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Consortium for Oral Health-Related Informatics: Improving Dental Research, Education, and Treatment

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Abstract

Advances in informatics, particularly the implementation of electronic health records (EHR), in dentistry have facilitated the exchange of information. The majority of dental schools in North America use the same EHR system, providing an unprecedented opportunity to integrate these data into a repository that can be used for oral health education and research. In 2007, fourteen dental schools formed the Consortium for Oral Health-Related Informatics (COHRI). Since its

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inception, COHRI has established structural and operational processes, governance and bylaws, and a number of work groups organized in two divisions: one focused on research (data standardization, integration, and analysis), and one focused on education (performance evaluations, virtual standardized patients, and objective structured clinical examinations). To date, COHRI (which now includes twenty dental schools) has been successful in developing a data repository, pilot-testing data integration, and sharing EHR enhancements among the group. This consortium has collaborated on standardizing medical and dental histories, developing diagnostic terminology, and promoting the utilization of informatics in dental education. The consortium is in the process of assembling the largest oral health database ever created. This will be an invaluable resource for research and provide a foundation for evidence-based dentistry for years to come.

Keywords

dentistry; dental education; informatics; education; research; evidence-based dentistry

According to the American Dental Association, Americans spent over \$101 billion on dental services in 2008. In 2006, Americans had an estimated 1,943,038,670 dental procedures completed by private practitioners during almost 390 million visits.¹ As the population of the United States and the average life expectancy both increase, these numbers are expected to rise. While the amount of information obtained during these visits is staggering, the data collected are rarely used in aggregate to help advance dental education, improve oral health research, assess outcomes of care, or promote evidence-based dentistry. Most of the oral health-related data instead reside in silos in dental school clinics and private practices.

Oral health researchers often rely on data from insurance companies that have a record of charged treatments. However, less than half of adult dental patients have dental insurance,² and insurance data have limited utility for research.³⁻⁵ Similarly, Medicare has very limited reimbursement for dental treatments, which precludes it from being a viable source of oral health data.⁶ Patient health surveys such as the National Health and Nutrition Examination Survey⁷ (NHANES) or the Behavioral Risk Factor Surveillance System² (BRFSS) have often been used to provide a view of the dental status of the U.S. population. Although data from these surveys have been used for oral health research,^{8,9} they can only provide a limited perspective. To date, no large oral health datasets exist for researchers, epidemiologists, or public health professionals to provide information about patients who have undergone dental treatments.

Electronic health records (EHRs) contain a wealth of information. Data extracted from EHRs differ from other data sources such as cross-sectional surveys or data obtained from payers, as they provide a more detailed and long-term view of patients, symptoms, diseases, treatments, outcomes, and differences among providers. The secondary use of health data in dentistry can provide valuable insight into oral health diseases and treatments performed on a large cohort of patients.¹⁰ EHRs also play an important role in enhancing evidence-based decision making (EBD) in dentistry and improving clinical effectiveness through assessment of outcomes of care.¹¹

Private practices typically use technology first for billing and tracking appointments, with the natural progression to then implement EHRs for recording of dental observations, diagnosis, and treatment planning. Almost 87 percent of dentists use a computer in their private practice.¹² In addition, the majority of North American dental schools already operate in a fully digital format or are on track to do so within the next two to three years. In fact, forty-two dental schools in the United States use the same EHR system.

Consortia have been developed in medicine for quality improvement,^{13–15} to coordinate patient services,¹⁶ to reduce disparities in patient care,¹⁷ and as a major resource for translational research.¹⁸ However, dentistry has been slow to follow. The Ivy League Dental Consortium, an agreement between the dental schools at Harvard University, University of Pennsylvania, and Columbia University, was formed in 1997 to support lifelong learning, but disbanded shortly thereafter. The American Association of Dental Schools (AADS; now the American Dental Education Association, ADEA) has had two sections with significant interest in the use of databases and electronic systems to administratively support their operations. These sections—Clinic Administration and Business and Financial Administration—have provided forums to discuss and act on common issues. During the 1980s, one of those common issues was improving Clinical Information Systems (CIS). As schools investigated this, it became apparent that this development was too costly to implement individually. The need by many schools to develop electronic CIS led to the establishment of the AADS Consortium for Clinic Information Systems, which grew from a collaborative meeting, “The Symposium on 2nd Generation Clinical Databases and Electronic Dental Record,” held in Alexandria, Virginia, in 1990.¹⁹

Subsequently, a grant was secured from the American Fund for Dental Health to support a working group in an effort to develop a monograph²⁰ that could serve as a guide for dental schools in their development or acquisition of oral health information systems. The monograph contained one section related to information about functionality of a computer-based oral health record with regard to registration, patient histories, and progress notes; a second section that contained functions related to processes like screening and patient assignment; and a third section on integrated information at the point of care.

Eventually, the AADS Consortium for Clinic Information Systems became the ADEA Section for Dental Informatics and expanded its scope to look at all aspects of information technology integration in the support of the dental school mission and goals. To date, no oral health consortia have been formed specifically to share data for research and education.

North American dental schools provide care for large, diverse patient populations and are regionally distributed across the United States, Canada, and Mexico. As a result, dental schools are uniquely positioned to be able to integrate data from electronic health records and use that information to improve oral health research, education, and treatment. Recognizing the benefits of data sharing, a critical mass of dental schools who use the same commercial electronic health record system, axiUm (Exan Corporation, Vancouver, Canada), have formed a consortium to work together to share data, educational tools, and enhancements to axiUm. This article will describe the formation, operations, and outcomes of this consortium.

COHRI Formation and Governance

In 2005, dental clinicians, educators, administrators, and researchers at the Tufts University School of Dental Medicine (TUSDM) formed a committee to enhance the way their EHR was used at the school. The introduction of an electronic health record system (axiUm) the previous year had provided an opportunity to focus on clinical discovery in a way that had previously not been feasible.

Exan, the developer of axiUm, hosts an annual meeting for the dental schools that use its EHR system. At the 2006 meeting, researchers from Tufts University presented the idea of sharing electronic health record data across institutions to enhance research. The following year, at the same annual meeting, seventeen representatives from fourteen dental schools in the United States, Canada, and Europe agreed to form a collaboration that would work toward, among other things, standardizing the way electronic health data are collected across

the dental schools and share data with other members of this consortium. As a result, the Consortium for Oral Health-Related Informatics (COHRI) was formed. Besides establishing the consortium and its name, a description of the patient composition was requested from each school, and Exan agreed to work with COHRI on this project (Table 1). Since its inception, COHRI has met semiannually (once in the winter at the Exan annual meeting and once in the summer at a host school) and has grown to fifty-two members from twenty dental schools. Membership is open to individuals from any dental school that uses axiUm and agrees to share data from its electronic health record.

The consortium has developed a governance structure with Research and Education Divisions, each overseen by a chair. The chairs are automatically members of the Board of Directors. Each division has a number of work groups to focus its efforts in a variety of ways and allow more members to participate. The work groups are tasked with a certain project; once that project is finished, the given work group will disband and new work groups will be formed to address the most immediate needs. In addition to the two division chairs, the Board of Directors has a chair, a vice-chair, a secretary, a treasurer (the chair of the Finance Committee), and three or four at-large members.

Needs Analysis for COHRI

At the July 2008 business meeting, which was held at the University of California, San Francisco (UCSF) School of Dentistry, a “needs analysis” for COHRI was performed. In addition, a group of founding COHRI members proposed individuals for the Board of Directors. After friendly, frank, and courteous discussion, the proposed members, with the addition of one more member, were elected to the Board of Directors. The group also agreed to officially have two divisions: a Research Division and an Education Division. The chairs of these divisions were made members of the Board of Directors (Figure 1).

The needs analysis was conducted to prioritize which research and educational issues would be addressed. First, brainstorming generated a list of more than sixty areas that could benefit from sharing data among dental institutions. Through a consensus process, the list was prioritized to eight activity areas of major emphasis based on needs:

1. Conduct outcome assessment for patient care (i.e., the ability to measure the success rates of procedures done in a dental school setting);
2. Explore the relationships between oral health and systemic diseases;
3. Use the EHR (axiUm) as a platform for clinical research, collaborative randomized prospective clinical trials, retrospective case control studies, and cohort and cross-sectional studies;
4. Develop and measure standard clinical practice metrics;
5. Measure student clinical performance;
6. Measure accuracy of treatment planning;
7. Measure accuracy and validity of educational outcomes; and
8. Perform an epidemiologic analysis of diseases and treatments by patient demographics.

These goals were then tackled by work groups within the Research and Education Divisions. The Research Division is focusing on standardizing and integrating the information collected in the electronic health record for clinical research, comparative effectiveness, and evidence-based dentistry. The increase in power and precision that will come from analyzing

the pooled data will make COHRI uniquely poised to respond to requests for applications (RFAs) and address challenging research questions.

The Education Division is focusing on curriculum, grading and assessment, and utilizing a set of virtual patients and their EHRs for educational purposes. This division seeks to advance dental education through the implementation of informatics such as enhancing distance learning, e-portfolios of patient care, and educational portals to support educational activities. The initial task and primary focus of the Education Division have been to establish a portal to share and discuss materials for dental education.

COHRI Work Groups and Committees

Research Division

In 2007, work groups for the Research Division were established to develop standardized medical and dental history forms; construct a set of uniform dental diagnostic terms; integrate data from various sources; and establish research objectives.

The group charged with standardizing the medical and dental history held conference calls several times over one year and drafted a standardized medical and dental history intake form for review (see Appendix). A set of questions regarding medical, dental, and demographic information was developed based on the schools' previous health history forms. Schools have an option of adding additional questions, but a core set of questions will be used by all schools; this will facilitate analyzing medical and dental data across several schools and within the context of socioeconomic and educational standards. This information has been approved by the work group tasked with its development and by the group as a whole. This form is currently being used at the Harvard School of Dental Medicine, Medical University of South Carolina College of Dental Medicine, and University of the Pacific Arthur A. Dugoni School of Dentistry.

A set of standardized diagnostic terms has also been developed. Diagnostic terms and descriptions were developed, incorporating concepts represented in other existing terminologies (ICD-9, ICD-10, and SNOMED) and through an iterative process of the work group members and others in the consortium reviewing and revising. Two members met virtually several times before sharing a rough draft with the group. This draft was further refined by members seeking input from specialists and general dental faculty at their respective institutions. The initial compiled list was agreed to by the work group, and the finalized list was presented to the COHRI group at the 2009 annual meeting and accepted for implementation by interested COHRI schools. Currently, five dental schools in the United States are using these diagnostic codes: the Harvard School of Dental Medicine, University of Washington School of Dentistry, University of Oklahoma College of Dentistry, Western University of Health Sciences College of Dental Medicine, and Virginia Commonwealth University School of Dentistry. The complete development process will be described in another publication.

The data integration and research work groups have been working closely together, as it will be the integrated data that will be used for the majority of research projects. These groups hold weekly conference calls and met at the UCSF School of Dentistry in October 2007 to develop a research strategy and agenda. The group decided to undertake a pilot project that demonstrated its ability to share and merge data. TUSDM, UCSF, and the University of Texas Health Science Center at Houston Dental Branch (UT-Houston) extracted the demographic, medical history, and dental history data from their EHRs for all new patient encounters from August 1, 2006, to July 31, 2007. These data represented almost 250,000 visits on more than 60,000 patients (Table 2). The results of the pilot project integrating data

from three different clinics were presented at the American Medical Informatics Association (AMIA) annual meeting in November 2008 in Washington, DC, and represented a proof of concept for the proposed work.

The data integration work group submitted a grant application to the National Library of Medicine in September 2008 to further the development of a data repository, to be housed at the University of Texas Health Science Center at Houston. This application was funded through the G08 mechanism. In addition, the group continues to aggregate data from the pilot project to facilitate research.

Members of the COHRI clinical research work group have also responded to three National Institutes of Health (NIH) challenge grants: ethical issues in dental informatics (PI at Harvard School of Dental Medicine [HSDM]); readiness of dental informatics for research (PI at UT-Houston); and caries management by risk assessment (PI at UCSF). While none of these grant applications was funded, revisions to the applications are ongoing.

Education Division

In 2008, work groups for the Education Division were founded to develop an education portal and database, develop virtual patients, and enhance grading and assessment of student learning. The Education Division has had several web meetings and has developed a pilot program of the portal.

The work group focusing on virtual patients is in the process of developing a repository for e-patients to be used for case-based teaching, axiUm training, and preclinical courses. In addition to this library of information, the work group is compiling a clinical photograph library to allow member schools to develop additional theoretical patients. These databases will be hosted by Creighton University and accessed by members of COHRI using a Microsoft SharePoint Server. This portal is presently in a pilot phase to evaluate uploading and downloading scenarios as well as stressing the system. The system should be available to members in December 2010.

The assessment work group is focusing on two main topics: grading and objective structured clinical examinations (OSCEs) to better meet the needs of the twenty-first-century student. OSCEs can be used to address areas of dentistry that do not lend themselves to traditional assessment methods such as student-patient interactions. The assessment group is also evaluating multiple aspects of clinical grading such as evaluator training and calibration and various competency evaluations.

Lastly, a poster presentation of COHRI accomplishments has been accepted for presentation at the Association for Dental Education in Europe's annual session in Helsinki, Finland.

Committees

There are three committees that are not part of either division and report directly to the Board of Directors: the Communications Committee, the Project Review Committee, and the Finance Committee.

The Communications Committee has had regular conference calls and web meetings. It has developed a website (www.cohri.org), introduced in January 2009, which has an open component that the public can view, as well as a secure section that only COHRI members can access.

The Project Review Committee is responsible for coordinating research projects and assisting in Institutional Review Board (IRB) applications and grant submissions. When a

member of COHRI is interested in undertaking a research project utilizing the pooled database, he or she will submit a written proposal to the Project Review Committee. The committee will then evaluate its merits and ensure that it has not been previously undertaken. The committee will also alert the members of COHRI to see if others are interested in participating in the research project. The committee will assist the potential investigator with the proposal to submit to his or her IRB. Lastly, the committee will stay current with all RFAs from the NIH to assist investigators in obtaining funding.

The Finance Committee will recommend a formal structure for the consortium and explore possible ways to raise revenue to support the group's efforts. The primary mechanism will be through grant applications, but the committee will also explore other options.

Discussion

Advances in the area of informatics represent an unprecedented opportunity for dental academia. With forty-two U.S. dental schools utilizing the same EHR system, oral health data can be integrated in a way that would be much more challenging for hospitals. It is clear that these advances have facilitated the collection of reliable data pertaining to oral health, clinical behavior, and education that can be shared between dental schools. Current work in medical and dental informatics suggests secondary use of data from EHRs is a powerful tool to enhance health care experiences for individuals, expand knowledge about diseases and treatments, and strengthen understanding about effectiveness and efficiency of health care systems.¹⁰ A group of dental schools throughout the United States took the initiative to form a consortium and are making the development of a dental data repository a priority. Since its inception, COHRI has grown to include dental schools in Canada and Europe.

While the use of informatics in dentistry is increasing, it still remains limited. The American Medical Informatics Association has a dental component, and ADEA has a Dental Informatics Section; COHRI members participate in meetings of both of these groups. Realizing the need to focus on dental education and oral health research utilizing informatics, COHRI was formed. To date, this self-motivated group of dental educators and researchers has a very clear focus: building a dental oral health data repository that can be used for research and education to improve patient care and curricula.

Individuals and schools currently working within COHRI have already benefited from the collaboration across schools. By sharing enhancements in the deployment and implementation of EHRs, dental educators have been able to learn from the experiences of their peers at other COHRI schools. The activities of COHRI fit very well with all dental faculty members' missions of teaching, service, practice, and research. The efforts of these faculty members have already made improvements to dental education and practice by improving the efficiency of some data collection tools.

A number of issues still exist for the consortium. One issue is data security and data use agreements. Although an initial pilot project sharing data from three dental schools was a success, this project involved using limited de-identified data. Ensuring data security and integrity are primary concerns moving forward. In order to build and maintain a large dental data repository with the approval of each school's IRB, the issues of scientifically valid discovery, data security, and data use are critical issues to be addressed together. Important questions of who has access to the data and for what purposes are the data being used need to be defined and addressed.

In addition, membership in COHRI has been limited to schools that use a specific software product. This facilitates the process of integrating data from various sources. At the moment, there is not a method for including other schools that use other software products.

Finally, data stewardship, project planning, and oversight are key components to address moving forward. To continue to be nimble and make rapid, important discovery in dental education and research with limited resources, a process for project prioritization needs to be in place. COHRI has initiated a strategic planning process to clarify its mission, vision, and goals. Through this process, it is expected that collaborations will continue to make advances in dental education, oral health research, and patient care.

Conclusion

This group of dental schools has come together with the purpose of building a dental data warehouse and advancing dental education and research by utilizing informatics. As a first step, it formed a consortium and built a solid foundation of governance and infrastructure. To date, COHRI has been successful in developing a data repository, pilot-testing data integration, and sharing best practices in EHR usage. This consortium has collaborated on standardizing medical and dental histories, developing diagnostic terminology, and promoting the utilization of informatics in dental education. The consortium is in the process of assembling the largest oral health database ever created. This will be an invaluable resource for research and provide a foundation for evidence-based dentistry for years to come.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
The structure of COHRI

Table 1

Milestones and outcomes of COHRI activities and dental schools participating

Milestones	Schools Represented	Outcomes
Formation of Consortium February 2007 Vancouver, BC	14 Dental Schools; 17 Attendees Creighton University School of Dentistry, Indiana University School of Dentistry, Loma Linda University School of Dentistry, Oregon Health & Science University School of Dentistry, Stony Brook University School of Dental Medicine, Tufts University School of Dental Medicine, University of Alberta Faculty of Medicine and Dentistry, University of California, San Francisco School of Dentistry, University of Detroit Mercy School of Dentistry, University of Maryland Dental School, University of Pittsburgh School of Dental Medicine, University of Rochester School of Medicine and Dentistry, University of Southern California Herman Ostrow School of Dentistry, University of Texas Health Science Center at Houston Dental Branch	<ul style="list-style-type: none"> Established the consortium Requested patient profile of each school Obtained support from vendor for the project
First Meeting June 2007 Boston, MA	10 Dental Schools; 20 Attendees Creighton University School of Dentistry, Harvard School of Dental Medicine, Indiana University School of Dentistry, Oregon Health & Science University School of Dentistry, Stony Brook University School of Dental Medicine, Tufts University School of Dental Medicine, University of California, San Francisco School of Dentistry, University of Detroit Mercy School of Dentistry, University of Maryland Dental School, University of Texas Health Science Center at Houston Dental Branch	<ul style="list-style-type: none"> Keynote Speaker: Dr. Isabel Garcia, Deputy Director, National Institute of Dental and Craniofacial Research Encouraged to form a data-sharing plan Established goal to develop core common information within EHRs to facilitate sharing of data for research purposes Established work groups for health histories and diagnostic coding Developed a website
Second Meeting February 2008 Vancouver, BC	11 Dental Schools; 21 Attendees Creighton University School of Dentistry, Dalhousie University Faculty of Dentistry, Harvard School of Dental Medicine, Indiana University School of Dentistry, Oregon Health & Science University School of Dentistry, Stony Brook University School of Dental Medicine, Tufts University School of Dental Medicine, University of California, San Francisco School of Dentistry, University of Detroit Mercy School of Dentistry, University of Maryland Dental School, University of Texas Health Science Center at Houston Dental Branch	<ul style="list-style-type: none"> Developed data integration plan Reviewed preliminary data Work groups updated others on progress Agreed on standardized health history data collection form Decided on composition of External Advisory Board
Third Meeting July 2008 San Francisco, CA	14 Dental Schools; 26 Attendees Academic Centre for Dentistry (Amsterdam), Creighton University School of Dentistry, Harvard School of Dental Medicine, Indiana University School of Dentistry, Medical University of South Carolina College of Dental Medicine, Oregon Health & Science University School of Dentistry, Stony Brook University School of Dental Medicine, Tufts University School of Dental Medicine, University of California, San Francisco School of Dentistry, University of Detroit Mercy School of Dentistry, University of Maryland Dental School, University of Minnesota School of Dentistry, University of the Pacific Arthur A. Dugoni School of Dentistry, University of Texas Health Science Center at Houston Dental Branch	<ul style="list-style-type: none"> Conducted needs analysis for COHRI Further refined the structure of COHRI Established a research and an education division of COHRI A business meeting was held Elected the Board of Directors
Fourth Meeting February 2009 Vancouver, BC	15 Schools; 26 Attendees	

Milestones	Schools Represented	Outcomes
Fifth Meeting July 2009 Indianapolis, IN	<p>Academic Centre for Dentistry (Amsterdam), Creighton University School of Dentistry, Harvard School of Dental Medicine, Indiana University School of Dentistry, Medical University of South Carolina College of Dental Medicine, Nova Southeastern University College of Dental Medicine, Oregon Health & Science University School of Dentistry, Stony Brook University School of Dental Medicine, Tufts University School of Dental Medicine, University of British Columbia Faculty of Dentistry, University of California, San Francisco School of Dentistry, University of the Pacific Arthur A. Dugoni School of Dentistry, University of Southern California Herman Ostrow School of Dentistry, University of Texas Health Science Center at Houston Dental Branch, University of Texas Health Science Center at San Antonio Dental School</p> <p>11 Schools; 18 Attendees</p> <p>Creighton University School of Dentistry, Harvard School of Dental Medicine, Indiana University School of Dentistry, Medical University of South Carolina College of Dental Medicine, Oregon Health & Science University School of Dentistry, Stony Brook University School of Dental Medicine, Tufts University School of Dental Medicine, University of California, San Francisco School of Dentistry, University of Medicine and Dentistry of New Jersey, University of Texas Health Science Center at Houston Dental Branch, University of Texas Health Science Center at San Antonio Dental School</p>	<ul style="list-style-type: none"> • Work groups updated others on progress • Decision to form a Finance Committee • Board of Directors decided to participate in a strategic planning workshop at the next meeting <ul style="list-style-type: none"> • Work groups updated others on progress • Board of Directors participated in a strategic planning workshop • The vision of COHRI was refined • A business meeting was held

Table 2

Number of patients and visits for four dental schools in research work group

	Date EHR Implemented	Total Number of Patients in EHR	Total Number of Visits in EHR	Number of Patients 8/1/06-7/31/07	Number of Visits 8/1/06-7/31/07
TUSDM	June 2004	115,238	362,562	20,806	97,225
UCSF	July 2005	338,208	601,502	26,667	81,802
UT-Houston	August 2006	34,989	145,728	14,724	68,847
HSDM	April 2009	70,553	267,000	5,037	49,912
Total		558,988	1,376,792	67,234	297,786

TUSDM: Tufts University School of Dental Medicine; UCSF: University of California, San Francisco School of Dentistry; UT-Houston: University of Texas Health Science Center at Houston Dental Branch; HSDM: Harvard School of Dental Medicine