# Health-oriented Electronic Oral Health Record for Health Surveillance

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# Abstract

Public health surveillance of oral health might benefit from increased access to and analysis of electronically available data including systematic collection, analysis, interpretation, and dissemination of outcome-specific data for use in public health action to improve oral health. This study aimed to develop and evaluate a new Health-oriented Electronic Oral Health Record (Health-EOHR) that integrated new oral health status graphical user interface, the health-oriented status and intervention model to facilitate oral health surveillance. We designed an experiment using focus groups and a Delphi process to develop health-oriented status and intervention model and graphical user interface. The Health-EOHR was implemented and integrated into the existing Electronic Health Record widely used in community hospitals. The study on usefulness for oral health surveillance was conducted. Overall, the dentists were significantly satisfied with the Health-EOHR compared to the existing EOHR (p < 0.001). The dentists found it easy to use and were generally satisfied with the function and the impact on their work, oral health services and surveillance.

#### Keywords:

Electronic health records, Health surveillance, Public health informatics, Managing care information and workflow.

# Introduction

Public health surveillance system requires an appropriate information system that can identify the population who are high risk and those who have need for treatment. The appropriate information system means nonprofessionals can do with low training cost, low cost data collection, transfer and interpretation. Furthermore, the outcome of data processing could be valid and reliable enough to provide individual treatment plans, community plans and can be used for evaluation of treatment provided and the program implemented. At present, Electronic Health Records (EHRs) are used to improve healthcare systems. The implementation of EHRs can help lessen patient suffering due to medical errors and improve the ability of analysts to assess quality [1].

Public health surveillance of oral health requires ongoing, systematic collection, analysis, interpretation, and dissemination of outcome-specific data for use in public health action to improve oral health. A recent report on oral health surveillance indicated that the coordinated use of EHR, administrative, and claims data could help in tracking progress of oral healthcare [2]. A substantial benefit to incorporating EHR data into public health surveillance efforts is that it could allow objective clinical data collected in real time to be available in an ongoing, systematic manner. Most important, the use of EHR data for public health surveillance would provide a direct feedback mechanism that could support efforts to improve screening and intervention activities.

Considering the scope of the concern in oral health surveillance enhanced by EHRs, the significant problems include the absence of a useful model for *health-oriented* oral care that links the concept of health and the goals of healthcare with all of the details about the health problems in healthcare. This study first aimed to develop a new Health-oriented Electronic Oral Health Record (Health-EOHR) that integrated the healthoriented status and intervention index to facilitate planning, managing, and evaluating the healthcare delivery system. Second, a comparative intervention study with qualitative and quantitative methods was used to compare the existing EOHRs to the Health-EOHR and focused on dentist satisfaction with the function and the impact on their work, oral health services and surveillance.

# **Materials and Methods**

We designed an experiment using questionnaires, focus groups and a consensus (Delphi process) method to develop healthoriented status and intervention model called the "SI model" as well as a graphical user interface that will be implemented in the Health-EOHR.

# **User Requirement Survey**

To gain a better insight in the context to develop and evaluate EOHR for providing benefits to holistic oral healthcare, evaluating the healthcare delivery system and facilitate oral health surveillance. We performed an exploratory literature scan to gain an overview of the context to develop the model and program. Specific goals of the literature scan were gaining insight in the need for effectiveness of the program for the healthcare delivery system and health surveillance.

Semi-structured interviews and focus groups were performed to identify expected needs of the existing EOHR users (Figure 1). The interview and focus groups participants were dentists and dental staff that used computer for recording patient's information. The user requirements that were mentioned by 20 existing EOHR users from 8 hospitals in Chiang Mai were inductively categorized. Almost all participants (88%, n=17) expected a need for systematic collection, analysis, interpretation of data for early identification of the size and character of oral diseases, and the need for oral healthcare in individual and community level. A need specifically targeted at the ease of use and flexibility was expected by 75 % (n=15). Decision support needs was expected by 65 % (n=13). Graphic user interface design needs were expected by 60% (n=12). Finally, 6 participants (30%) expected a need for program linkage to the government information center.





b.

Figure 1 – An Example of the existing EOHRs user interface (a, b)

#### Development of the Health-Oriented status and Intervention model

With the assistance of the World Health Organization (WHO), the Inter-country Center for Oral Health (ICOH, Chiang Mai, Thailand) has pioneered an alternative community oral healthcare model based on the primary healthcare concept since 1978 [3]. The ICOH's primary aims are to recognize the importance of oral health and support and disseminate technology and knowledge about oral health among developing countries. The projects were developed to provide healthpromoting comprehensive oral healthcare to the community in accordance with its needs and, at the same time, evaluated the acceptability, effectiveness and economic feasibility of the model, the service system, the associated training programs, and the recording and information system.

We adopted the idea from the ICOH's WHO project and developed the SI model. It was used to record health statuses and care needs and classified the tasks, instruments, and personnel needed to provide the care required. Each oral health status was represented by a well-design graphic aiming for easy to use and understand. Each oral health status was linked to expert suggested intervention, instruments, cost, intervention time and personnel needed. Table 1 shows an example of the graphical user interface design for the status as well as the translation of the intervention into International Classification of Diseases (ICD) codes.

Status		Intervention				
Status description	Graphic	Index	Intervention Description	ICD-9- CM		
Calculus < 2 mm		1	Self-care	96.54		
Calculus = 2-3 mm		1	Self-care	96.54		
Calculus > 3 mm		2	Scaling	96.54		
Horizontal Pocket	Y	4	Root planning	24.31		
Color Variation		5	Replacement (Laboratory processed)	23.41		
Pulpitis/ Necrosis		6	Root Canal Treatment	23.71		
Supernu- merary Tooth	11 9 21	7	Tooth Removal	23.09		
Missing	$\times$	8	Replacement (Tooth)	23.42		

Table 1 - Part of Status and Intervention (SI) model

Five ICOH experts participated in the evaluation of the proposed SI model. The evaluation consisted of questionnaires, focus groups and a Delphi assessment. The experts were asked to grade their agreement with 80 items in the SI model on a 5point Likert scale; both positive and negative statements were included to avoid bias. All experts took part in focus groups. The experts were invited to discuss positive and negative aspects of the SI model and to give suggestions for its development. To provide a robust evaluation of specific components of the SI model, a consensus method was used, which consisted of a two-panel, three-round adapted Delphi technique. A well-executed Delphi technique provides an effective method of group communication [4].

The SI model provided the basis for a complete recording system that can cover all of the data on oral status treatment needs, records of planned and completed procedures, clinic organization and scheduling of patients as shown in Table 2. The model also enabled the epidemiological evaluation of community status and the quantity, quality and effectiveness of care provided. The data can be rapidly and economically summarized by a computer.

Table 2 – An example of oral status treatment needs, tree	at-
ment planning and clinical management	

N0.	Status Description	Intervention index	Operator	Time (min.)	Instrument Set	Cost (Baht)
1	Supernumerary Tooth	7	Dentist	20	Extraction	350
2	Pulpitis/Necrosis	6	Dentist	45	Endodontic	2,900
	Roots/Enamel	5	Dentist	15	Restoration	300
4	Color Variation	5	Dentist	45	Res/Pros	3,500
5	Missing	8	Dentist	5	Impression	1,300
6	Calculus 2-3 mm	1	Dental nurse	12	Scaler	280

# System Development

Our idea is to develop an open-source Health-EOHR that can plug into the existing Hospital Information System. The Health-EOHR operates in client-server architecture that connects infrastructures and networks of community and healthcare centers. An example of the patient oral health status and an oral health status user interface are shown in Figure 2.

#### System Evaluation

A comparative intervention study approach involving qualitative and quantitative research aspects was used. Based on the questionnaires, interviews, oral health status recording reports, the dentist satisfaction in planning, managing, evaluating the healthcare delivery system and surveillance were assessed to complete the oral health status recording reports while the existing EOHRs were used for compiling reports in June 2012. The Health-EOHR was then tested in August 2012. The study was not designed to investigate the existing and the Health-EOHR in the same period of time. We made the following hypotheses: 1) the dentists who use the Health-EOHR will be more satisfied than those who use the existing EOHRs, and 2) the useful tool for systematic collection, analysis, and interpretation of data in the Health-EOHR will be higher than the existing EOHRs.

Interviews and questionnaires were conducted from June to August 2012 to assess dentist satisfaction with the existing EOHRs and the Health-EOHRs. The criteria for the dentists who participated in this interview included having at least 1 year of experience using EOHRs in the hospital. Therefore, we decided to interview a sample of 26 dentists from 11 ICOHcollaborating hospitals.

The questionnaire was developed by modifying questionnaires from previous studies [5-8]. The questionnaire comprised questions that covered the level of satisfaction or dissatisfaction with each of the following issues: holistic oral health index, decision support and treatment planning, and interpret oral health information to support oral health surveillance system. We used the scale Very Satisfied, Satisfied, Neutral, Dissatisfied, and Very Dissatisfied. Researchers also asked participants to indicate their level of agreement or disagreement with each of the following issues: monitor patient progress, improve the quality of dental care, and useful tools for disease management. We used the scale Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. The questions were openended and had suggestions for system improvement.

The Wilcoxon test was used to detect any differences in user satisfaction between the existing EOHRs and the Health-EOHRs. Statistical significance was defined as a p value less than 0.05. All analyses were performed using SPSS version 13.0 (SPSS Inc., Chicago, IL, USA).





Figure 2 – An Example of the patient oral health status (a) an oral health status user interface (b)

# Result

Twenty-six dentists from 11 government hospitals were recruited. Participants' range of experience with EOHRs was quite wide. Participants reported experience with their EOHRs system ranging from one to nineteen years. When asked to estimate their skill in using their EOHR systems, most participants said they considered themselves average (65.4 percent, or 17) or novice users of their EOHR systems (11.5 percent, or 3).

For the survey results, we ranked the percentage of respondents for each system to indicate their level of satisfaction and agreement. To help clarify the array of numbers, the highest four rankings for each statement are tinted green, and the lowest four are tinted orange.



c. Interpret oral health information to support oral health surveillance system

Figure 3 – The response spectrums are based on the percentage of respondents for each system to indicate their level of satisfaction (a-c).



c. Useful tools for disease management

Figure 4 – The response spectrums are based on the percentage of respondents for each system to indicate their level of agreement (a-c).

The systems are listed by the sum of their ranks. To better visualize the full range of responses, we turn to charts such as the "Response spectrum" below. The bars are divided into sections representing, from top to bottom, that the function was installed but not used (or no opinion), and the answers of very dissatisfied (or strongly disagree), dissatisfied (or disagree), neutral, satisfied (or agree), and very satisfied (or strongly agree).

To interpret the chart, the existing EOHRs had 3.8 percent Satisfied responses for holistic oral health index, decision support and treatment planning, and interpret oral health information to support oral health surveillance system (42.3 percent Function installed but not used), 26.9 percent Agree responses for monitor patient progress, 34.6 percent Agree responses for improve the quality of dental care, 15.3 percent Agree responses for useful tools for disease management. In this survey, the Health-Oriented EOHR had positive responses: 80 percent Satisfied responses for holistic oral health index, 88 percent Satisfied responses for decision support and treatment planning, 91.7 percent Satisfied responses for interpret oral health information to support oral health surveillance system, 84.6 percent Agree responses for monitor patient progress, 92.3 percent Agree responses for improve the quality of dental care, and 84.7 percent Agree responses for useful tools for disease management (Figures 3 and 4).

A Wilcoxon test was conducted to evaluate dentist satisfaction in the existing EOHRs and the Health-Oriented EOHRs. The results of user satisfaction with holistic oral health index, decision support and treatment planning, interpret oral health information to support oral health surveillance system, monitor patient progress, improve the quality of dental care and useful tools for disease management indicated a significant difference (p<0.001).

# Discussion

In 1984, with the assistance of the World Health Organization (WHO), Staff from the Intercountry Centre for Oral Health (ICOH) trained forty-eight health workers as the status recorders by performance simulation method and SI Model, adding recording to their usual duties. The duration of the training was two weeks (10 working days). Trainees learned to record the information on oral health status and treatment needs [3]. The common mistakes found in recording were incomplete personal information, wrong information, filling out wrong code for the column, and error in recording tended to be concentrated in specific oral health education performers data. The Data entering operation error on average was about 10% [9]. After we adopted the idea and SI Model in the Health-EOHR, the graphic user interface of each oral health status item has been designed to consider the concept of cognitive ergonomics [10] and human-computer interaction [11]. Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as these processes affect the interactions among humans and other elements in a system. The concept has been widely used in several domains, including human-computer interaction. Humancomputer interaction involves the study, planning, and design of the interaction between people (users) and computers. The user interface in the Health-EOHR allows the user to follow steps in status recording, such as chief complaint to hygiene and periodontal condition, defect and restoration, prosthodontics condition. Graphics for each status item have no ambiguity and are easy to remember. The overall accuracy of the new Health-Oriented EOHR was 97.15%, and its completeness was 93.74%. For future work, it is recommended that the classification used in the SI index be further tested and considered as a basis for training, instrumentation, monitoring, and evaluation. There is a need for an improved flow of information to promote flexibility and provisions for change.

The Health-EOHR used production rules that had the format "IF condition THEN action", where the condition was a Boolean logical expression with certain factors associated with the terms. When given a particular criterion, the appropriate treatment plan was automatically provided as an output of the program. In addition, it can be converted into the information needed for system management, such as the intervention along with the care provider, place and duration of time for the treatment, and cost. The Health-EOHR that interprets healthoriented status and intervention provides tangible benefits to holistic oral healthcare and helps plan, manage and evaluate the healthcare delivery system.

Public health surveillance is a tool to estimate the health status and behavior of the populations. Because surveillance can directly measure what is going on in the population, it is useful both for measuring the need for interventions and for directly measuring the effects of interventions [12]. Accordingly, Oral health surveillance systems need to be refined. In this study we used the health-oriented status and intervention index for early identification of the size and character of oral diseases and the need for oral healthcare in individual and community level. The purpose is to empower decision makers to lead and manage more effectively by providing, useful oral health record and evidence.

The assessment of user satisfaction and general observations by the researchers revealed that the dentists mainly appreciated the ability to record the oral health status and patient information, precision, holistic oral health index, decision support and treatment planning, interpret oral health information to support oral health surveillance system, monitor patient progress, improve the quality of dental care, and useful tools for disease management. The dentists do understand the potential benefits of using electronic oral health records in their practices, not only for patient care but also for outcome measurements (when linked with other health and social care datasets), quality improvement, public health surveillance, and research [13, 14]. Similar to Elizabeth et al. [15], a limitation of this study is the lack of blinding. The participants may have been biased by the novel nature of the study and the impression that the researchers wanted results favoring the Health-EOHR.

# Conclusion

We introduced a new Health-EOHR that integrates a health-oriented status and intervention model. This research concludes that the health-oriented status and intervention model implemented in the Health-EOHR improves dentist satisfaction, provides benefits to holistic oral healthcare, a useful tool for systematic collection, analysis, and interpretation of data helps plan, manage and evaluate the healthcare delivery to support oral health surveillance system.

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