Health Informatics Meets eHealth
G. Schreier et al. (Eds.)

doi:10.3233/978-1-61499-645-3-230

Medical Informatics and Information Technology Supporting Oral Medicine

Janat ZVÁROVÁ[a,1], Karel CHLEBORÁD[b] , Karel ZVÁRA[a] and Taťjána DOSTÁLOVÁ[b]
[a]*Institute of Hygiene and Epidemiology, 1st Faculty of Medicine, Charles University Prague, Czech Republic*
[b]*Department of Stomatology, 2nd Faculty of Medicine, Charles University Prague and University Hospital in Motol, Czech Republic*

Abstract. Electronic healthcare documentation is the key element of electronic healthcare (eHealth). Electronic oral health record (EOHR) supporting oral medicine is discussed. To provide dentists with a methodology and instrument to create oral health documentation in more efficient way, support information exchange and integration in dental domain and to ease dental decision-making and forensic dentistry identification tasks.The proposed methodology is used to model lifelong EOHR based on a small specific ontology where the use of other classification systems and nomenclatures, e.g. SNODENT, is possible. EOHRwith Lifelong DentCross user interface was developed and it has been supporting dental care at the University Hospital in Prague-Motol. The user interface is working in four languages and controlled by voice or keyboard. Lifelong DentCross user interface is reflecting the way of the work in dentistry and the EOHR can provide both structured and free text information to oral medicine.

Keywords. Oral Medicine, Electronic Health Record, User Computer Interface, Medical Informatics

1. Introduction

A broad overview of eHealth concepts is presented alongside an in-depth analysis of some of the most important related issues is in the book *Managing eHealth* [1]. The concept of Information-based Holistic Electronic HealthCare (IHE-HC) was introduced in [2]. It focuses on information in the form of data or knowledge that can be stored, processed or transmitted in an electronic form (Fig. 1). IHE-HC is connecting the e3 Health concept [3] with the application in a given healthcare system via co-operation among three main stakeholders (State, Academy and Industry). The inability to share information across these main stakeholders is just one of the major obstacles towards quality, efficiency, security and cost-effectiveness of healthcare. The gap between the demand for IHE-HC from an increasingly well-informed citizens and the ability of the government and healthcare organizations to meet this demand is widening all the time.

The electronic health records that are based on a common information architecture with highly standardized data definitions will play the key role in the electronic healthcare. Main goal of EHRs is the support of continuing, efficient and high quality integrated healthcare by sharing patient health information among authorized users. However, EHRs allow collection of data for other reasons than for direct patient care,

[1] Corresponding Author: Prof. Dr. Jana Zvárová, Charles University, 1st Faculty of Medicine, Katerrinska 32, 12108 Prague, Czech Republic, E-Mail: jana.zvarova@lf1.cuni.cz

such as quality improvement, outcome reporting, resource management and public health communicable disease surveillance, see e.g. [4-12].

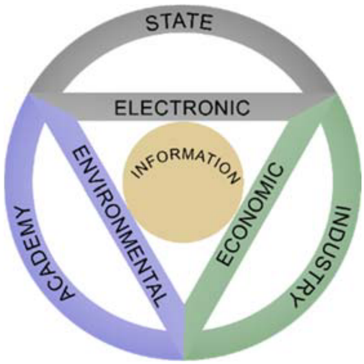

Figure 1: Information-based Holistic Electronic Healthcare

The part of EHR focused on oral health is called electronic oral health record (EOHR), see [13]. EOHR can fulfill the need of dentistry for more detailed description of problems and procedures using new granular and sophisticated coding sets. In advanced healthcare environment a dental clinics can connect oral health information to a hospital EHR. It means that past medical history, laboratory tests and other information can be retrieved from the hospital EHR to EOHR directly.

New strategy to advance the consistency of data in dentistry is emerging. Systematized Nomenclature of Dentistry (SNODENT), an official subset of SNOMED CT, is a vocabulary designed for the use in the electronic environment. The SNODENT can be considered as rising ontology for dentistry that should in future to standardize coding and present lists of problem and procedure terminology in a detail and granular way with the goal to cover all possibilities [14]. In spite of the general support for ontologies within the biomedical community, there are relatively few ontologies available to be used by the dental community at the present time. What ontology engineering efforts have been undertaken have largely been directed to the provision of small, special purpose and application of specific ontologies; large-scale dental ontologies with broad coverage of the dental domain are currently absent. Apart from specific ontologies like Tooth Positional Ontology [17], two large-scale ontologies are under development the Ontology for Dental Research (ODR) [18] and the Oral Health and Disease Ontology (OHD) [19].

We developed the small specific ontology for permanent dentition based on about 60 different actions, treatment procedures or tooth parameters. The ontology was developed by Czech dentists from University Hospital in Prague-Motol for promoting consistency of collected data in dental care. The ontology made possible to develop the first version EOHR with the DentCross interactive user interface in 2005. The user interface enabled recording fully structured dental information in a consistent and user-friendly way. The main requirement for EOHR was the structured way of data storage combined with free text with possibility of dynamic extension and modification of the set of collected attributes without any change. We used the DentCross user interface for collecting data for computer-supported treatment of patients with temporomandibular joint disorder parafunction [15] and in forensic dentistry [16].

The research objective of our approach is to provide dentists with a methodology and instrument to make lifelong oral health documentation by more effective way, support information exchange and integration in the dental domain and use collected information in dental decision-making and identification problems in forensic dentistry.

2. Methods

Based on our extensive experience with the interactive DentCross user interface of EOHR for permanent dentition, we have created a new object-oriented EOHR model compatible with HL7 RIM and implementable using EHRcom hierarchical structure that includes the possibility of entering the data not only for permanent, but also for mixed and deciduous teeth. We call this model Electronic Oral Health Record in Dentistry.

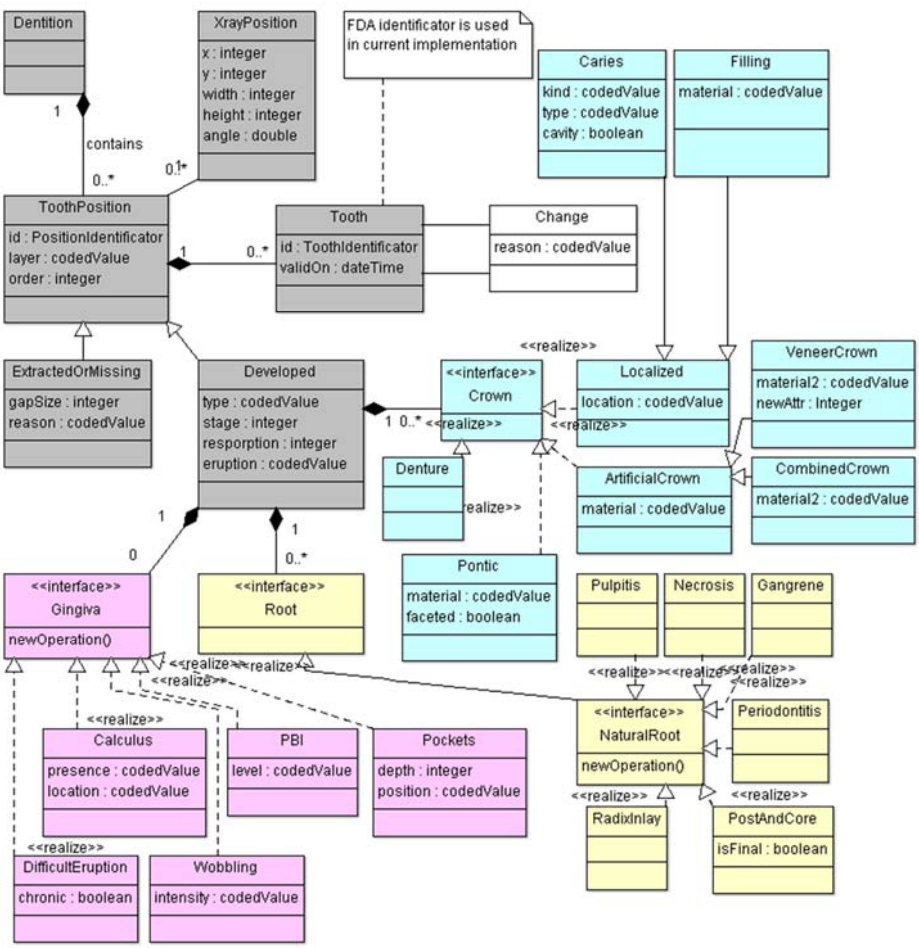

Figure 2: Model of Electronic Oral Health Record

The EOHR model (Fig. 2) is meant to represent the ontology of basic human dental structures. It is based on the premise that the model should be able to describe all valid situations and not to lose any substantial information. Model instance (in the form of linked objects) itself represents a static view of patient's dentition at the given time. Coded values are shown in Table 1. The model includes the possibility of entering the data not only for permanent, but also for mixed and deciduous teeth. Each existing tooth is described using the basic anatomical structures – a crown, root, suspension system of the tooth.

The model has its root at *Dentition* class that holds tooth *Positions*. Two-dimensional X-ray images may be mapped to individual positions. Any position may be "occupied" by a tooth. The tooth may exist on that position or may be missing. Any existing tooth is described using its basic properties and three parts: the gingiva, the root and the crown. The gingival properties include eruption problems, dental calculus, wobbling, papilla bleeding index (PBI) and pocket. The root interface is extended by specialized interface *NaturalRoot* that represents natural root conditions as pulpitis, necrosis, gangrene, periodontitis, root canal treatment and root inlay. The R*oot* interface is directly implemented by the *Implant* class that represents an implant. The crown interface supports localized properties such as Caries and Filling that are bound together in order to not lose the information on what caries have been fixed by the filling. The *Crown* interface is implemented by *Denture* class, *Pontic* class and is extended by the *Artificial Crown* interface. The *Localized* class *location* property is divided up to 9 square parts to further specify location. The *Artificial Crown* interface is implemented by *Veneer Crown* and Combined Crown interfaces to store the information about materials used. Tooth and Crown interfaces may be linked with their other "instances", specifically with their previous and next states (if available).

Table 1: List of attributes with codedValue in EOHR model

Class	Attribute	codedValue	Class	Attribute	codedValue
ToothPosition	level	deciduous, permanent, denture	Caries	kind	primary, secondary, relapsing
ExtractedOrMissing	reason	diagnosed, agenesis, unknown	Caries	type	acute, chronic, stopped, initial carious lesion
Developed	type	incisor, canine, premolar, molar	Filling	material	amalgam, composite, compomer, glassionmer, provisional
Developed	eruption	none, partial, full	Pockets	position	mesial, distal, vestibular, oral, interradicular
Calculus	presence	present, absent, unknown	Localized	location	mesial, distal, vestibular, oral, interradicular
Calculus	location	supragingival, subgingival	VeneerCrown	material2	resin, composite, base metal, gold, ceramic
Wobbling	intensity	none, level I, level II, level III	CombinedCrow n	material2	resin, composite, base metal, gold, ceramic
PBI	level	0, 1, 2, 3, 4, 5	ArtificialCrown	material	resin, composite, base metal, gold, ceramic

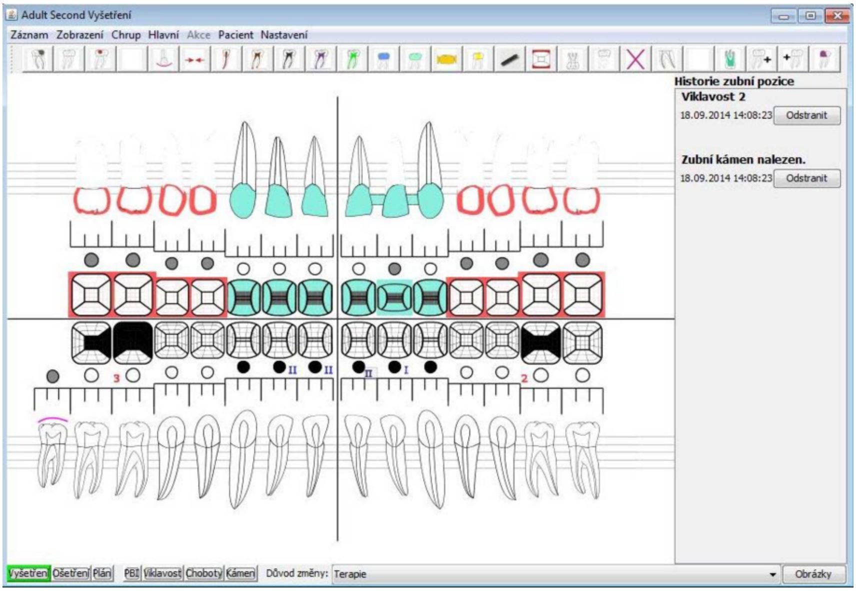

Figure 3. Lifelong DentCross user interface of EOHR

3. Results

The EOHR model was implemented using the new graphical design of user interface Lifelong DentCross (Fig. 3).

Lifelong DentCross user interface is dominated by a graphical dental cross. In addition to the basic information needed to identify the patient (name, surname and ID number) one can also find user interface controls. These are chosen so that the user can easily enter the history of treatment, treatment plan and the dentist can also use other forms of periodontal detailed examination, such as recording the presence of tartar, record the depth of periodontal pockets, and looseness of the teeth and gums condition called PBI (papilla bleeding index). We can demonstrate a record number of complex examinations including periodontal compared with intra-oral radiographs. In the right part of the screen we can find two options – history and legend. History brings us to the chronological treatment of the individual. Legend contains mainly a variety of different materials in the color scale to facilitate orientation in the user record. Individual teeth are called a double-digit number by quadrants, for example the Tooth 27 is the second upper molar upper left.

The crowns of the teeth are divided into seven fields to locate carious lesions or restorations, individual fields are marked according to the anatomic custom M – mesial, D – distal, O – occlusal, I – incisal, R – oral, V – vestibular, C – cervical. Size of the lesion seeing a number 1 to 4, which is to Mount classification of carious defects. By the selection of the filling different colors denote the type of material used. The blue color indicates photo composite, black amalgam and the green color indicates glassionomer dental restorations. So the embedded information from the examination and X-ray documentation becomes much more valuable than photographs of dental state or mere X-ray image. Dentists can also add dental reports in free text to all this structured data.

Nowadays, the Lifelong DentCross interactive user interface for EOHR can be controlled by voice or keyboard and it is running in four languages. These languages are Czech, English, German, and Spanish. Each language has its set of definitions, which contains about 300 dental terms.

4. Discussion

The most important source of information for biomedicine and healthcare is the data. We can see a huge amount of data collected in an unstructured form, e.g. in narrative medical reports. The unstructured data is very difficult to analyze and most information in the unstructured data is used rarely or never. With penetration of ICT in healthcare comprehensive lifelong EOHR combined with appropriate representing, accessing and visualizing health data have been developed. We tried to minimize unstructured data in EOHR to make information reusable for other tasks.

EOHR with the interactive Lifelong DentCross user interface has been used in dental care at the University Hospital in Prague-Motol. Lifelong DentCross user computer interface has been supporting data recording in dentistry very well. .Unfortunately, the retrieving data from hospital information system to EOHR is not supported by hospital information system. In 2016 the Czech Republic became the member of International Health Terminology and Standards Organization (IHTSO) that opens the possibility to use SNODENT classification in EOHR. The usability of EOHR with the DentCross user interface was partially studied in [20]. The comparison of three methods for time-consuming data entry in dentistry was performed on 126 patients: a) dental registration in the WHO card, b). EOHR controlled by keyboard and c) EOHR controlled by voice. In the study on 126 patients dentists added textual comments very rarely. Due to sufficient information in structured data there was no need to enrich the EOHR model with part extracting information from narrative dental reports [21]. In clinical practice, it is required to find ways to avoid the manual operation using a keyboard, mouse or touch screen. Therefore, the added automatic voice recognition allows the dentist to use the software without having to touch. This eliminates the need for a second person making the entry to the computer or redundant hygienic procedures (washing hands, changing gloves, etc.). Dental expertise occupies an important position in the identification process and is necessary especially when the priority is a recognition, the results of DNA analysis and fingerprint comparison. Properly conducted dental documentation is often the key to successful identification of unknown persons or skeletal remains. Not only the teeth, but also the analysis of the materials used to rehabilitate our teeth with the help of modern technology can lead to a clear identification of the individual. The EOHR can support a rapid identification of unknown individuals as well as decision making in dentistry, see e.g. [22], [23].

Acknowledgement.

The present study was supported by the grants PRVOUK P28/LF1/6, P29/LF2 and SVV 260267 of Charles University in Prague.

References

[1] Rosenmoller M, Whitehouse D, Wilson P. (Eds.) Managing eHealth - from Vision to Reality, Palgrave M8cmillan 2014

[2] Zvarova J. Holistic electronic healthcare. Int J on Biomedicine and Healthcare 3(2).; 2014: 2–8

[3] Zvarova J, Zvara K: eHealth: Three main features of modern healthcare, In: A. Moumtzoglou, A. Kastania (Eds.) E-Health Systems Quality and Reliability: Models and Standards, IGI Global; 2011:18–27

[4] Häyrinenn K. Saranto K, Nykänen P. Definition, structure, content, use and impacts of electronic health records: A review of the research literature. Int J Med Inf 2008, 5: 291–304

[5] Hammond K, Helbig S, Benson C, Brathwaite-Sketoe B. ‚Are Electronic medical records trustworthy? Observations on copying, pasting and duplication. AMIA Annual Symposium Proceedings, 2003; 269-273

[6] Boonstra A, Versluis A, Vos J.: Implementing electronic health records in hospitals: a systematic literature review. BMC Health Services Research 2014, 14:370

[7] Blobel B: EHR/PHR systems today and in the future. Int J on Biomedicine and Healthcare 4 (1) 2016::

[8] Ceusters W, Elkin P, Smith B. Negative findings in electronic health records and biomedical ontologies: a realist approach. Int J Med Inf 2007; 76:326–333.

[9] Ludwick DA, Doucette J. Adopting electronic medical records in primary care: lessons learned from health information systems implementation experience in seven countries. Int J Med Inf 2009; 78:22–31.

[10] Van Ginneken AM, Stqam H, van Mulligen EM, de Wilde M, van Mastrigt R, van Bemmel JH. ORCA: the versatile CPR. Methods Inf Med 1999; 38:332–38.

[11] Van Ginneken AM. Considerations for the representation of metadata for the support of structured data entry. Methods Inf Med 2003, 42,226-235

[12] Blobel B, Hasman A, Zvarova J (eds): Data and Knowledge for Medical Decision Support, IOS Press, Amsterdam, 2013

[13] Heid W.D., Chasteen J., Forrey A.W.: The electronic oral health record, J Contemp Dent Pract 2002, 3:43–54.

[14] Torres-Urquidy MH, Schlezer T. Evaluation of the Systemaic Nomenclature of Dentistry (SNODENT]) using Case Reports: Preliminary Results. AMIA Symposium Proceedings, 2006, 1124

[15] Dostalova T., Seydlová M., Zvarova J., Hanzlicek P., Nagy M.: Computer-supported treatment of patients with the TMJ parafunction. In: Blobel B., Pharow P. Zvarova J., Polez D. (Eds) eHealth: Combining health telematics, telemedicine, biomedical engineering and bioinformatics to the edge. CEHR Conference Proceedings 2007, Berlin, 171-8

[16] Zvarova J., Dostalova T., Hanzlicek P., Teuberova Z., Nagy M., Pies M.: Electronic health record for forensic dentistry. Methods Inf Med. 2008, 47: 8–13

[17] Park SG, Kim HG, Kim HK, Tooth Positional Ontology Represented in OWL, In: Kuhn K, Warren J, Leong T (Eds) MEDINFO 2007, IOS Press 2007, 2288-2289

[18] Smith B, Goldberg IJ, Ruttenberg A, Glick M. Ontology and the future of dental research informatics. JADA 2010, 141(10): 1173-11

[19] Schleyer TK, Ruttenberg A, Duncan W, Haendei M, Tornial C, Acharya A, Song M, Thyvalikakath TP, Liu K, Hernandez P. An ontologybased methods for secondary use of electronic dental record data. AMIA J Summit Transl Sci Proc. 2013,234-238

[20] Chleborad K, Zvara K Jr, Dostalova T, Zvara K, Hippmann R, Ivancakova R, Trmal Z, Psutka J. Evaluation of voice-based data entry to an electronic health record system for dentistry. Biocybernetics and biomedical engineering 2013, 33:204-210.

[21] Zvara K, Svatek V: Amenability of Czech Medical Reports to Information Extraction. Eur J Biomed Inform 2012; 5:43–7.

[22] Hippmann R, Dostalova T, Zvarova J, Nagy M, Seydlova M,, Hanzlicek P, et al. Voice supported electronic health record for temporomandibular joint disorders. Methods Inf Med 2010; 49:168–72.

[23] Hippmann R, Nagy M, Dostalova T, Zvarova J, Seydlova M. Electronic system for data record and automatic diagnosis assessment in the temporomandibular joint disorder. Eur J Biomed Inform 2011;7:11–6