REVIEW ARTICLE

Dental Informatics: A Click to the Future

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ABSTRACT

Biomedical informatics is one of the upgrading maturing disciplines. One of its subdisciplines, dental informatics, is beginning to emerge as its own entity. While there are numerous trained dental informaticians, dental faculty, and administrators, in general, they are not very familiar with dental informatics as an area of scientific inquiry. Scientific investigations in informatics center primarily around model formulation, system development, system implementation, and the study of effects. Informatics draws few of its scientific methods mainly from information science, computer science, cognitive science, and telecommunications. Dental informatics provides many types of research questions and methods from its parent discipline, biomedical informatics. However, there are indications that certain research questions in dental informatics require concrete solutions that have not yet been developed in other informatics fields. This article provides an overview of the unique features of biomedical and information sciences.

Keywords: Dental informatics, Health informatics, Research discipline, System implementations.

INTRODUCTION

Definition of informatics is the discipline focused on the acquisition, storage, and use of information in a specific setting or domain. Informatics can be differentiated from information science and computer science by its rooting in a domain. Informatics is more about information than technology, with the latter being a tool, to make best use of information. Friedman has defined his "fundamental theorem" of informatics, which states that informatics is more about using technology to help people do cognitive tasks better than about building systems to mimic or replace human expertise.[1]

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Dental informatics is the application of computer and information science to improve dental practice, research, education, and management, and it is a developing subdiscipline of biomedical informatics. Many confuse dental informatics with the few application of computers (information technology). Informatics is a research discipline, and most of its basic research is about information, not computers. The methods used in this research come from the fields, such as information science, computer science, cognitive science, and telecommunications. Eventually, many innovations in the informatics field are converted into computer programs or devices, and that is where informatics becomes information technology.

As so often happens within the spectrum of primary health care, dentistry is treated as the poor relative—it is the Cinderella of medicine. Nowhere is this more apparent today than in the field of Information and Communications Technology (ICT). General medical practitioners have enjoyed massive taxpayer subsidies to provide them with the necessary education and training not only in the use of ICT but also the accompanying hardware, software, and an exclusive secure electronic communication network (NHS Net). Dentistry, therefore, is left in a state of detached anarchy in the hands of internet service providers and software engineers. No electronic "look and book" facilities are practiced to make a general dental practitioner's (GDP's) life easier for patient referrals to the NHS Hospital, but the best old-fashioned use of pen and paper delivered by the Royal Mail must remain the order of the day! The specially designed NHS mechanism to deliver futuristic personal dental services—the primary care trusts or PCTs—has been disorganized and an integrated information technology (IT) strategy for dentistry is as far away as ever, archived somewhere within the Department of Health plans for the long-awaited new NHS dental contracts.[2]

Dental journals have established sections for informatics and there is one journal dedicated exclusively to dental informatics (the *Journal of Computerized Dentistry* published by Quintessence Publishing Co., Inc.). Dental informatics is represented by few working groups and sections in several professional societies, such as the American Medical Informatics Association and the American Dental Education Association. The purpose of this article is to differentiate informatics from IT, explain the major types

of scientific questions that dental informaticians typically investigate, and discuss few research methods they use. A broader understanding of dental informatics will help faculty and administrators to understand the value of dental informatics and its methods that can be exploited to elevate the state-of-the-art in education, research, and patient care. The article also presents a global view of biomedical informatics and its subdisciplines in order to allow readers to appreciate the context in which dental informatics functions.[3]

HISTORICAL GLIMPSE

The word was coined in the 1960s by the French as "informatique". It was gathered from applied information science and concerned with science or technological communication and development of much more efficient systems/techniques. It was popularized by the Soviets as Informatika and now it is considered as a branch of social sciences. France considered it to be applied computer science; the United States continued to use the term "computer science". In the 1960s, "informatics" emerged as a distinct concept. For the first time, it was Aleksei Mikhailov of the Moscow State University who gave the term as the discipline that "studies the structure and general properties of scientific information including laws of all the processes of scientific communication".[4]

Dental informatics has developed significantly since the 1960s, when there was the first use of informatics approaches to address dental issues (Ledley). Similar to informatics researchers in medicine, researchers in the nascent field of dental informatics were individuals who had been trained in dentistry and other disciplines, such as engineering, or dentists who had partnered with other professionals, such as computer scientists.

HEALTH INFORMATION TECHNOLOGY

The promise of HIT for improving the quality and safety of health care while reducing costs has caught the eye of policy makers and other leaders in health care.

Since the American Recovery and Reinvestment Act (ARRA) legislation focused on health information technology (HIT), it is the term used to describe the application of computers and technology in health care settings. Sometimes, the term "information and communications technology" is used when the use of HIT has a broad networking or communications component.

Health informatics is derived from epidemiology and has the potential as a new academic discipline for the promotion of evidence-based health care.[5]

FUNDAMENTALS OF HEALTH INFORMATICS

Interoperability in Health Information System

Interoperability in the health care information system is one of the abilities of varied systems within information technology to communicate and exchange data accurately.[6]

Electronic Prescribing

It can be understood as a computer-based support for the establishment, transmission, dispensing, and monitoring of pharmacological therapies. The goal of electronic prescribing systems is to minimize any medication errors and consequently improve standards of patient safety.[7] The electronic oral health record (EOHR) is considered as the centerpiece of information for dentistry (Fig. 1).[8] The EOHR can be a basis for the establishment of favorable dentist–patient relationship, as it can mostly act as a central repository of information about the patient that includes clinical data pertaining to the patient's oral condition as well as psychological and
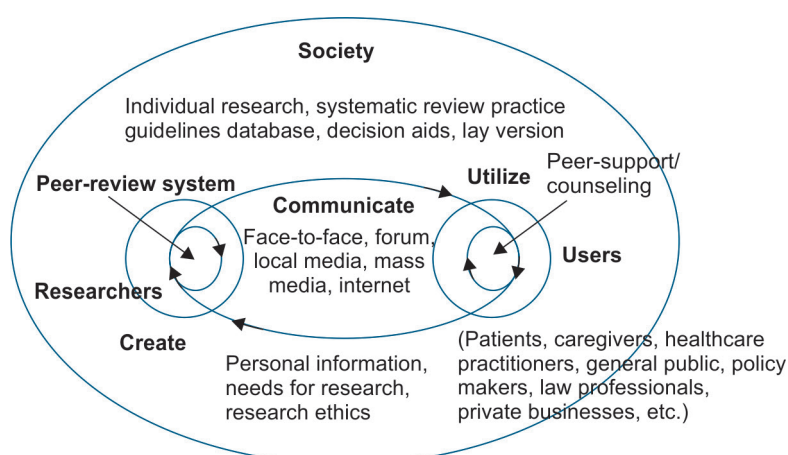

Fig. 1: Flow and circulation of health and medical informatics in the society

medical information about the patient.[8] The EOHRs can be of immense help to improve the efficiency, quality, and, most importantly, safety of care. These features help equip clinicians to formulate better and accurate clinical decisions, which would prevent avoidable errors. Clinicians must start employing such clinical decision support tools.

Information Retrieval

This concept can be understood as an art and science of searching documents, pertinent information, and searching and exploring metadata, which might be of standalone database type or hypertext networked databases like Internet or Intranets, text, sound, or images.[9]

Information Extraction

It is about selecting the relevant details regarding a specified subject from documents.[10]

Information Visualization

It is one of the techniques to represent information. It depicts the computer-supported abstract data more cognizable visually.[11]

Artificial Intelligence

It is a creation of artificial intelligence programs in the computer setups in the medical/dental fields, which aids in performing diagnosis flawlessly and helps in recommending therapeutic measures.[12]

Expert Laboratory Information System

Computers are provided with some programs that can automatically interpret the test results when relevant data are entered for interpretation of lung function tests or liver function tests (LFTs),and many more.[12]

Clinical Decision Support System

For the improvement of patient safety and its prognosis, Clinical Decision Support Systems are available. These are active knowledge systems, which exercise various items from the patient data and help to generate case-specific advice.[13]

Health Information Exchange

The Health Information Exchange (HIE) is the need of the hour as it helps in the exchanging health information of patient care across conventional business boundaries in the health care field as well as maintaining confidentiality.

The HIE has arisen from the convergence of four historic trends:

- Upgrading the quality within the cost-effective range of the health care.
- Countering appropriately to public health emergencies and imperative need for developed surveillance systems.
- Emergence of technologies capable of providing electronic per-centric health information on demand.
- Development of user-friendly technologies by which information would be easy to share between the users and the providers.[1]

DENTAL INFORMATICS

Dental informatics can be considered a specialty of medical informatics. A number of models, methods, and applications can be shared and transferred between the two disciplines. For instance, the National Library of Medicine's MEDLINE is the world's largest biomedical literature database and is equally provided and applicable to all health care disciplines. The same applies to GenBank, a database of gene and protein sequence information to which researchers from numerous domains contribute. Methods for building expert and decision-support systems, such as neural and Bayesian networks, can be applied easily across disciplines.[14]

Research

- Developing knowledge bases targeted to the information needs of dental practitioners.
- Integrating such knowledge bases into the dental workflow—for instance, through decision-support systems.
- Establishing electronic communication networks for rapid dissemination and collaboration that includes various goals that help enabling:
  - Methods for sharing knowledge bases and problem-solving methodologies among researchers;
  - Standardized interfaces with existing clinical and population record systems; and
  - automated systems that store and retrieve the standardized patient records and even make existing biomedical databases, which is highly useful for the dental community.
- Creating a dental literature database called DENTLINE within the MEDLARS (MEDical Literature Analysis and Retrieval System), which serves as a guideline for dental professionals.
  - Assessing the adequacy of coverage for dental topics in existing MEDLARS databases, such as MEDLINE.
  - DENTLINE should include areas, such as dental products, drugs, and literature references.

– Providing alternative suggestions for the information in DENTLINE—for instance, by clinical issue.

– Base the development of DENTLINE on information needs and usage among dental practitioners. Development of a national automated information system of computer-based resources for oral health can ease the data storage work.

• Establishing a cohesive collection of information resources useful for dentistry that includes bibliographic databases, epidemiological surveys, practice linked, data banks, health services research databases, biomedical research data banks, and biomedical knowledge bases.

• Developing an integrated dental component of the Unified Medical Language System. Initiate various new approaches to collect information about oral diseases.

• Establishing descriptive databases and conducting epidemiological surveys for a broader scope of oral conditions.

• Maintaining such data sources in a standardized format in a central resource accessible to practitioners and scientists through a comprehensive directory. Develop databases for risk assessment, decision analysis, and health services research.

• Collecting data from a variety of sources, such as dental practices and clinical biomedical studies, and establish disease registries and research data clearing houses.

• Making raw data available to researchers to conduct analyses and develop models along with data resources for molecular biology studies of oral disorders.

• Creating and maintaining databases for basic science information related to oral conditions.

• Establishing mechanisms by which molecular, cellular, and microbiological research results can be contributed to those databases.

• Providing the capability to correlate data from a variety of databases, including clinical and epidemiological studies. Apply computer technology to clinical care.

• Investigating clinical computer applications, such as simulations for research and practice, computer-assisted decision making, computer-assisted image interpretation and processing, and computer applications in restorative dentistry.

• Making resulting information and research available through the proposed national information system of computer-based resources for oral health.

• Conducting evaluations to determine the effects of such systems on research and clinical performance.[15]

ORAL HEALTH INFORMATION SYSTEMS

Monitoring of oral disease patterns and trends over time and data regarding the same are the essential components of oral health information systems. The World Health Organization (WHO), in 1996, established the oral health database online on the Internet, which was supported by the WHO Collaborating Centre of oral health at Malmö University, Sweden, and University of Niigata, Japan. The School of dental medicine (SDM) is the fifth school nationwide to join the Consortium for Oral Health Research and Informatics (COHRI) Big Mouth Dental Data Repository—an oral health database developed from electronic health records (EHRs) contributed by dental schools. It enables the students and faculty to query for more than 1.5 million deidentified oral health records for clinical research.[16]

CURRENT RESEARCH PROJECTS

Electronic Health Records

Cloud technology to improve dentistry—the center is currently involved in refining and implementing a cloud-based EHR system. This system will mostly support the extensive educational and research needs of dental schools. This next-generation, EHR system offers data sharing opportunities for large-scale research projects with the aim of improving patient outcomes. As a start, these include the tasks essential in creating any medical record, which includes the entry of basic data: Patient's vital signs and demographics, active medications and allergies, proper up-to-date problems, lists of current and active diagnoses, and smoking status. Other core objectives can be achieved which include creating several software applications that begin to realize the true potential of EHRs to improve the safety, quality, and efficiency of care. These features always help the clinicians to make better clinical decisions—and avoid preventable errors.

Educational Projects

• The National Institutes of Health Center (Excellence in Pain Education)–The National Institutes of Health Pain Consortium designated Centers of Excellence in Pain Education in health professional schools. The University of Pittsburgh is one of the 11 schools chosen nationally to receive the designation under the leadership of Debra Weiner, MD. This center always supports the instructional technology aspects of this large-scale attempt to develop, evaluate, and distribute curricular resources, which enhance pain education for health care professionals. Center faculty and staff integrate video-based learning modules into

one of the advanced electronic learning management systems for the predoctoral curriculum of all participating schools at the University of Pittsburgh. This effort helps to provide a wide range of educational opportunities.

- Biomedical Informatics Online Certificate Program—The Biomedical Informatics Online Certificate Program (OCP) is a 15-credit (minimum) experience developed in collaboration with the Department of Biomedical Informatics at the School of Medicine. This center supports the OCP by converting existing face-to-face lectures into a proper online format using evidence-based educational principles.
- E-portfolios for dental education—evidence that learning has taken place—E-portfolios have become the digital repositories of students' lives, both academic and personal. They offer dental educators the opportunities for formative and summative assessments and for students the integrated, self-reflective, self-directed, and longitudinal learning. The center supports the instructional technology aspects of the SDM plan for integration of E-portfolios into global student assessment. The integration of E-portfolios into dental education opens myriad questions from various software, infrastructure, and evaluation strategies to Health Insurance Portability and Accountability Act compliance, teacher training, and workload management, even as portfolio access beyond the dental school is possible.
- The COHRI—In 2010, the SDM became a member of COHRI, allowing its students and faculty to benefit from the interactions and power of many institutions. Members of the COHRI work together to create, standardize, and integrate data in EHRs; improve informatics solutions in dental education, health care, and research; develop research projects to promote evidence-based dentistry; define standards of care; and facilitate implementation of best practices.
- Evidence-based dentistry (EBD) faculty development program—This program is beginning its third cycle of training, with the goal of providing EBD training to the majority of clinical faculty within the SDM.

Social Network

- A virtual and global community for dental informatics users—this online community would connect people and help them share ideas, problems, and research opportunities.

Software in Support of EBD

- *Curriculum management tool (CMT)*: Supporting dental education is one of the pillars of dental informatics research and practice. It would help in managing a dynamic dental curriculum efficiently and effectively, and this can be a daunting task without the assistance of technology. To eliminate redundancy and ensure proper sequencing in the curriculum as it continues to evolve, the center created the CMT to enable rapid search through courses for topics and competencies. Not only can the CMT assist the Curriculum Committee in managing the curriculum, but also the faculty, students, and administrators, who need to locate information.
- *Disaster medicine*: It is the "area of clinical specialization that deals with the provision of health care to disaster survivors and responders and the planning of medically related disaster preparation, planning, response, and delivery". The discipline defines protocols for dealing with the clinical events in a disaster, even the competencies required for clinical personnel and the training of personnel. E-health means the "transfer of health resources and health care by electronic means" (World Health Organization, 2013). E-health technologies are revolutionizing the plan to deliver mainstream health care. These technologies serve as the potential to exert the same major impact on the health component of disaster management. In a disaster, members of a multidisciplinary medical team have to function under highly adverse and dangerous conditions; so rapid and accurate communication between the specialists is literally vital.[17]

Patient Record and Communication

The most standard way to maintain proper records are through good intersectoral communication.

- The communication of these records in an interdisciplinary arena will provide scope for a nonhesitant and determined approach. An approach that will instill confidence not only to the dentists' concerned, but also to the patients (Flow Chart 1).[18]

Flow Chart 1: Patient record and communication
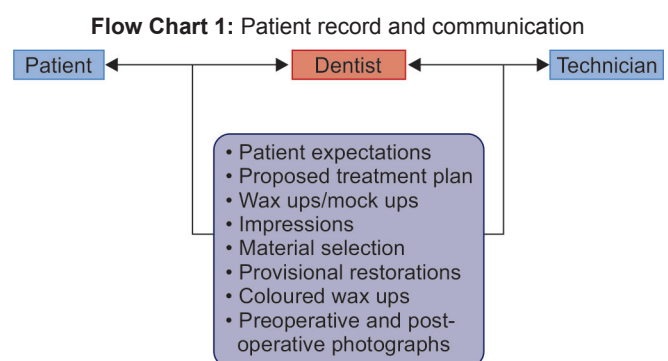
CONCLUSION

Today's digital era provides us with the freedom of use of a number of software systems that would make maintenance of records easy and feasible. Moreover, any advanced technology in the field of dentistry, such as the use of equipment, such as radiovisuography and cone-beam computed tomography make communication of information all the more simplified.

The diagnosis made by any one department can be effortlessly correlated with the treatment plan of another and vice versa. Considering an insight into the future, well-maintained records that established communication can play a significant role in prevention of problems. Globalization should be the target! It might not seem such a big deal, but we could prevent even the greatest of problems and diseases with the right records. "Research" is the key foundation of new developments and also helps comparing the present and the future. Well-developed communication and proper records can go quite a long way in promoting better research by engaging in retrospective studies, which could entail a wider and more comprehensive vision.

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