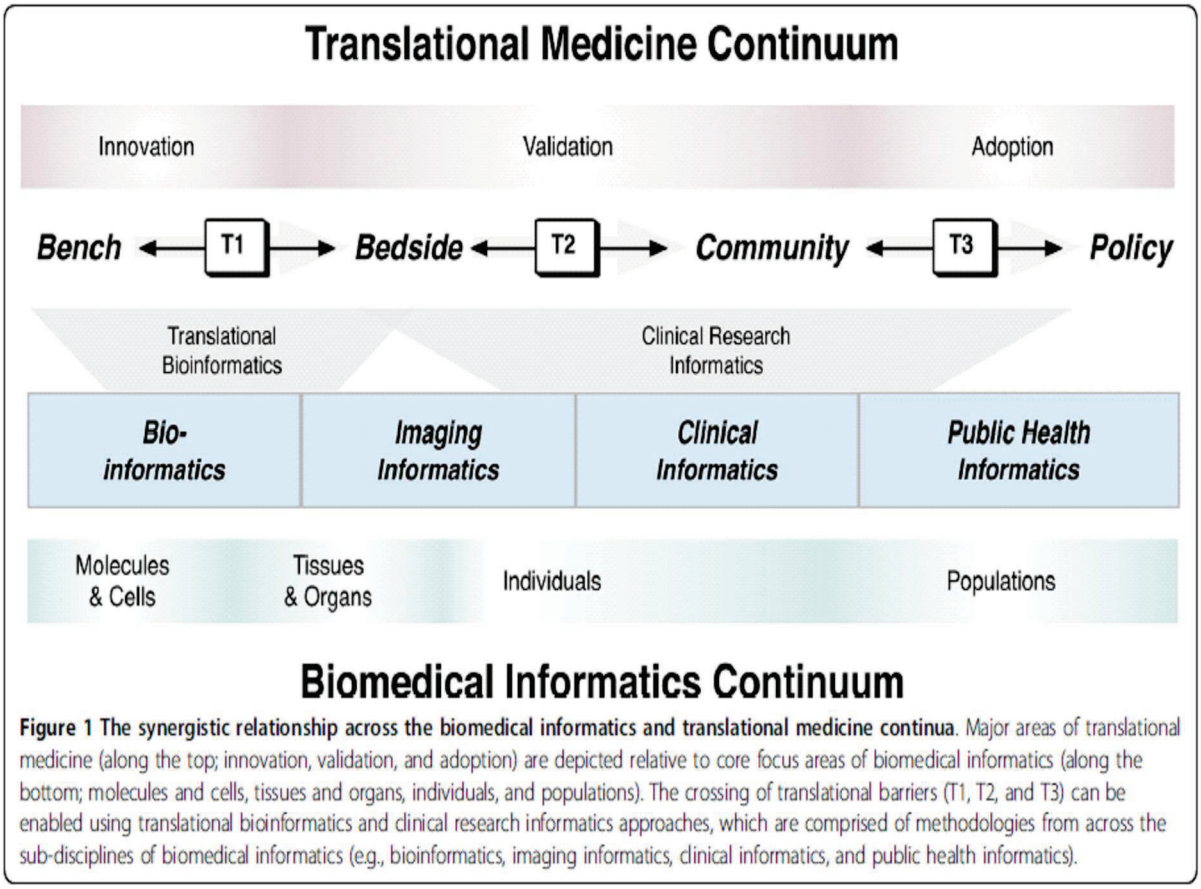

Figure 1 The synergistic relationship across the biomedical informatics and translational medicine continua. Major areas of translational medicine (along the top; innovation, validation, and adoption) are depicted relative to core focus areas of biomedical informatics (along the bottom; molecules and cells, tissues and organs, individuals, and populations). The crossing of translational barriers (T1, T2, and T3) can be enabled using translational bioinformatics and clinical research informatics approaches, which are comprised of methodologies from across the sub-disciplines of biomedical informatics (e.g., bioinformatics, imaging informatics, clinical informatics, and public health informatics).

the applied domain, where discipline-specific solutions are most needed. To give a practical example, much energy, thought and effort has been expended on the development of computer-based patient records.[19] Many innovations in computerizing medical records, however, have had little or no utility for dentistry. For instance, representational schemes and standards for clinical data, such as the SNOMED, the Reed Codes, the ICD and HL-7, typically don't represent dental concepts and data very well. Since the representations are not the same, computer systems for inputting, storing, managing and analyzing information must necessarily differ. Differences at the systems level, such as the practice setting (which in dentistry is heavily weighted towards the solo practitioner model), the distribution of generalists and specialists, and reimbursement schemes also tend to limit the transferability of theories, methods and applications from one setting to another. However, despite the fact that many practical problems require discipline-specific solutions, broad and interdisciplinary collaboration within the biomedical informatics community seems to one of the best ways to develop these solutions. As inclusive and broad communities of researchers, such as the American Medical Informatics Association, continue to illustrate, enormous opportunities for cross-fertilization and collaboration across health disciplines exist. This spirit is also embodied in the philosophies of most biomedical informatics training programs[20-22] that train physicians, dentists, nurses, pharmacologists, computer scientists and individuals from many other disciplines with curricula that share a common core, but are adapted to the needs of specific disciplines.

Teledentistry[12]

Teledentistry is a relatively new field that combines telecommunication technology and dental care. Most dentists and dental educators are unaware that teledentistry can be used not only for increased access to dental care, but also for advanced dental education. Teledentistry in education can be divided into two main categories: self-instruction and interactive videoconferencing. The interactive videoconferencing method has had better results because of its ability to provide immediate feedback. Teledentistry can extend care to underserved patient populations, such as those in rural areas, at a reasonable cost.

Web-based Teledentistry Systems[23]

Internet provides an appealing medium for the communication of health related information due to its ease of use and growing popularity. The Web-based teledentistry system which has been deployed since October 1997 consists of a laptop, a digital camera, a Web browser and requires Internet access. Since most of the dental clinics in Europe now have a local Area Network (LAN) and access to Internet through the medical hospitals, this system is being used in over 50 tri-service dental clinics in Europe. A Web-based clinical database has been developed for storing the consults. This system uses MS SQL Server 7.0 for storing the consults as the database server and MS Internet Information Server 4.0 as the Web server. The Referring dentist logs into a secure server using a Web browser. He chooses a specialty (orthodontics, oral medicine, oral and maxillofacial surgery, endodontics, oral pathology periodontics, prosthodontics or pediatric dentistry). He then sends the patient demographics, complaint, images and radiographs to the specialist of his choice. The data gets sent to the database and an electronic mail notifies the specialist of the pending consult, which he will access *via* the Internet. The specialist reviews the consult and writes his diagnosis and treatment. A plugin developed in Visual C++ enables him to do image manipulations, such as contrast and brightness changes of the radiographs within the Web browser. He then types the diagnosis and suggested treatment. The completed consult is now stored on the database server. The referring dentist receives an email indicating that his consult has been answered.

High tech dentistry[24,25]

Digital Photography

Digital photographs can be modified by

using readily available photograph editing software (such as Adobe Photoshop, Adobe Systems, San Jose, Calif.). When digital photographs are modified to demonstrate possible changes in patients' appearance, treatment plan acceptance is increased and patients are educated more easily about their treatment. This concept is one of the most indispensable of all of the high-tech choices.

Digital Radiography

The advantages of immediate image observation, image storage, image transfer by electronic means and the ability to enhance images make most users of digital radiography pleased that they have changed from conventional radiography to digital.

Intraoral Television

An intraoral television scanning of each patient's mouth should be accomplished by a staff member at each recall appointment. The findings should be recorded and the patient education continued at each subsequent recall appointment concerning the previously observed needs. Intraoral television is highly useful for patient education, and most dentists use this concept.

Computerized shade selection

Several automated shade determination devices are available. Some shade selection devices are relatively simple, while others require several steps for color determination. Shade selection devices appear to be a useful elective high-tech item.

Conclusion

There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things." Niccolò Machiavelli's words describe the challenge to dental informatics well. Computer technology has reshaped our lives already. The question is to what degree it will reshape dentistry. The ubiquitous reach of today's computer networks presages significant change: dentistry is not an isolated province of health care anymore. We are now, more than ever, connected to a larger system of stakeholders, regulations, expectations, accountability and risk. The road to clinical practice that is invisibly and seamlessly supported by informatics will be nothing short of arduous. 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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