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DENTAL HYGIENISTS' COGNITIVE PROCESS IN PERIODONTAL SOFT TISSUE CHARTING

by

Kelsey M. Schwei

A Dissertation Submitted in

Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

in Biomedical and Health Informatics

at

The University of Wisconsin-Milwaukee

December 2015

ABSTRACT

DENTAL HYGIENISTS' COGNITIVE PROCESS IN PERIODONTAL SOFT TISSUE CHARTING

by

Kelsey M. Schwei

The University of Wisconsin- Milwaukee, 2015
Under the Supervision of Professor Timothy Patrick

Introduction: Dental hygienists have not had the opportunity to be involved in the design and development of the periodontal soft tissue charts and the surrounding interface features that are used while examining dental patients in daily practice. In some cases, dentists are able to give their opinions, wants, and needs into the development of the health information systems that they use on a daily basis, but too often, the dental hygienist is forgotten about and no input is ever given to the developers from the dental hygienists. This project considers the impact of well-designed interfaces on effectiveness and workflow particularly in regard to the dental hygienists. It is focused on improving the surrounding interface of the electronic periodontal soft tissue chart in order to provide effective and efficient patient-centered cognitive support to the dental hygienist during a patient's periodontal examination. Current periodontal soft tissue charts used in daily practice lack dental hygienists' input during development. This study will fill a gap in knowledge by defining dental hygienists' workflow and needs, and then proposing a layout and prototype for a periodontal soft tissue chart interface that will meet those needs.

Methodology: Using a multi-phase methodology (ethnographic observations, focus groups, and cognitive task analysis) the wants and needs of practicing dental hygienists were defined. Based

on the results of the ethnographic observations, focus groups, and cognitive task analysis sessions, a prototypical periodontal soft tissue chart interface was developed. The prototype then underwent usability testing by dental hygienists to compare its usability versus the existing commercial software, Dentrix.

Results: Ten dental hygienists participated in the ethnographic observations, focus groups, and cognitive task analysis sessions. The wants and needs of dental hygienists were determined, as well as a "common" workflow among them. Using these results, the prototypical periodontal soft tissue chart interface was developed. Usability testing comparing Dentrix and the prototype revealed that the dental hygienists completed tasks on the prototype with greater success and speed than on Dentrix. Furthermore, the dental hygienists provided more positive comments toward the prototype than Dentrix.

Conclusions: This study exhibits the need to properly involve the end users – dental hygienists – in the creation of a prototypical periodontal soft tissue chart interface. Health information systems need to involve the end users at all stages in the development process in order to design and develop a system that is efficient and usable for them.

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To

my parents

and my husband

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LIST OF ABBREVIATIONS

ARRA	American Recovery and Reinvestment Act
EDR	Electronic Dental Record
EHR	Electronic Health Record
EMR	Electronic Medical Record
HIT	Health Information Technology
HITECH	Health Information Technology for Economic and Clinical Health
NPS	Net Promoter Score
PD	Pocket Depth
SUS	System Usability Scale

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PURPOSE

Dental hygienists have not had the opportunity to be involved in the design and development of the periodontal soft tissue charts and the surrounding interface features that are used while examining dental patients in daily practice. This project considers the impact of well-designed interfaces on effectiveness and workflow particularly in regards to the dental hygienists. It is focused on improving the surrounding interface of the electronic periodontal soft tissue chart in order to provide effective and efficient patient-centered cognitive support to the dental hygienist during a patient's periodontal examination. Current periodontal soft tissue charts used in daily practice, lack dental hygienists' input during development. This study will fill a gap in knowledge by defining dental hygienists' workflow and needs, and then proposing a layout and prototype for a periodontal soft tissue chart interface that will meet the workflow and needs of dental hygienists. The following research questions will be answered:

1) What is the pattern of information review, processing, and decision-making when dental hygienists examine patients during a periodontal exam?
2) What information do dental hygienists collect and use to make clinical decisions?
    a) In what workflow do dental hygienists review that dental information?
3) Can a digital prototype of a periodontal soft tissue chart that improves dental hygienists' workflow be developed?

I. INTRODUCTION

Due to governmental regulations, the use of Electronic Health Records (EHR) has grown substantially over the past decade. EHRs contain the standard medical and clinical data that is gathered in a provider's office, all in one place.[1] EHRs help improve patient care, increase shared data between providers for holistic care, as well as help to support research when it comes to retrieving data.

Many different types of patient-related data are stored within an EHR. EHRs contain nursing data, allied health information, occupational therapy data, surgical data, etc. Having these different types of patient data stored within the same place should make the exchange of information between departments easier for holistic care.

Epic[2] is the leading EHR system available within the medical communities. **Figure 1** shows a list of the functionalities that Epic offers.[3]

- Allergy – Immunology
- Bariatric Surgery
- Cardiology
- Cardiothoracic Surgery
- Dermatology
- Endocrinology
- ENT
- Family Medicine
- Gastroenterology
- Gerontology
- General Surgery
- Genetics
- Gynecology
- Infectious Disease
- Internal Medicine
- Mental Health
- Nephrology
- Neurology
- Neurosurgery
- Obstetrics
- Occupational Therapy
- Oncology
- Ophthalmology
- Orthopedics
- PM&R
- Physical Therapy
- Plastic Surgery
- Podiatry
- General Pediatrics
- Psychiatry
- Pulmonology
- Radiation Oncology
- Respiratory Therapy
- Rheumatology
- Sleep Lab
- SLP
- Sports Medicine
- Substance Abuse
- Transplant
- Urgent Care
- Urology
- Vascular Surgery

Figure 1. Functionalities that Epic supports[3]

Another commercial EHR is Cerner.[4] Cerner is a hospital and health systems EHR.[4] Like Epic, Cerner offers many different functionalities to the medical community within its EHR. **Figure 2** lists the functionalities of Cerner.[5]

- Acute Care Electronic Medical Record
- Cardiovascular
- Cerner Network
- Cerner RevWorks Services
- Cerner Services
- Clinical Imaging
- Community Hospitals
- CPOE
- Critical Access Hospitals
- Critical Care
- Emergency Department
- Enterprise Content Management
- Facility Design Services
- Knowledge Solutions
- Laboratory
- Medical Devices
- Member Engagement
- Mobility
- Oncology
- Women's Health
- Workforce Management
- Perioperative
- Pharmacies
- Point of Care
- Public Health Reporting
- Quality and Performance Improvement
- Radiology
- Reporting and Outcomes
- Revenue Cycle
- Segments
- Supply Chain
- Technologies

Figure 2. The capabilities that Cerner offers[5]

The healthcare field has shifted its care model from disease-centered to patient-centered. In a patient-centered model, patients become involved in their healthcare and the decision-making process, rather than the provider just treating a disease based off past experiences.[6] Providers are also switching to a holistic care approach, incorporating the use of all forms of medicine, including learning the possible prior conditions of a patient and the provider(s) that diagnosed them. These two approaches to care are strong enforcers of the notion that patient data between medical specialties needs to be shared and exchanged.

Figures 1 and **2** show examples of existing commercial EHR functionalities. However, dental or oral health is not included in either list of functionalities. While there is a need for oral health data to be exchanged with medical data and vice versa, this is not yet occurring ubiquitously. Furthermore, the oral cavity is treated separately from the rest of the body, as medical and dental are two separate silos of care. However, research is helping to bridge the gap between medicine and dentistry by showing that the mouth is indeed an important part of the body regarding systemic disease.

Due to the increasing amount of oral-systemic research that is emerging, the possible connections between oral and systemic diseases are growing.[7-17] Studies have found an association between periodontal disease -- a highly prevalent infectious disease that is caused by heavy colonization of negative, anaerobic bacteria in the subgingival plaque of the oral cavity[14] -- and systemic ailments, such as diabetes mellitus,[10-13] adverse pregnancy outcomes,[14] Alzheimer's disease,[15] and lung ailments.[16,17]

Since evidence between oral and systemic health is increasing, communication between dental and medical providers should also be increasing. Today, health information technology (HIT) is appearing ubiquitously, allowing patients to become more involved in their healthcare. Mobile applications are being used by patients to research health-related issues or to check personal health summaries. Since a patient can now be increasingly involved in his or her health, the medical and dental providers should be too. There should be an exchange of information between medical and dental providers to achieve the highest level of holistic care for a patient.

Dentistry has become increasingly computerized in the past 30 years. One very important component of dentistry, particularly when it comes to the viewing, storing, and sharing of patient data, is an Electronic Dental Record (EDR). An EDR is very similar to an EHR, but it stores dental data that was accumulated by a dental provider rather than medical data stored by a medical provider. An EDR is used in dentistry while an Electronic Medical Record (EMR) is used in medicine, as seen in **Figure 3**.

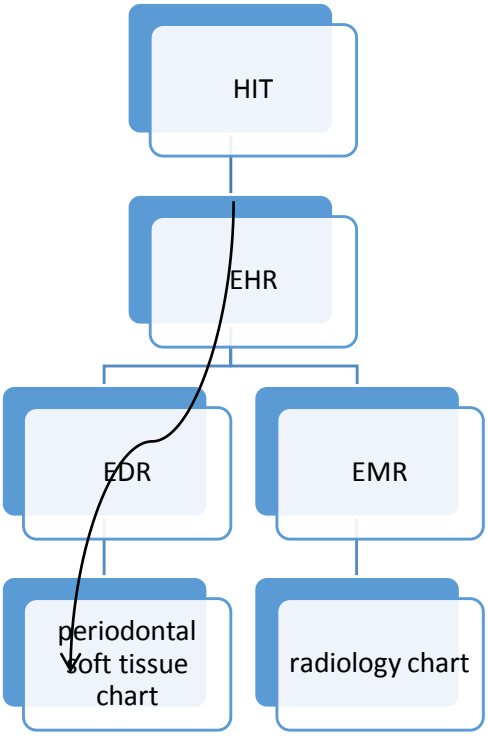


Figure 3. The relationships between EHR, EMR, and EDRs

Currently, few EDRs share data with EMRs and vice versa. The few that share medical and patient data have systems that use similar terminologies to communicate with each other. However, this is not a foolproof process, as not all medical and dental patient data is exchanged; rather, select pieces of information are shared. This two-way flow of dental and medical data is important for providing a holistic view of care for patients, as well as for diagnosing oral-systemic diseases. Sharing of dental and medical data can help reduce duplicate work and testing while supporting medical and dental providers' workflow by allowing for easier diagnosis of oral-systemic diseases. Furthermore, if both the medical and dental providers are checking patients for oral-systemic diseases, the likelihood of noticing a disease at an earlier stage can also increase.

Over the past four decades, the use of computers in dentistry has grown dramatically. In 2009, more than 85% of the 166,000 dental practices in the United States used computers,[18] compared to 11% in 1984.[19] This growth can be contributed in part to the American Recovery and

Reinvestment Act (ARRA) and the Health Information Technology for Economic and Clinical Health (HITECH) Act, which went into effect in 2009.[20] These Acts provide meaningful use objectives[21] and other guidelines for adopting HIT into clinical practice. These guidelines must be adhered to by the practicing organization for it to receive incentive payments.[22] For dental providers to receive incentives through meaningful use, the practice must use a certified EHR and accept Medicare and Medicaid patients.[23]

Within a dental practice, multiple different roles use the EDR: the front desk staff, the dentist, the dental hygienist, and the dental assistant. The dentist primarily diagnosis patients and completes treatments, while the dental assistant aids the dentist with procedures, mainly associated with the hard tissue of the mouth and teeth. The dental hygienist primarily works with the gums and teeth. During a typical new patient visit, some of the duties of dental hygienists include charting existing procedures that have been done in the mouth, taking radiographs, cleaning the teeth, conducting a periodontal exam with probing, and providing patient education. The periodontal examination includes several different data elements. A periodontal soft tissue chart is the part of an EDR that is specifically used by the dental hygienist. This soft tissue chart is used to document things such as probe depth, gingival margin, furcation, bone loss, etc. When inputting probe depth, there can be up to six different depths per tooth (up to 32 teeth) that need to be entered in numeric form on the periodontal soft tissue tooth chart. Often, dental hygienists are able to remember multiple probe depth numbers before recording them. The periodontal soft tissue chart is then reviewed by the dentist. Examples of existing commercial periodontal soft tissue charts are seen below in **Figures 4-6**.

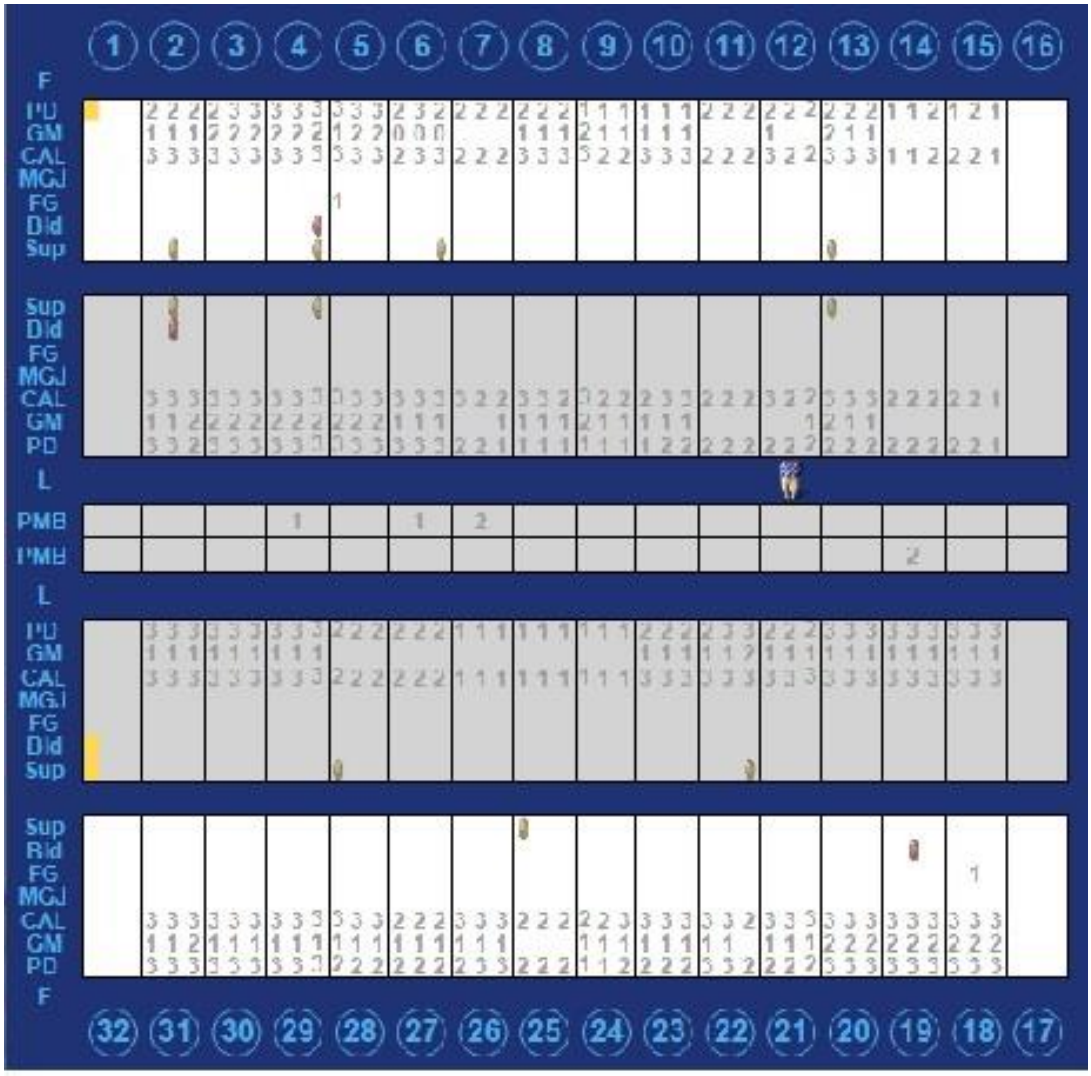


Figure 4. Dentrix periodontal soft tissue chart[24]

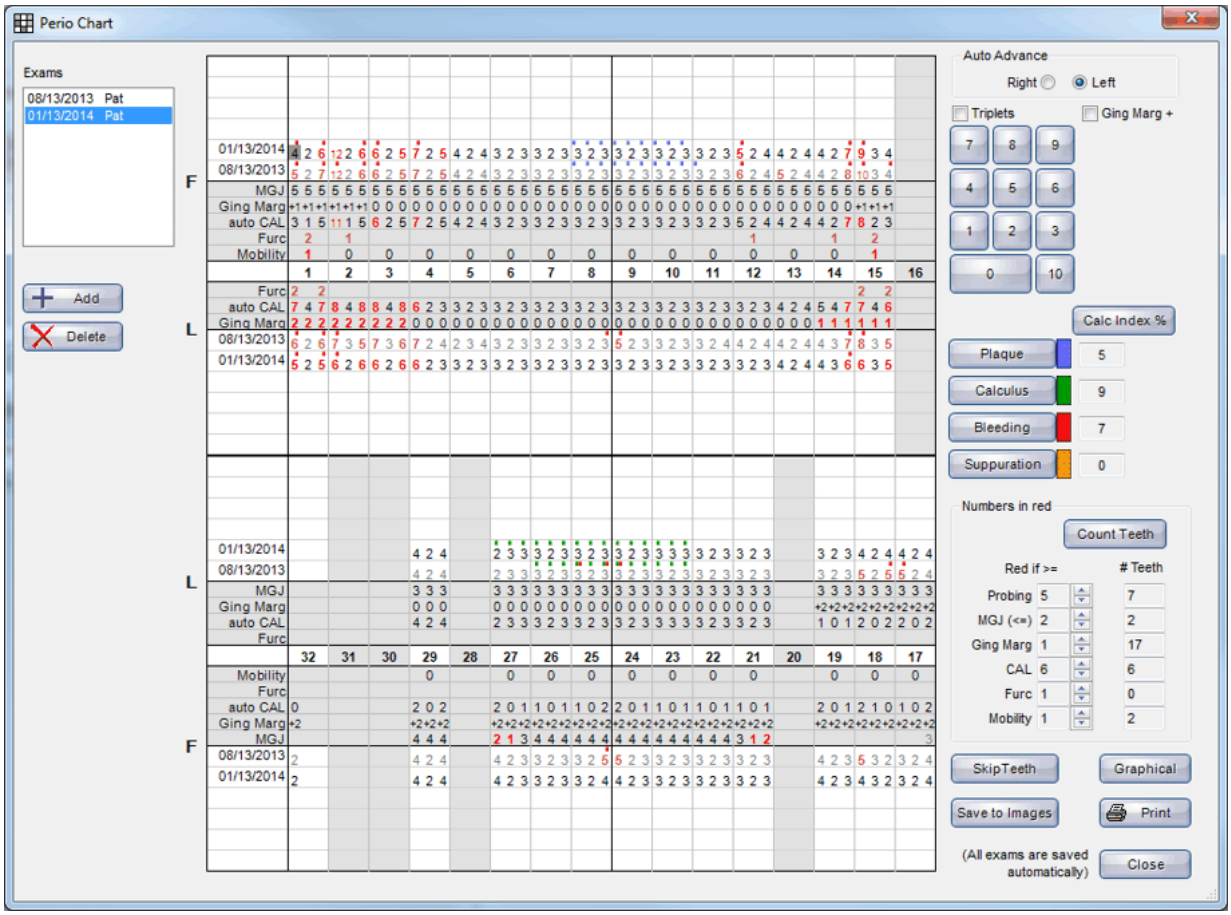


Figure 5. Open Dental periodontal soft tissue chart[25]

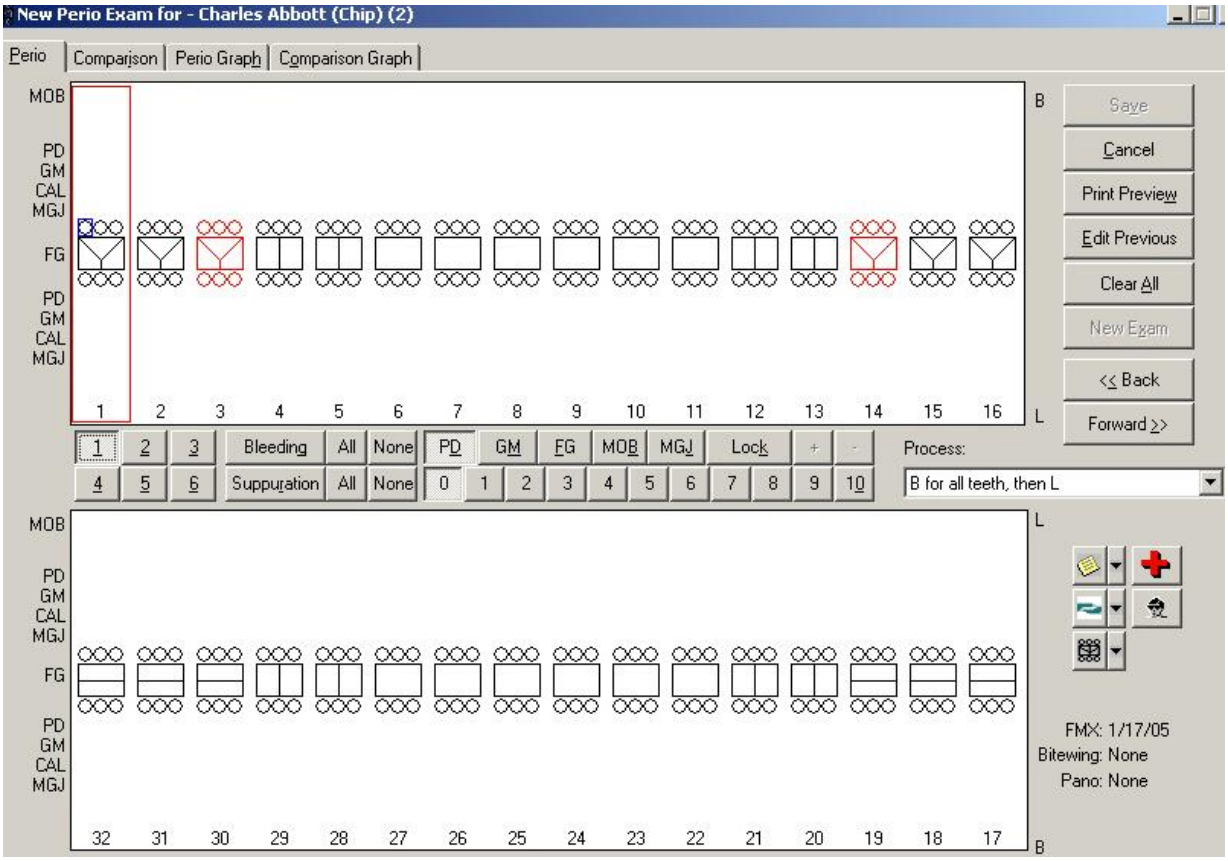


Figure 6. Patterson, EagleSoft periodontal soft tissue chart[26]

The dental hygienist also has the role of educating the patient. Dental hygienists play a unique and important role in these inter-professional practices and healthcare opportunities due to their routine observational access to the patients' oral cavity and tongue, as well as opportunities for patient education during examinations.

Although EDRs and EMRs help provide better holistic care to patients and support research and data retrieval, the use of HIT influences clinicians' workflow and efficiency.[27-31] However, HIT has the capabilities to improve quality, efficiency, and patient-centered care.[32] The switch from paper to electronic records drastically changed the daily practices of clinicians and supporting staff,[31-32] sometimes causing various interruptions in the workflow. For example, some EDRs require hygienists to open a separate program to view the radiographs, increasing the number of

steps required to view the radiographs and the time needed to load the radiograph program. This also requires dental hygienists to depend on two separate programs rather than one when trying to do a comparison on the patient's mouth. Further breakdowns in a workflow are especially visible when cognitive science methods are not used in the design of such systems. Cognitive science methods should be used to understand the end users'-- the dental hygienists-- needs and workflow, before the development of the system. Furthermore, there is currently no empirical model or any defined rules for clinical workflow in the dental office.[18] More specifically, there is no empirical model for dental hygienists using the periodontal soft tissue chart within an EDR.

Dental hygienists have not had the opportunity to give input toward the design and development of interfaces used for recording dental patient data. Additionally, current periodontal soft tissue charts and the surrounding features do not fit the needs of the dental hygienists. Therefore, in order to develop a periodontal soft tissue chart with surrounding features that does not inhibit workflow, the needs of dental hygienists must be addressed. Besides inhibiting the workflow, inappropriate interfaces can lower efficiency and cause time-consuming workarounds to be developed. Cognitive science methods have been shown to frame the design, development, and evaluation of HIT. A gap in knowledge exists when developing periodontal soft tissue charts and surrounding features for dental hygienists to use when inputting patient data because currently, dental hygienists have not been involved in the design and development of the periodontal soft tissue charts. The end products (periodontal soft tissue charts and the surrounding interface) are not user-friendly and conducive to the dental hygienists' needs and workflow. I hypothesize that if a proper needs analysis is conducted on dental hygienists, and the dental hygienists are involved in the development of a periodontal soft tissue chart interface, a prototype can be created that

allows for greater usability than an existing commercial interface and periodontal soft tissue chart. Furthermore, the prototype will fit the needs and workflow of dental hygienists.

II. BACKGROUND

Defining the Need for Usable Periodontal Soft Tissue Charting

This chapter presents previous work related to dental charting, the dental hygienist's cognitive task analysis, the usability of electronic systems, and justifications for end user (dental hygienist) involvement in creating a usable dental system.

Oral-Systemic Connection

Dental hygienists have an increasingly important role in dental and overall health. An increasing number of studies are showing the possible connection between oral and systemic health.[7-17, 33-37] Studies have shown that gingivitis or periodontal disease has associations with several systemic conditions.[7-13, 16,17, 35-40] Therefore, it is important that patients receive education regarding these possible connections to receive the most holistic care. A study conducted at Marshfield Clinic Health System, in collaboration with the University of Minnesota School of Dentistry, found that during the patient examination, the dental hygienists spent much of the appointment time providing oral health education to the patient.[41]

Previous Dental Work

Growth in EDR Adoption

Few studies have been conducted that focus on the adoption rate of EDRs in dental practice. A study conducted in 2006 aimed to measure the adoption, utilization of, opinions about, and attitudes in the United States towards clinical computing in dentistry.[19] A phone interview of a random sample of 256 active dentists in the United States found that 24.6% of dentists have chair-

side computers in their operatories (exam rooms).[19] Although nearly a quarter of active dental practices is using computers in their daily practice, paper remains an essential part of their daily workflow. Moreover, 1.8% of respondents were completely paperless.[19] A survey administered by the American Dental Association (ADA) in 2007 found that the number of dental practices using computers was 55.5%, and the number of dental practices that were completely paperless was 9.2%.[42] In the state of California in 2010, 23% of dental practices had fully implemented an EDR into their dental practice.[43]

In 2012, a national, 39-question survey was administered to over 6,000 registered ADA dentists that aimed to obtain a clearer understanding of the current knowledge and adoption rate of EDRs.[44] With a response from 484 active dentists across the United States, 52% of participants reported using an EDR.[44] Although the adoption rate of EDRs has grown substantially, a large percentage of dental practices still do not use them. The same study included questions regarding the reason for adoption or non-adoption of EDRs in dental practice.[44] The high expenses of implementation were rated as the top reason for non-adoption.[44-46] Other reasons found to hinder EDR adoption included dentists saying they do not need EDRs, training staff to use EDRs is time-consuming, and they have low value and poor usability.[44]

Periodontal Chart

EDRs contain many different features. The main feature used by dental hygienists is the periodontal soft tissue chart. The periodontal soft tissue chart is used to document patient information regarding the periodontal tissue (gums). **Table 1** displays the different data elements that are typically found on most periodontal soft tissue charts.

Table 1: Common elements of periodontal soft tissue charts

Data Element	Definition
Tooth Identification	Denotes which tooth the data is being entered for
Mobility	How the tooth moves within the socket. Scale: O-III
Bone Loss	Alveolar bone loss. Scale: None to severe
Furcation Grade	Division of the roots. Class: I - IV
Calculus	Coating on tooth
Bleeding	Gum bleeding
Suppuration	Formation/discharge of pus
P/D or Probe	Pocket Depth
Mucogingival Junction	Distance between mucus membrane of lips, cheek, and gingival tissue
Gingival Margin	Distance between tooth and the gum line
Clinical Attachment Level	Calculation of probe depth and level of gingival margin
Periodontal Type	Level of gum health. Type" I- V

It is important to note that all periodontal soft tissue charts are not the same and do not always display all of the same information. **Figures 4-6** are examples of commercial periodontal soft tissue charts from Dentrix,[24] Open Dental,[25] and Patterson EagleSoft [26] EDRs, respectively.

EDRs cause breakdowns in workflow and can require workarounds to be developed. From a previous study that I was involved with, which is pending publication, time and motion methodology was used with a Microsoft Access 2000 (Microsoft Corporation, Seattle, WA) data collection tool[47] to study human-computer interaction and workflow of the dental providers. Furthermore, from personal observations on previous studies, I have seen dental hygienists record probe depths for a patient on a piece of paper towel to later enter into the EDR. This is a massive breakdown in the workflow, as the dental hygienist should not have to record the patient data (probe depths) twice. Breakdowns in workflow are inefficient and take away valuable time during a patient examination. Often, this is because the EDRs were not developed with input from the end users (dental providers). This includes the periodontal soft tissue chart that dental hygienists use to document all data from a patient examination on a daily basis. If a periodontal soft tissue

chart is created with the dental hygienists' input on needs and workflow, the dental hygienists should become more efficient in their practice, and their workflow should improve. This would also help to increase the amount of time for patient education.

Usability of EDRs

Defined by the International Organization for Standardization, usability is "the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use."[48] Usability is comprised of five basic components:[49]

1) **Learnability:** During first encounters, how easy is it for the user to accomplish minimal tasks?
2) **Efficiency:** Once the design is learned, how quickly can tasks be performed?
3) **Memorability:** How easily can proficiency be reestablished after an extended state of non-use?
4) **Errors:** What is the error rate, severity, and how does the user recover from the errors?
5) **Satisfaction:** Does the end user find the design pleasant and appropriate?

Usability keeps people engaged in what they are doing. For example, if a website has poor usability or the user gets lost on a website, the user will not stay on the website.[49] Ten percent of a design project's budget should be spent on usability, and it should be involved in every phase of the development process.[49] Often, during the development of clinical information systems, usability design is never included.

One study aimed to develop a basic content model for clinical data in paper-based records and to examine the degree in which the clinical data is covered in computer-based patient records.[50] Existing paper-based records and computer-based patient records have limited agreement as to what types of dental information should be recorded; computer-based record only covered part of the dental information that paper-based records covered.[50] Furthermore, the majority of EDR

systems do not organize their data in a user-friendly way.[50] A heuristic evaluation is "a method in which reviewers judge the user interface and system functionality to determine if they conform to established principles of usability and good design."[51] A study of four commercially available dental practice management systems aimed to find potential usability problems within the systems.[51] **Figure 7** illustrates the number of usability problems and heuristic violations that were found within each of the four EDR systems.[51] Dentists with chair-side computers in their operatories identified computer interfaces with steep learning curves as one obstacle to clinical use of computers.[19, 51]

Number of unique heuristic violations for the four PMSs* found by three evaluators.†

HEURISTIC	NO. OF VIOLATIONS, BY PMS‡				TOTAL
	EagleSoft	Practice-Works	Dentrix	SoftDent	
Consistency and Standards	7	11	11	16	45
Match Between System and the Real World	9	15	13	7	44
Error Prevention	11	9	11	10	41
Visibility of System Status	6	4	7	9	26
Esthetic and Minimalist Design	10	4	6	5	25
Recognition Rather Than Recall	5	7	—	5	17
User Control and Freedom	2	3	4	2	11
Flexibility and Efficiency of Use	1	3	3	2	9
Help Users Recognize, Diagnose and Recover From Errors	—	2	1	4	7
Help and Documentation	2	—	1	1	4
TOTAL	53	58	57	61	229

* PMS: Practice management system.
† Data were sorted by descending frequency of violations for each heuristic.
‡ EagleSoft, Version 10.0, is manufactured by Patterson Dental, St. Paul, Minn.; PracticeWorks, Version 5.0.2, is manufactured by Kodak, Rochester, N.Y.; Dentrix, Version 10.0.36.0, is manufactured by Dentrix Dental Systems, American Fork, Utah; and SoftDent, Version 10.0.2, is manufactured by Kodak.

Figure 7. Usability Problems of EDRs from a Heuristic Evaluation[51]

Usability and Cognitive Engineering

In 2003, a study was published that provided a review of different methodologies on human-computer interaction and the usability of computer systems in a naturalistic setting.[52] The procedures behind each methodology were based on 10 years of refining theories rooted in usability engineering and cognitive task analysis, as applied to health information systems.[52] **Figure 8** demonstrates an approach to system design.[52]

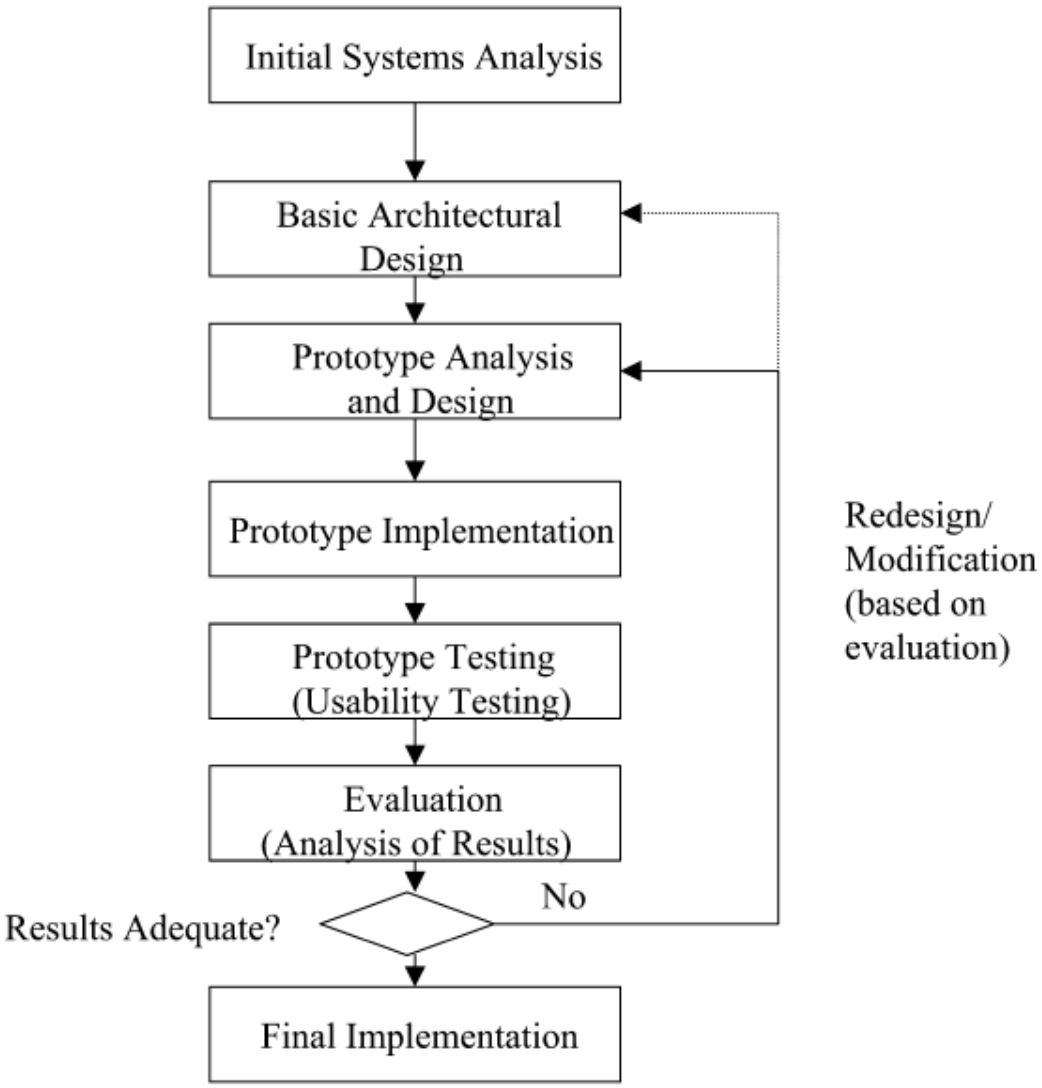


Figure 8. An Option for System Design based on Prototyping and Iterative Usability Testing

It is becoming more common to use an iterative evaluation of systems during the development process to improve the design and deployment of the systems, thus producing an effective system within the healthcare industry.[53] In the software industry, it has been recognized that iterative evaluation methods help to meet expectations of designers, users, and organizations.[53, 54] Traditionally, the waterfall approach, as seen in **Figure 9**, was used.[55] This approach was used under the assumption that all requirements were gathered upfront during the requirements phase instead of getting end user input throughout the development process.

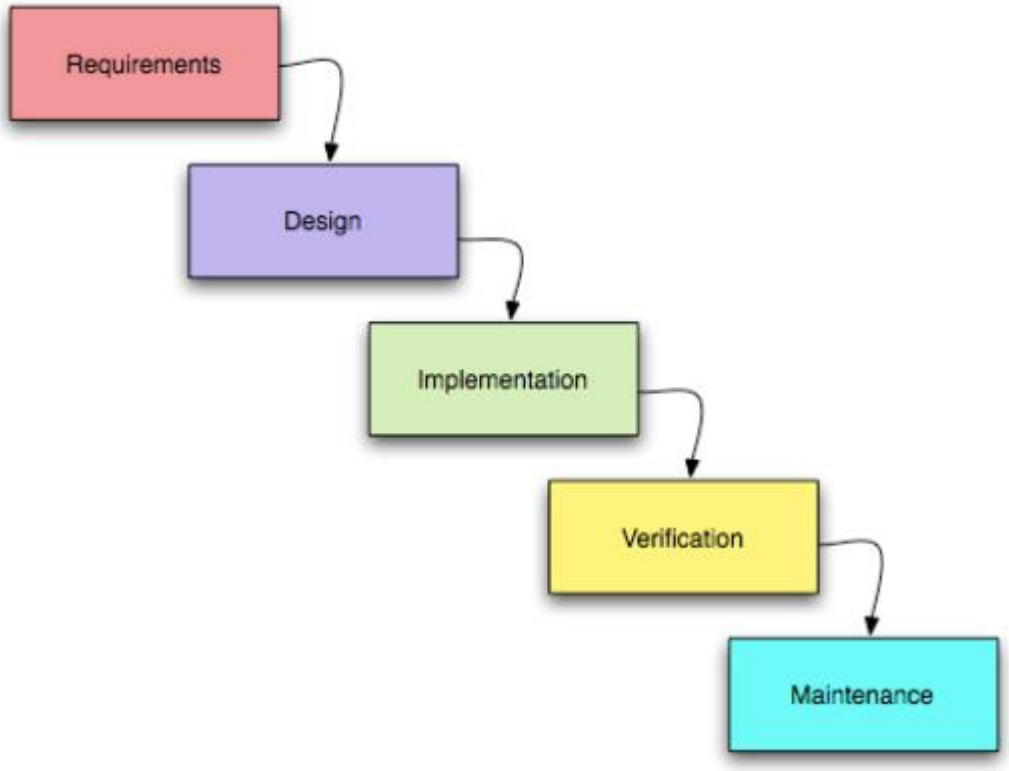


Figure 9. Traditional Waterfall Development Methodology[55]

Cognitive Task Analysis

Adoption of computers into dental practice is on the rise but continues to lag behind the adoption into medical practice.[19, 42-44] Usability issues of computerized clinical systems seem to

be a contributing factor.[44] A cognitive task analysis (CTA) is defined as an "extension of traditional (behavioral) task analysis techniques to yield information about the knowledge, thought processes, and goal structures that underlie observable task performance."[56] One CTA study was conducted on 10 general dentists to document the cognitive processes and information management strategies used during a patient dental examination.[32] The dentists' patterns of navigation through the patient's information and the informational needs of the dentists during a typical visit were then defined.[32]

Thus far, only one CTA of dental hygienists has been done on cognitive process of dental hygienists to define the elements necessary to simulate a dental hygiene examination.[57] This study focuses more on the processes of conducting a CTA[57] than it does use the information found from the CTA.

Dental Hygienists Involvement in Testing

To date, dental hygienists have had extremely limited amounts of involvement in the creation of periodontal soft tissue charts and the surrounding interfaces. Dental informatics, as a whole, is an emerging discipline that has many areas yet to be explored by research. Most dental informatics studies have focused on the dentist for the creation of informatics systems, and dental hygienists often are not involved. Therefore, there is limited, if any, literature surrounding dental hygienists and the design and creation of periodontal soft tissue charts and the surrounding interface features.

Discussion and Conclusions

EDRs must become highly usable if the adoption rate is to climb. User-centered design should be conducted only after laborious research has been done.[58, 59] In the case of dental

hygienists using periodontal soft tissue charts, there has been no interface developed taking into account their cognitive processes in alignment with their needs and workflow.

Through the study of the mind and its process, cognitive science methods have shown potential to formulate the design, development, and evaluation of HIT. Rarely does a development process for HIT involve cognitive engineering and research before development and, as such, is not evaluated until after the developmental phase. Additionally, a gap in knowledge exists when creating electronic periodontal soft tissue charts for dental hygienists to use when examining a patient, ultimately making the charts unconducive to the dental hygienists' needs. Cognitive engineering methods can be used to influence the systemic design of an electronic periodontal soft tissue chart used by dental hygienists. Considering the effect of well-designed and developed interfaces on effectiveness, quality, and patient safety, this project is focused on improving the interface of the electronic periodontal soft tissue chart. Thus, effective and efficient patient-centered cognitive support can be provided to the dental hygienist during a patient's periodontal examination.

III. RESEARCH METHODS

As stated in previous chapters, dental hygienists find current available EDR systems hard to use because they were not involved in the development of such systems. User-centered design methods include an iterative development and formal evaluation with the end user. Therefore, this study was done using a two-part methodology that analyzed both qualitative and quantitative metrics surrounding user-centered design.

Institutional Review Board

This study was approved as minimal risk expedited under Category 6 and 7 as governed by 45 CFR 46110 by the University of Wisconsin-Milwaukee's Institution Review Board (IRB).

Timeline

Figure 10 depicts the timeline for this study.

	2014	2015	January	February	March	April	May	June	July	August	September	October	November
Project Development	■												
IRB			■	■									
Participant Recruitment				■									
Ethnographic Observations					■	■							
Focus Groups					■	■							
CTA					■	■							
Ethnographic Observations, Focus Groups and CTA Analysis							■	■					
Prototype Development									■	■	■		
Usability Testing												■	
Usability Testing Analysis												■	
Thesis Writing	■		■	■	■	■	■	■	■	■	■	■	■

Figure 10. Study Timeline

Part I: Workflow, Needs, and Cognitive Task Analysis

Objective

Determine the workflow, needs, and cognitive process of dental hygienists during the care process of a patient.

Focus Groups (Appendix A: Recruitment and Focus Group Testing Documents)

Four focus groups were conducted at three different dental provider locations. One to six dental hygienists were present at each session. Dental hygienists were recruited via phone and email, and sessions were scheduled at the convenience of the dental hygienists. All sessions were conducted using a moderator script to ensure the accuracy of the content being conveyed to participants. The dental hygienists were asked the following questions as talking points:

- Do you currently use paper or digital soft tissue charting? Do you use both?
    - What specifically is paper still used for?
    - What specifically is electronic?
    - If paper charting is used, have you ever used digital charting previously?
    - If digital charting is used, have you ever used paper charting previously?
    - What system is used?
    - What other systems have you used?
- Did you use electronic charting during your schooling?
- What point during the appointment do you enter information into the soft tissue chart?
- How do you do data entry?
    - Does someone help you with data entry or do you do it on your own?
    - If done on your own, how do you do it while examining the patient?
- What is the process that you take when a patient enters your operatory?
    - Do you have a routine of steps that you follow for each patient?
        - If yes, why is this your routine?
    - If yes, is this routine standard throughout your dental clinic?
- What would be your ideal layout for your soft tissue chart?
    - Would you like to have a link to radiographs from within the periodontal soft tissue chart?
    - Would you like to have an educational component to the periodontal soft tissue chart?
    - Other needs?
- Is there anything on your current soft tissue chart that you feel is missing?

- Any other comments for me?

Detailed notes were taken during all sessions for later analysis. A thematic analysis was done to look for patterns in the dental hygienists' needs and workflow. The grounded theory approach was used as patterns emerged when the notes were analyzed.

Ethnographic Observations (Appendix B: Ethnographic Observation Testing Documents)

In parallel to the focus groups and by using the same participant pool as the focus groups, 10 ethnographic observations of dental hygienists examining different patients were conducted to determine communication patterns and describe the behaviors, workflow, and tasks of the dental hygienists in their operatories. Ten female dental hygienists were observed examining patients at three different dental clinics across Wisconsin. All observation sessions included conducting periodontal probing and entering the data into the EDR. Verbal consent was obtained from the patient prior to beginning the ethnographic observations of the dental hygienists. Notes were taken using a template to ensure that the same questions were being answered during each observational sessions. Following the ethnographic observations, the notes were analyzed to identify work and information flows.

Cognitive Task Analysis (Appendix C: Cognitive Task Analysis Testing Documents)

The same 10 dental hygienists from the focus groups and ethnographic observations were used for the cognitive task analysis (CTA) sessions. Following the focus groups and ethnographic observations, CTA methodology was used to detect the concepts, goals, contextual cues, and strategies that aid in the thought process of dental hygienists when conducting data entry and retrieval, education, and instruction during patient examinations. A moderator script was used by the moderator to ensure consistency in the directions given to the dental hygienists. The dental

hygienists were asked to use a think-aloud protocol, which was practiced prior to the beginning of the CTA sessions.

The CTA was conducted on 10 dental hygienists examining three simulated patients. The simulated patients contained fictitious patient information and did not involve actors or real patients. The patient cases were reviewed by one dental hygienist to ensure that the cases represented patients typically seen in a dental hygiene practice.

The cases were presented to the dental hygienists. The dental hygienists were given the patients' *chief complaint* and *demographics*. Additional patient information (*medical history, dental history, radiographs, intra-oral images, tooth chart, insurance, vitals,* and *periodontal chart)* was then given to the dental hygienists upon request, one at a time. The hygienists were asked to verbalize the situation with the patient, what information they desired about the patient, and what they were thinking while examining the patient and entering information.

Each CTA session took approximately 30 minutes. During each session, detailed notes were taken in order to capture the dental hygienist's interactions with the simulated patient information. Prior to beginning the CTA sessions, the goal and process of the testing was reviewed with the dental hygienists. Once all CTA sessions were completed, the session notes were coded based on the definitions of reputable codes used in a previous CTA study[32] that was conducted by well-known experts in the field of dental informatics. The codes were: [32]

- *Information Retrieval:* "actions or processes involved with retrieving and reviewing patient information, such as requesting information, asking a follow-up question, scanning records or reviewing images."
- *Processing:* "actions involved with processing the information reviewed, such as setting a goal, hypothesizing, contextualizing and comparing/cross-checking."
- *Deciding:* "decision-making actions such as establishing a finding, diagnosis or a treatment and making recommendations for a treatment or on a diagnostic procedure."

Part II: Prototype Development and Usability Testing

Objective

Based off data analyzed from the focus groups, ethnographic observations, and CTA sessions, a prototype of a periodontal soft tissue chart interface was developed using Numbers for Mac (Apple Inc., Cupertino, CA).[60] The prototype was then compared to a pre-existing, commercial periodontal soft tissue charting interface.

Prototype Development

Using the results of the focus groups, ethnographic observations, and CTA sessions, both the needs and the most "common" workflow of the dental hygienists involved in this study were developed. An interface for the periodontal soft tissue chart was drawn on paper. Based on the drawing, Numbers for Mac was used to develop the prototype. Since a dentist often reviews the periodontal soft tissue chart when diagnosing a patient, the prototype was also reviewed by one dentist to see if it was beneficial to the dentist's requisites.

Dentist Review

One dentist reviewed the prototype to see if it was legible upon easy glance when needed for review by the dentist. The dentist said that the layout of information was good. However, regarding the periodontal soft tissue chart, he would like to see pocket depths from 6mm and deeper in red colored font. Furthermore, he liked the idea of a medication dictionary. Finally, the dentist explained that there are not many standards in dentistry, and it is hard to create a system that is usable for all the different workflows. He went on to tell a story about one of his clinics that primarily services farmers who want their teeth removed when there is an issue and he compared it to his current clinic that does many teeth restorations, rather than extractions. He said

the primary factor is patient demographics. Some changes were made to the prototype based off the dentist's feedback.

Dentrix

Dentrix Educational Version[61] was purchased from Henry Schein for usability testing. Prior to making the purchase, phone calls were placed to Henry Schein to ensure the sameness of the educational version of Dentrix with the commercial version of Dentrix. Moreover, Henry Schein verbally approved the use of Dentrix educational version for this study.

Usability Testing (Appendix D: Usability Testing Documents)

Usability analysis was conducted with the periodontal soft tissue chart prototype on an iPad 2 and was compared with a commercial software's (Dentrix) periodontal soft tissue chart on a laptop computer with a touchscreen. Four dental hygienists were chosen from the same participant pool as the dental hygienists that participated in Part I of the study. The four were selected randomly by the dental hygienists' manager, based off schedule availability. The dental hygienists were given the option of using the touchscreen or the keyboard to enter data into Dentrix and were given the option of using a pen-stylus or their finger to enter data into the prototype.

One-on-one sessions were conducted between the moderator and the dental hygienists. A moderator script was used by the moderator to ensure that all dental hygienists were being told the same information. The dental hygienists were asked to complete 10 tasks on Dentrix. After waiting at least 24 hours, the dental hygienist then completed the same 10 tasks on the prototype. Tasks that aligned with the five components of usability[48] required finding and clicking on specific elements within each interface, as well as entering probe depths and bleeding amounts for specific teeth into the periodontal soft tissue chart. Each task had four options as to how it could be completed:

1) **Successful:** completing the task correctly without assistance.
2) **Unsuccessful**: not completing the task or completing the task incorrectly but with no assistance.
3) **Successful with assistance:** completing the task correctly, but only after receiving assistance.
4) **Unsuccessful with assistance:** not completing the task or incorrectly completing the task even after assistance was given.

A think-aloud protocol was used to gauge the thought process of the dental hygienist participants. During each session, Morae Recorder (TechSmith, Okemos, MI)[62] was used for computer-screen capture and for the prototype testing sessions, Reflector 2 (Squirrels, LLC, North Canton, OH)[63] was used to mirror the iPad 2 screen to the laptop computer for screen recording by Morae Recorder. Using Morae Manager (TechSmith, Okemos, MI),[62] the screen recordings were analyzed by breaking down the tasks into specific time intervals. The tasks were said to begin once the dental hygienist was done reading the task and were complete once the dental hygienists had said, "Done." The time taken to complete the tasks was then reviewed and compared between the two systems. An exit interview was conducted with the participants regarding the usability of both the prototype interface and the Dentrix interface periodontal soft tissue charts. The exit interview consisted of asking the dental hygienists three brief questions regarding the platform used, administering the System Usability Scale (SUS)[64] survey, a Product Reaction Cards (desirability exercise) (Developed by and © 2002 Microsoft Corporation. All rights reserved),[65] and a Net Promoter Score (NPS)[66] test for both systems.

Examination of the usability analysis sessions included comparing task completion, memorability and learnability of tasks, the efficiency of completion, and satisfaction comparisons between the prototype and Dentrix. Word clouds were created from the desirability exercise using WordItOut[67] (Enido, Antwerp, Belgium). SUS survey and NPS scores were calculated. The SUS survey, desirability exercises, and NPS for Dentrix and the prototype were then compared.

IV. RESULTS

This chapter presents the results from the ethnographic observations, focus groups, CTA sessions, prototype development, and the usability testing.

Ethnographic Observations

Descriptive Statistics

Ten female dental hygienists were observed examining patients at three different dental clinics across Wisconsin. All observation sessions included the dental hygienists conducting periodontal probing and entering the data into the EDR. Ten percent (1/10) of dental hygienists used a dental assistant to input the periodontal data while 90% (9/10) of dental hygienists input the periodontal data themselves while conducting the patient examination.

Observations

No two dental hygienists followed the exact same methods for conducting the periodontal examinations on the patient. Thirty percent (3/10) of dental hygienists used only a mouse to enter information while 70% (7/10) used both a mouse and a keyboard. Thirty percent (3/10) of dental hygienists entered one surface of the teeth at a time while 30% (3/10) of dental hygienists entered two or more at a time. Thirty percent (3/10) of dental hygienists entered a random number of tooth surfaces at a time and 10% (1/10) entered an entire quadrant of tooth surfaces. The remaining dental hygienists had their own methods for entering periodontal data, which even included doing so randomly.

Fifty percent (5/10) of dental hygienists began probing the gums starting on the top arch. Fifty percent (5/10) of dental hygienists started probing the gums in the first quadrant while 40% (4/10) started probing in the fourth quadrant. Ten percent (1/10) of dental hygienists started

probing in a random spot. Eighty percent (8/10) of dental hygienists recorded bleeding of the gums during probing.

The odontogram (hard tissue tooth chart) and radiographs were viewed by all dental hygienists throughout the appointment. To view these items, 80% (8/10) of the dental hygienists either had to click to a different screen to view them, or in the case of radiographs, 20% (2/10) of dental hygienists had to take their eyes and hands off the computer to look manually at the non-digital radiographs.

Education was given to the patient 70% (7/10) of the time by dental hygienists. Not all patients required education.

Focus Groups

Descriptive Statistics

The 10 female dental hygienists from three different dental clinics across Wisconsin who participated in the ethnographic observations also participated in four focus groups. One dental clinic had two different focus group sessions due to a scheduling conflict. **Table 2** shows the breakdown of the focus groups' participants. The mean age of the participants was 14.3 years old.

Table 2. Descriptive Statistics of Participating Dental Hygienists.

	Number of Participants	Gender	EDR Currently Used
Dental Clinic 1	3	Female	QSI Dental
Dental Clinic 2	1	Female	Dentrix
Dental Clinic 3	2	Female	EagleSoft
Dental Clinic 1	4	Female	QSI Dental

EDR Use

All 10 dental hygienists currently use EDRs in the workplace. Twenty percent (2/10) of dental hygienists had previously used an EDR in a different workplace while 10% (1/10) had used

an EDR while in school, and the other remaining 90% (9/10) of dental hygienists were taught to record periodontal data using paper. **Table 3** shows the breakdown of exposure to different EDRs compared to dental hygienists.

Table 3. Paper and Electronic Dental Records Previously Used by Dental Hygienists.

	Number of Hygienists Used
Dentrix	3
EagleSoft	3
QSI Dental	7
Paper	10

Coding

Using a grounded theory approach, the focus groups' notes were reviewed to code the dental hygienists' needs into categories. From discussing with the dental hygienists during the focus group sessions, specific functionalities were noted as "needs and wants" by the dental hygienists to have within their EDR. These results can be seen below:

- Link to radiographs;
- Draw fillings onto the hard tissue tooth chart;
- Medication dictionary;
- Educational materials / comparisons;
- Signature capabilities;
- Intra Oral images;
- Email / messenger to patients and dentists;
- Pocket depth with decimals or +;
- Mobility for teeth;
- Overall periodontal status.

Each of the above mentioned "needs and wants" are incorporated into the interface of the periodontal soft tissue chart prototype.

Cognitive Task Analysis

Descriptive Statistics

The same 10 female dental hygienists from the three different dental clinics across Wisconsin who participated in the ethnographic observations and focus groups also participated in the individual CTA sessions. All dental hygienists reviewed all the three fictitious patients' data in the same order.

Coding

The data elements that were presented to and reviewed by the dental hygienists were broken into four different categories of information, as seen in **Table 4**. Using coding from an existing study,[32] they were also coded into the three categories, as seen in **Table 5**.

Table 4. Data Elements and Information Presented to the Dental Hygienists.

Categories of Information	Information Presented
Patient Information	Medical and Dental Histories and Chief Complaint
Examination Information	Tooth Chart and Periodontal Chart
Images	Intra Oral Images and Radiographs
Other	Insurance and Vitals

Table 5. Coding used for Data Elements.

Coding	Information Presented
Decision Making	Insurance and Vitals
Processing	Medical and Dental Histories, Tooth Chart, Radiographs, and Intra Oral Images
Information Retrieval	Periodontal Chart

Workflow

As observed in all portions of the methodology, there is no standard workflow for examining a periodontal patient, and this was confirmed during the CTA sessions. **Figures 11-13** show the 10 dental hygienists' workflows for each of the three fictitious patients.

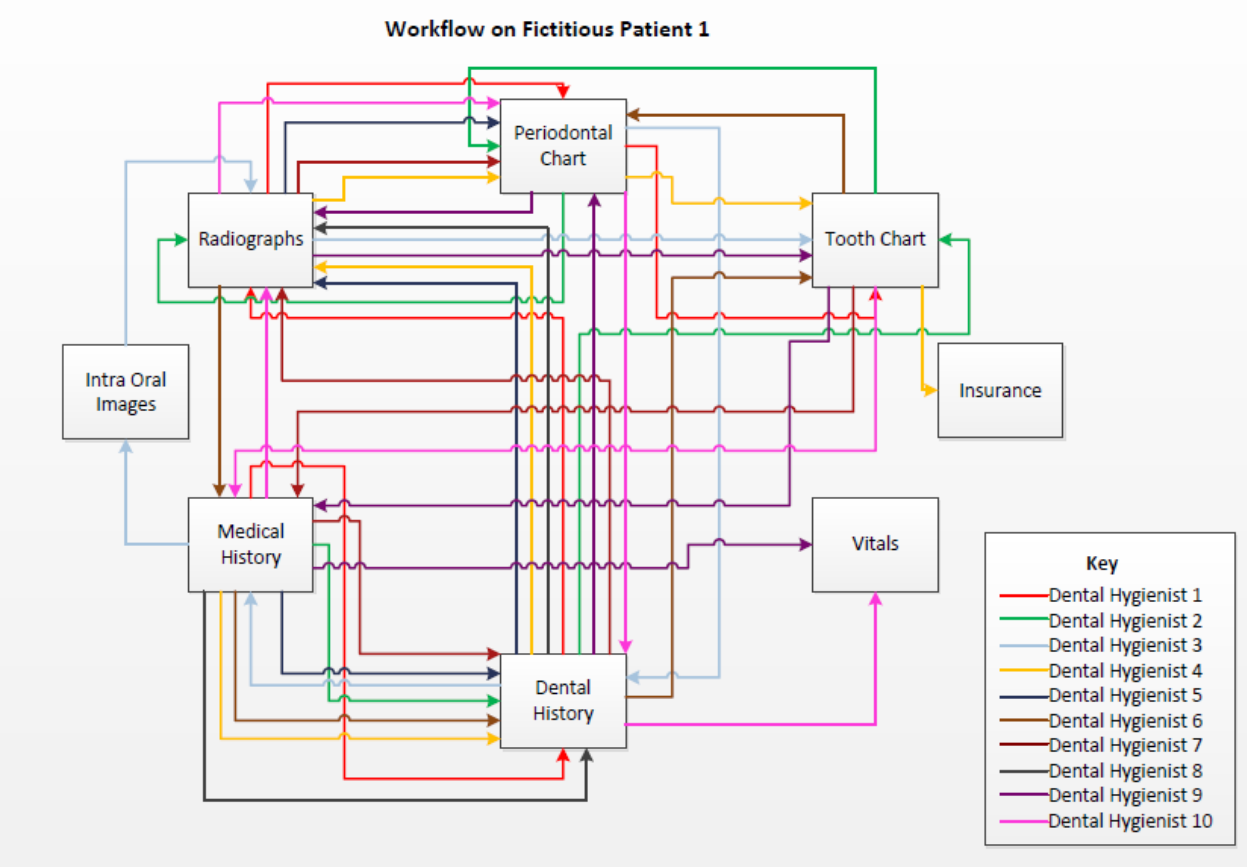


Figure 11. Workflow of Dental Hygienists for Fictitious Patient 1

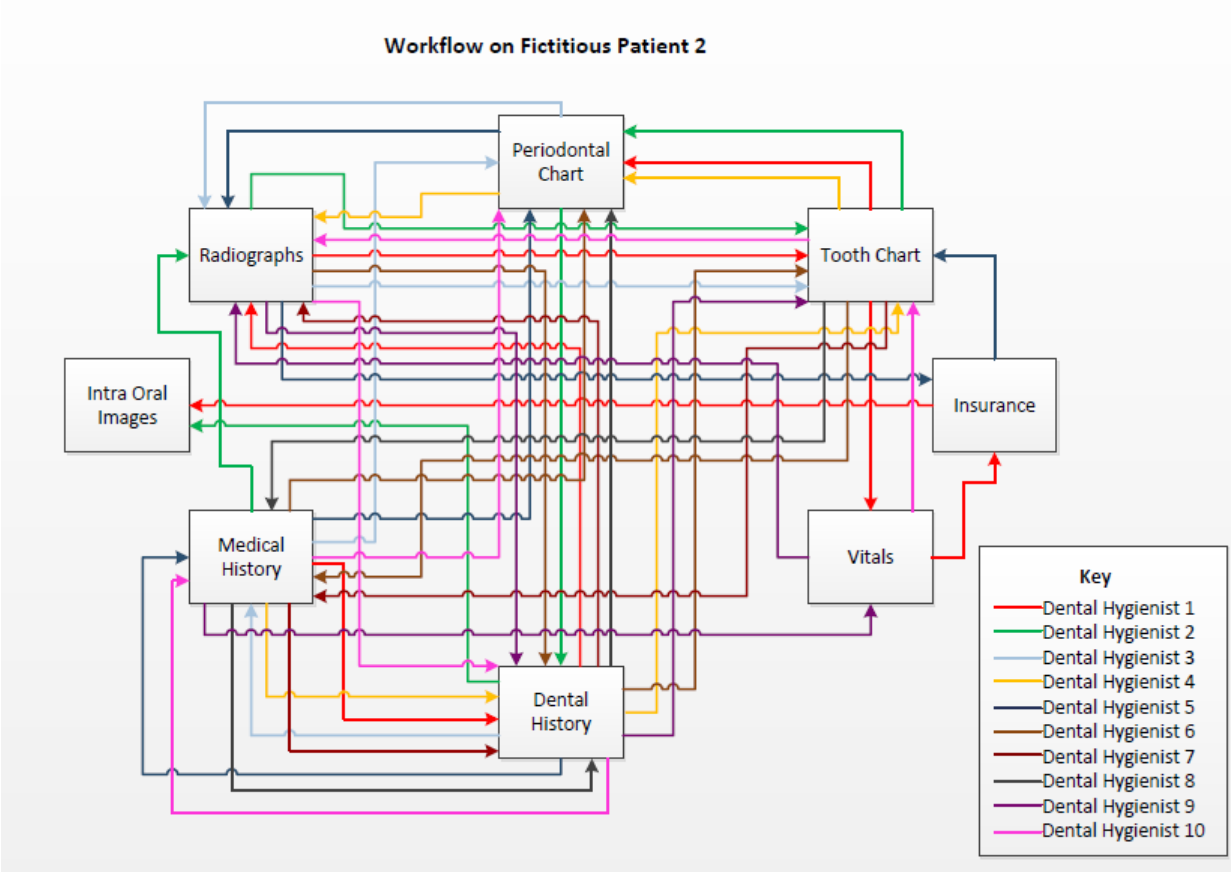


Figure 12. Workflow of Dental Hygienists for Fictitious Patient 2

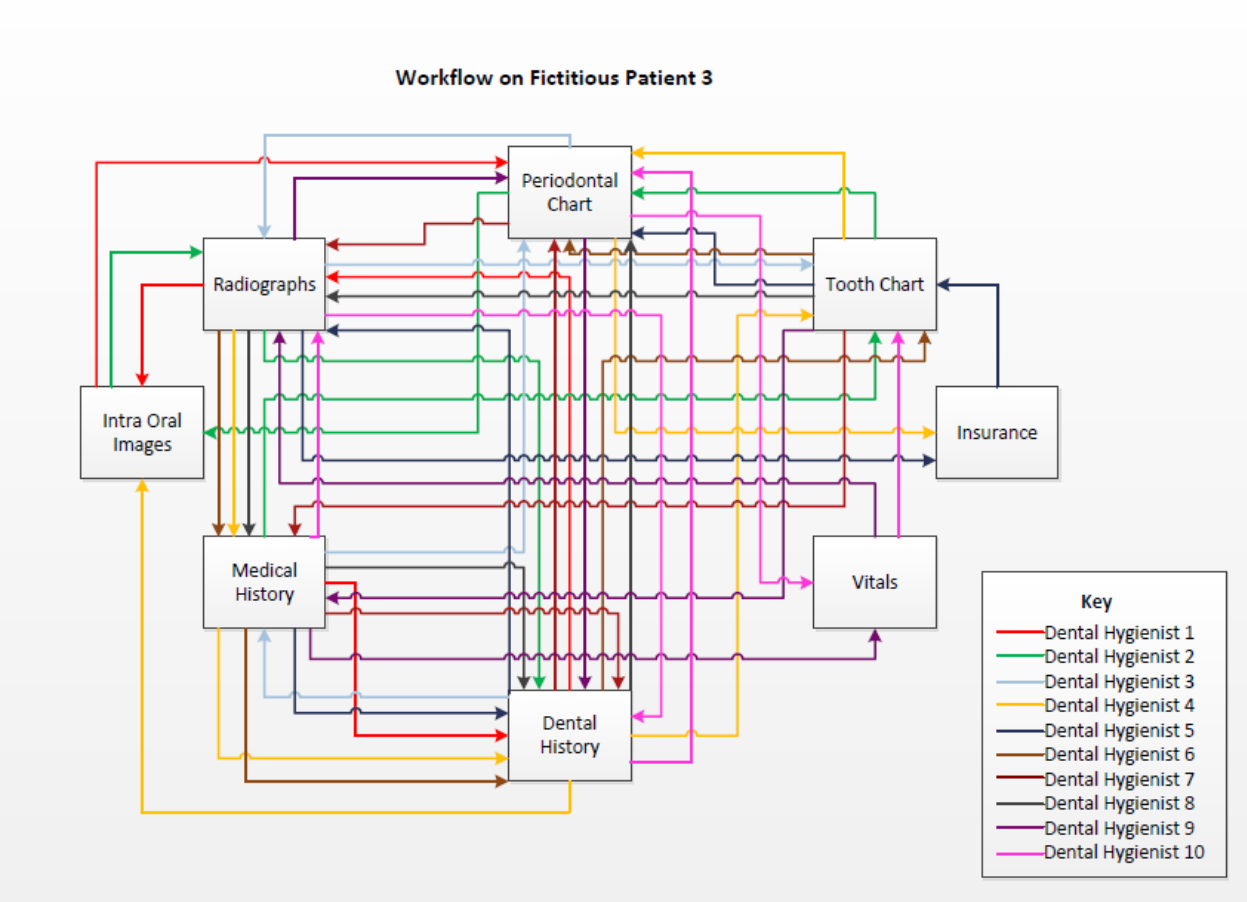


Figure 13. Workflow of Dental Hygienists for Fictitious Patient 3

The CTA analysis of all 10 dental hygienists' workflows when reviewing the three fictitious patient cases yielded that no dental hygienist followed the exact same workflow for every patient. **Figures 14** and **15** are examples of two of the dental hygienists (6 and 9) reviewing the three fictitious patient cases.

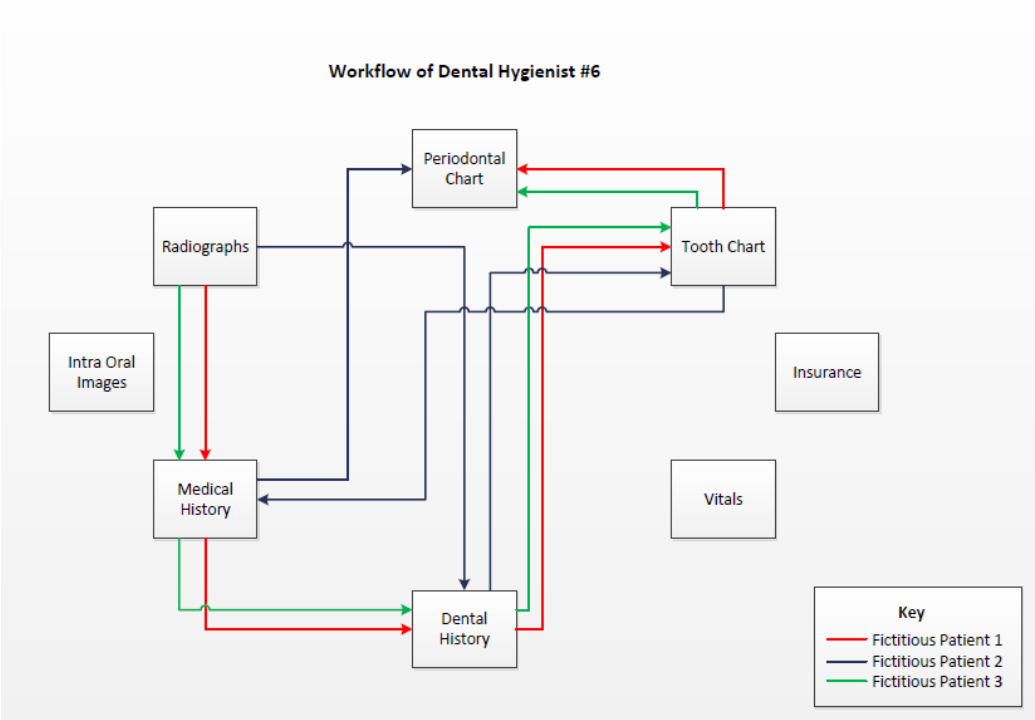


Figure 14. Dental Hygienist #6 Reviewing Three Different Fictitious Patient Cases

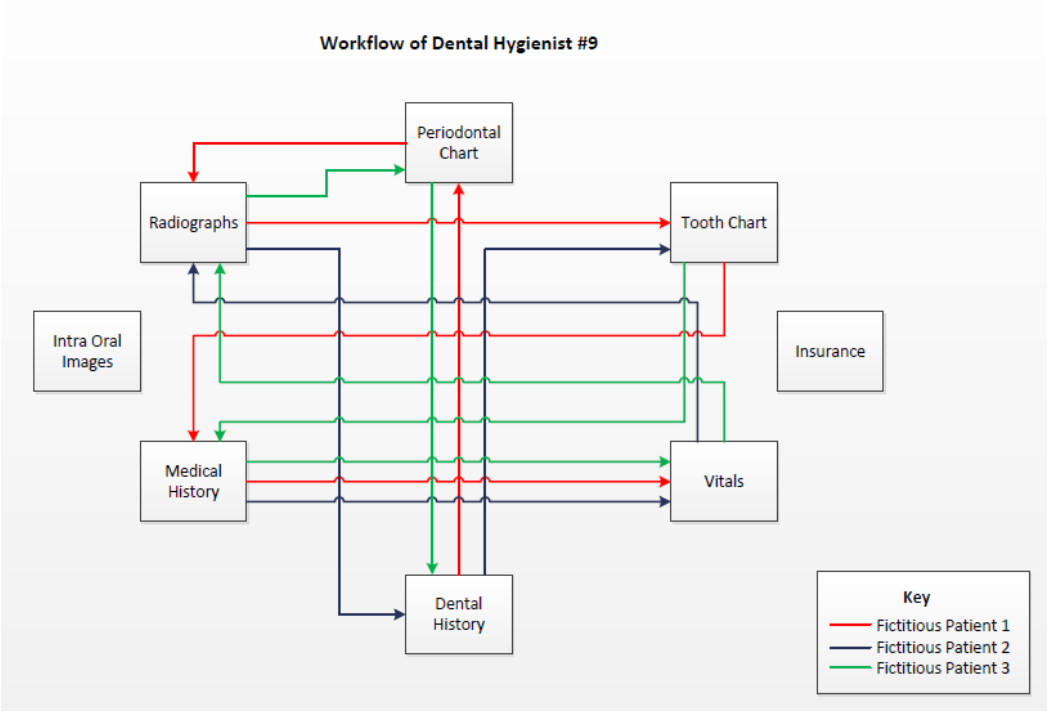


Figure 15. Dental Hygienist #9 Reviewing Three Different Fictitious Patient Cases

Prototype Development

Based on the results of the ethnographic observations, the focus groups, and the CTA results, a paper interface was drawn, as seen in **Figure 16**. Using Numbers for Mac (Apple Inc., Cupertino, CA) for Macintosh, the prototype was developed on a laptop. It was then converted to an iPad 2 for usability testing. Screenshots of the prototype can be seen in **Figures 17-20** below.

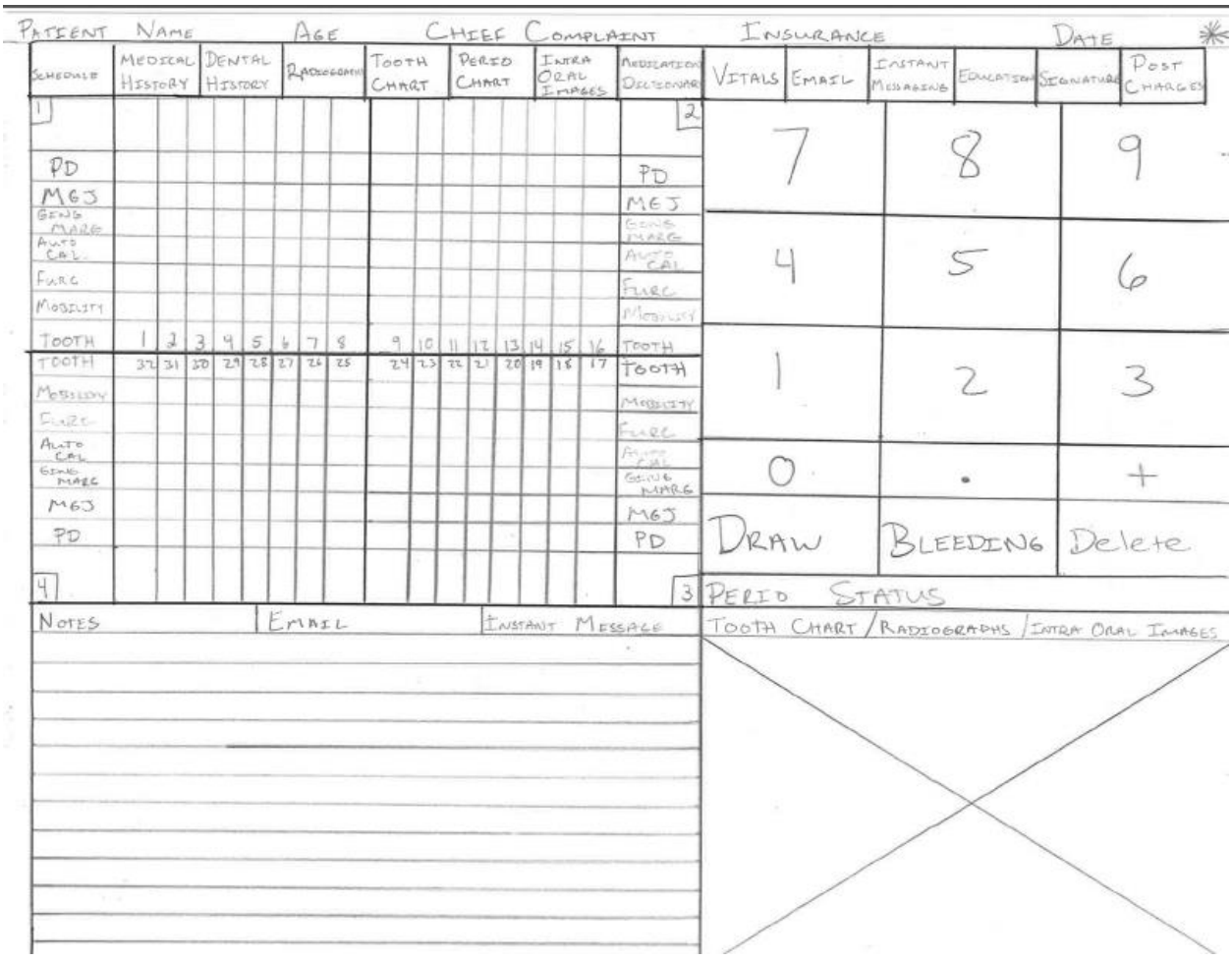


Figure 16. Prototype Paper Interface

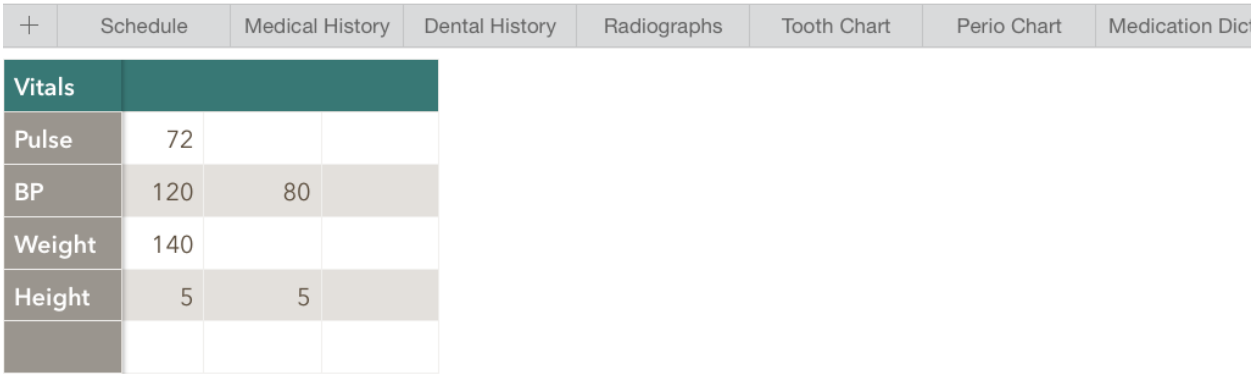


Figure 17. Screenshot of Vital Page on the Prototype

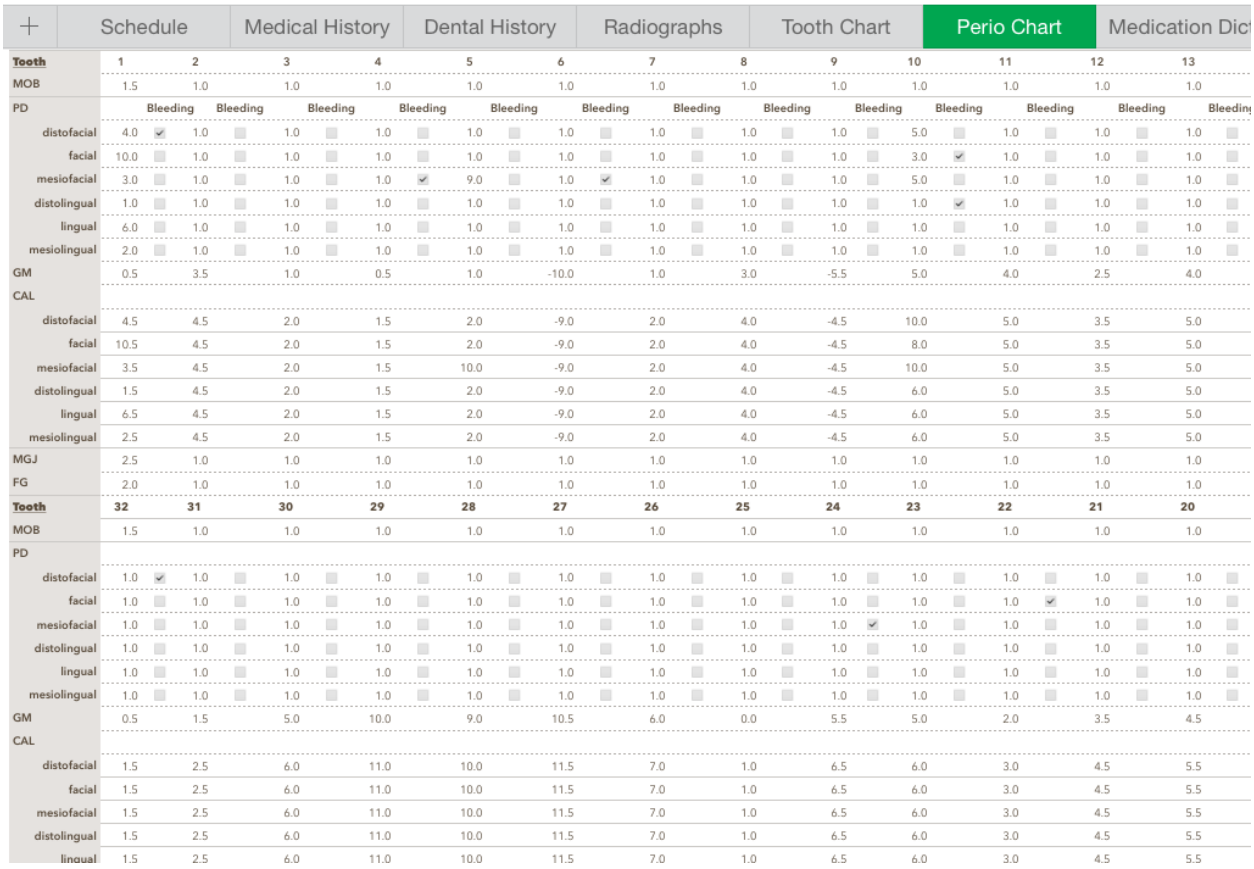
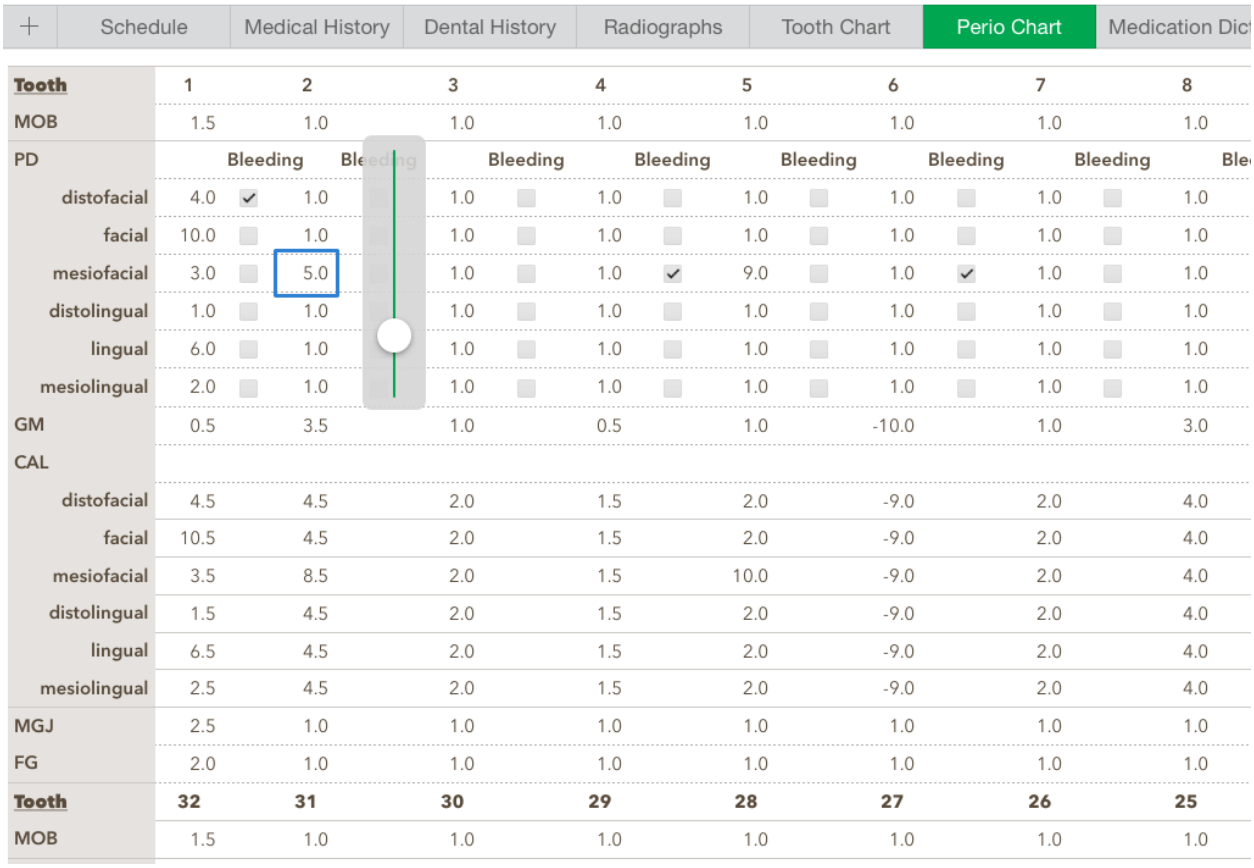


Figure 18. Prototype Periodontal Soft Tissue Chart



Tooth	1	2	3	4	5	6	7	8
MOB	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PD	Bleeding	Bleeding	Bleeding	Bleeding	Bleeding	Bleeding	Bleeding	Bleeding
distofacial	4.0 ✓	1.0	1.0	1.0	1.0	1.0	1.0	1.0
facial	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
mesiofacial	3.0	5.0	1.0	1.0	9.0	1.0 ✓	1.0	1.0
distolingual	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
lingual	6.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
mesiolingual	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
GM	0.5	3.5	1.0	0.5	1.0	-10.0	1.0	3.0
CAL								
distofacial	4.5	4.5	2.0	1.5	2.0	-9.0	2.0	4.0
facial	10.5	4.5	2.0	1.5	2.0	-9.0	2.0	4.0
mesiofacial	3.5	8.5	2.0	1.5	10.0	-9.0	2.0	4.0
distolingual	1.5	4.5	2.0	1.5	2.0	-9.0	2.0	4.0
lingual	6.5	4.5	2.0	1.5	2.0	-9.0	2.0	4.0
mesiolingual	2.5	4.5	2.0	1.5	2.0	-9.0	2.0	4.0
MGJ	2.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
FG	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Tooth	**32**	**31**	**30**	**29**	**28**	**27**	**26**	**25**
MOB	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 19. Entering Pocket Depth into the Periodontal Soft Tissue Chart

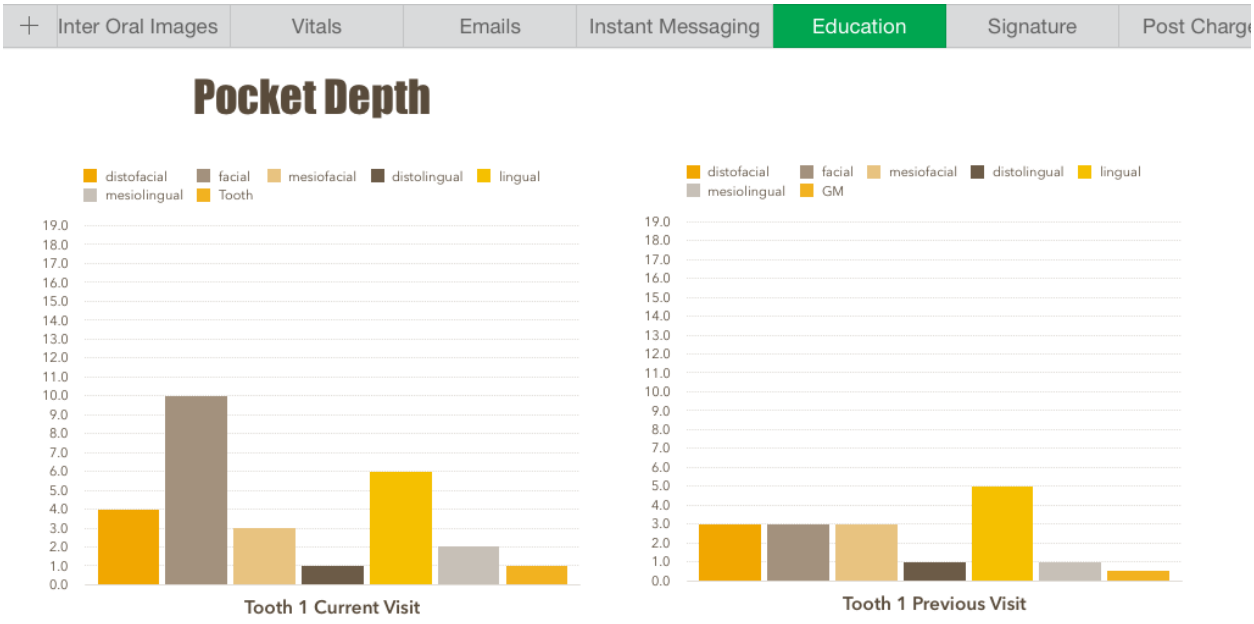


Figure 20. Screenshot of the Education Component Regarding Pocket Depth

The tabs across the top of the prototype are customizable with an easy click, drag, and drop feature.

Usability Testing

Descriptive Statistics

Four dental hygienists who had participated in the ethnographic observations, focus groups, and CTA sessions also participated in the two usability sessions with Dentrix and the prototype. No dental hygienists had any exposure to the prototype prior to testing. One hundred percent (4/4) of dental hygienists who participated in the study currently use QSI Dental.[68]

Tasks

All four dental hygienists were instructed to attempt all 10 tasks on both Dentrix and the prototype on two separate occasions. **Table 6** shows the tasks used for the usability testing.

Table 6. Tasks Used for Conducting Usability Testing

	Task:
Task 1	Click where in the system you would look to view patient history
Task 2	Click on the radiographs
Task 3	Find out how to access the hard tissue chart and click on it
Task 4	Click on the patient education component of the system
Task 5	On the periodontal chart, record pocket depths for tooth 10 on the facial side as 444
Task 6	Change the recorded pocket depths of the facial side of tooth 10 to 535
Task 7	On the periodontal chart, record tooth 18 as having bleeding
Task 8	Review the patient's education regarding tooth 10
Task 9	Click on where you would go to send a message to a patient or colleague
Task 10	Click on where you would view vitals

Dentrix

Completion Rate

One hundred percent (4/4) of dental hygienists attempted to complete all 10 tasks within Dentrix. **Table 7** shows the breakdown of completion rate per task on Dentrix.

Table 7. Task Completion Status on Dentrix

	Successful	Unsuccessful	Successful with Assistance	Unsuccessful with Assistance
Task 1	25% (1/4)	25% (1/4)	50% (2/4)	0% (0/4)
Task 2	25% (1/4)	0% (0/4)	75% (3/4)	0% (0/4)
Task 3	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 4	25% (1/4)	25% (1/4)	50% (2/4)	0% (0/4)
Task 5	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 6	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 7	75% (3/4)	0% (0/4)	25% (1/4)	0% (0/4)
Task 8	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 9	75% (3/4)	0% (0/4)	25% (1/4)	0% (0/4)
Task 10	75% (3/4)	0% (0/4)	0% (0/4)	25% (1/4)

Time on Task

Table 8 shows the time to complete each task in seconds, per dental hygienist, on Dentrix.

Table 8. Time to Complete Each Task on Dentrix

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Task 10
Time on Task (Seconds)										
Participant 1	75.93	122.84	3.53	176	177.46	29.89	118.79	114.36	117.78	50.21
Participant 2	119.67	87.72	3.88	145.71	29.11	7.45	47.75	66.72	50.77	147.9
Participant 3	108.69	72.14	3.99	99.77	36.65	10.6	72.92	11.09	33.23	43.59
Participant 4	164.15	81.2	6.61	63.58	15.9	4.45	51.58	10.15	35.13	13.15
Minimum	75.93	72.14	3.53	63.58	15.9	4.45	47.75	10.15	33.23	13.15
Maximum	164.15	122.84	6.61	176	177.46	29.89	118.79	114.36	117.78	147.9
Mean	117.11	90.97	4.5	121.26	64.78	13.1	72.76	50.58	59.22	63.72
Standard Deviation	36.45	22.18	1.42	49.61	75.61	11.47	32.62	50.08	39.82	58.4

Exit Interview

The dental hygienists were asked three verbal questions after attempting the tasks in Dentrix.

1) Have you used Dentrix before?
2) You have been working with Dentrix for about 30 minutes. Tell me your impressions about its ease or difficulty of use.
3) How do you like the layout of information within Dentrix?

With an exception of one dental hygienist who had learned about Dentrix in school, but never physically used it, no dental hygienist had exposure Dentrix before. The dental hygienists said that it was difficult to use. Furthermore, they thought there were too many icons that were not well marked or labeled, but once they got used to it, it could get easier to use. The dental hygienists also said that the layout was "okay."

System Usability Score (SUS)[64]

All four dental hygienists completed the SUS survey. The average calculated SUS score for Dentrix was 29.3.

Net Promoter Score (NPS)[66]

All four dental hygienists completed the NPS. The calculated NPS score for Dentrix was -100, which is the lowest possible score.

Desirability Exercise[65]

All dental hygienists chose at least five words from a list of 118 to elicit emotions regarding Dentrix. **Figure 21** is the word cloud that was developed based on the frequencies of words chosen.

Figure 21. Frequency of Words Chosen by Dental Hygienists that Elicit Emotions Regaring Dentrix

Prototype

Twenty-five percent (1/4) of dental hygienists elected to use a pen-stylus instead of their finger to complete the tasks on the prototype. After the first task was complete, the one dental hygienists decided to use her finger instead of the pen-stylus for all remaining tasks.

Task Completion Rate

One hundred percent (4/4) of dental hygienists attempted to complete all 10 tasks within the prototype. **Table 9** shows the breakdown of completion rate per task.

Table 9. Breakdown of Task Completion on the Prototype by Dental Hygienists

	Successful	Unsuccessful	Successful with Assistance	Unsuccessful with Assistance
Task 1	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 2	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 3	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 4	50% (2/4)	0% (0/4)	50% (2/4)	0% (0/4)
Task 5	75% (3/4)	0% (0/4)	25% (1/4)	0% (0/4)
Task 6	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 7	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 8	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 9	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)
Task 10	100% (4/4)	0% (0/4)	0% (0/4)	0% (0/4)

Time on Task

Table 10 shows the time to complete each task in seconds, per dental hygienist, on the prototype.

Table 10. Time to Complete Each Task (in seconds) on the Prototype

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Task 10
Time on Task (Seconds)										
Participant 1	4.6	1.45	3.73	46.93	71.62	28.62	10.81	26.97	3.29	2.79
Participant 2	3.72	2.25	5.05	29.88	119.39	10.71	12.48	39.9	2.1	4.1
Participant 3	5.94	5.93	5.97	29.93	50.38	23.71	12.68	13.26	3.38	2.63
Participant 4	2.09	1.95	4.64	54.47	62.3	19.04	27.62	3.06	4.06	2.38
Minimum	2.09	1.45	3.73	29.88	50.38	10.71	10.81	3.06	2.1	2.38
Maximum	5.94	5.93	5.97	54.47	119.39	28.62	27.62	39.9	4.06	4.1
Mean	4.09	2.89	4.85	40.3	75.93	20.52	15.9	20.8	3.21	2.98
Standard Deviation	1.62	2.05	0.93	12.39	30.25	7.62	7.86	16.06	0.81	0.77

Exit Interview

The dental hygienists were asked three verbal questions after attempting the tasks in the prototype.

1) Have you used an iPad before?
2) You have been working with the prototype for about 30 minutes. Tell me your impressions about its ease or difficulty of use. Do you like the iPad format?
3) How do you like the layout of information within the prototype?

No dental hygienist had ever used or seen the prototype prior to testing. The dental hygienists found the prototype to be "great," "good," or "nice." One dental hygienist also commented that she loved the tabs across the top and that you could pull/slide to see more tabs. Seventy-five percent (3/4) of dental hygienists had used an iPad before and liked the weight, size, and portability of it for data entry. The overall impression from the dental hygienists that participated in the usability testing was that the prototype was easy to use. The dental hygienists liked the layout, but would need to get used to it before finding it more favorable than their current system. Seventy-five percent of the participating dental hygienists mentioned that they liked the educational tools of comparison graphs, as seen in **Figure 20,** to educate their patients.

System Usability Score (SUS)[64]

All four dental hygienists completed the SUS survey. The average calculated SUS score for the prototype was 85.6.

Net Promoter Score (NPS)[66]

All four dental hygienists completed the NPS. The calculated NPS score for the prototype was 40.

Desirability Exercise[65]

All dental hygienists chose at least five words from a list of 118 to elicit emotions regarding the prototype. **Figure 22** is the word cloud that was developed based on the frequencies of words chosen.

Figure 22. Frequency of Words Chosen by Dental Hygienists that Elicit Emotions Regarding the Prototype

V. DISCUSSION AND CONCLUSIONS

This chapter discusses the results, draws conclusions, and answers the study's research questions. It also discusses limitations of the study and possible future work.

Research Questions

1) What is the pattern of information review, processing, and decision-making when dental hygienists examine patients during a periodontal exam?
2) What information do dental hygienists collect and use to make clinical decisions?
    a) In what workflow do dental hygienists review that dental information?
3) Can a digital prototype of a periodontal soft tissue chart that improves dental hygienists' workflow be developed?

Hypothesis

I hypothesized that if a proper needs analysis is conducted on dental hygienists, and the dental hygienists are involved in the developments of a periodontal soft tissue chart interface, a prototype can be created that allows for greater usability than an existing commercial interface and periodontal soft tissue chart. Furthermore, the prototype will fit the needs and workflows of the dental hygienists.

A periodontal soft tissue chart prototype was successfully developed based on the needs and wants of practicing dental hygienists. Ethnographic observations, focus groups, and CTA sessions involving dental hygienists practicing at different dental center locations, while using various EDRs, yielded the necessary data on the workflow of dental hygienists to develop a prototypical periodontal soft tissue chart interface. Moreover, usability testing with dental hygienists was conducted both on the prototype and on a commercial EDR, Dentrix. This comparative testing demonstrated the end users' (dental hygienists) ease of use of the prototype, which stems from a proper needs analysis being conducted, as well as strong involvedness of the end user in its development.

The results of the focus groups yielded the wants and needs of the dental hygienists. Typically, if a dental hygienist wanted or needed a functionality for their current system, the other dental hygienists present in the focus groups would agree. Based on the agreement, the list of dental hygienists' wants and needs was formulated. These wants and needs were all incorporated into the prototype that was developed.

The results of the ethnographic observations and CTA sessions helped to define the workflow of the dental hygienist. As seen in **Figures 11-13** there is no standard workflow for any of these dental hygienists. Notably, there is no consistent workflow between the dental hygienists. Rather, they exhibited differences in workflow depending on the specific patient case and data. This was further confirmed by personally communicating with the dentist who reviewed the prototype. Furthermore, **Figure 14** depicts the same dental hygienist reviewing three different fictitious patient cases. This can also be seen with different dental hygienists in **Figure 15**. All other data on workflow revealed the same inconsistencies in the dental hygienists' workflow; therefore, only two were chosen as examples. The lack of workflow from the dental hygienists also made the process of information review, processing, and decision-making random. However, decision-making was never conducted before at least one data element from either information review or processing was completed. After finding small patterns in the workflow of the 30 different patient cases, the prototype tabs were organized. However, since there is no standard or common workflow among the dental hygienists, it is very important that the prototype is customizable. For this reason, the tabs across the prototype, as highlighted in **Figure 23**, can easily be dragged and re-organized per dental hygienist user.

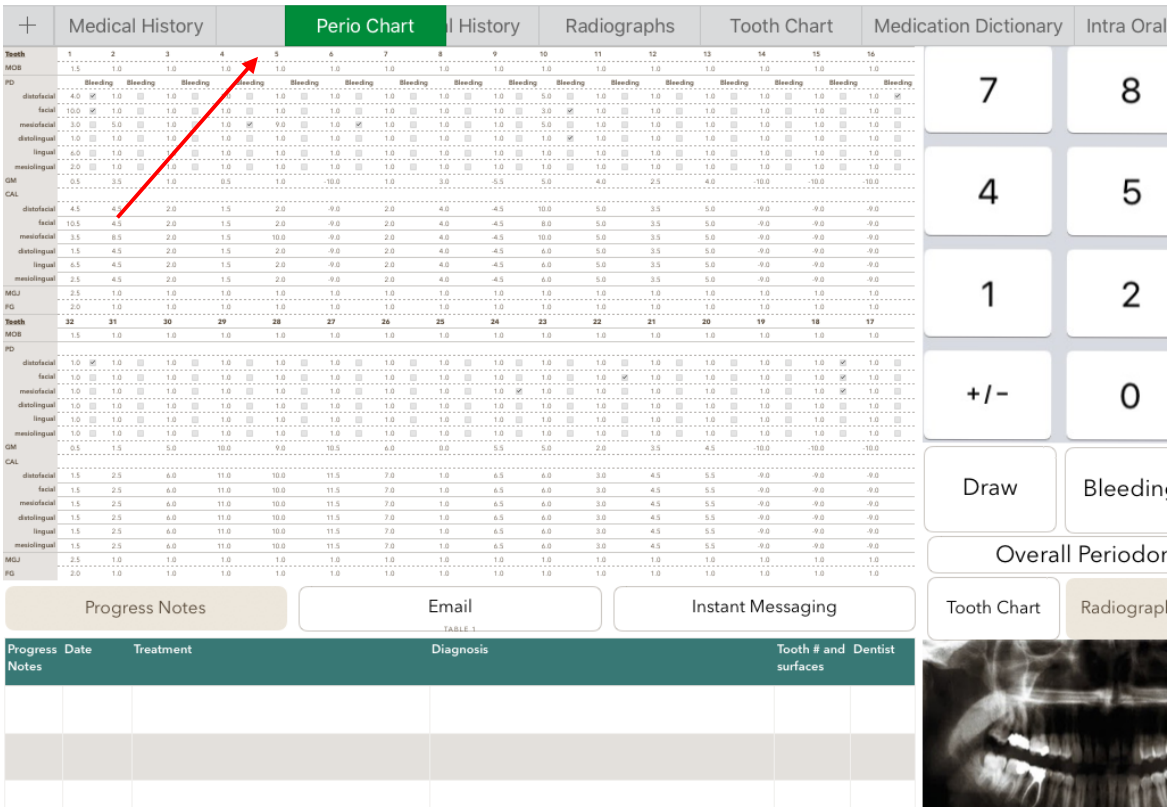


Figure 23. Customization of the Layout of the Prototype Interface (Perio Chart Moving)

Based on the usability testing, the prototype scored higher than Dentrix regarding the NPS and SUS survey scores. The NPS uses a standard scale to allow comparison between systems, and it is used to compare systems by asking the question, "How likely are you to recommend this system to a colleague?" The question is answered on a scale of 0 to 10 with 1-6 being detractors, 7 and 8 being neutral, and 9 and 10 being promoters. Typically, positive scores (1 to 100) indicate that users are likely to promote the product, while negative scores (-1 to -100) indicate that the user is not likely to recommend the product. By calculating the selected promoters and detractors (scale of 1 to 10) by the four dental hygienists regarding Dentrix, the NPS was -100, whereas the NPS for the prototype was 40. Dentrix has the lowest possible NPS because every dental hygienist gave it a detractor (1 to 6 score). The prototype, however, had many promoters (9 and 10). Additionally, the SUS measures overall participant attitude or satisfaction with the device being

tested. It is also a standardized way to score usability between systems. By calculating the SUS survey score based off the 10 questions answered using a 5-point Likert scale, the score for Dentrix was 29.3, while the prototype score was 85.6. The SUS scale ranges from zero to 100 and is graded with a letter grade. Dentrix received a grade of an F while the prototype received a B. A letter grade of C is considered average and usable. That being said, according to the SUS survey, the prototype was considered usable by the tested dental hygienists, but Dentrix was not.

An analysis of the exit interview comments revealed that the dental hygienists found the prototype to be "easy" and other comments were primarily positive. The majority of dental hygienists (3/4) verbally noted that the patient education feature on the prototype provided a nice visual to show to their patients in order to educate them on their pocket depths. Furthermore, the desirability exercise elicited emotions regarding both Dentrix and the prototype. **Figures 21** and **22** show the word clouds that were created based on the selected words. The larger words in the word cloud have a higher frequency of being chosen by the dental hygienists. The words chosen for Dentrix were primarily negative words, while the words chosen for the prototype were mostly positive.

Figure 24 shows that on average, the time to complete the same task on the prototype was much faster than completing the same task on Dentrix.

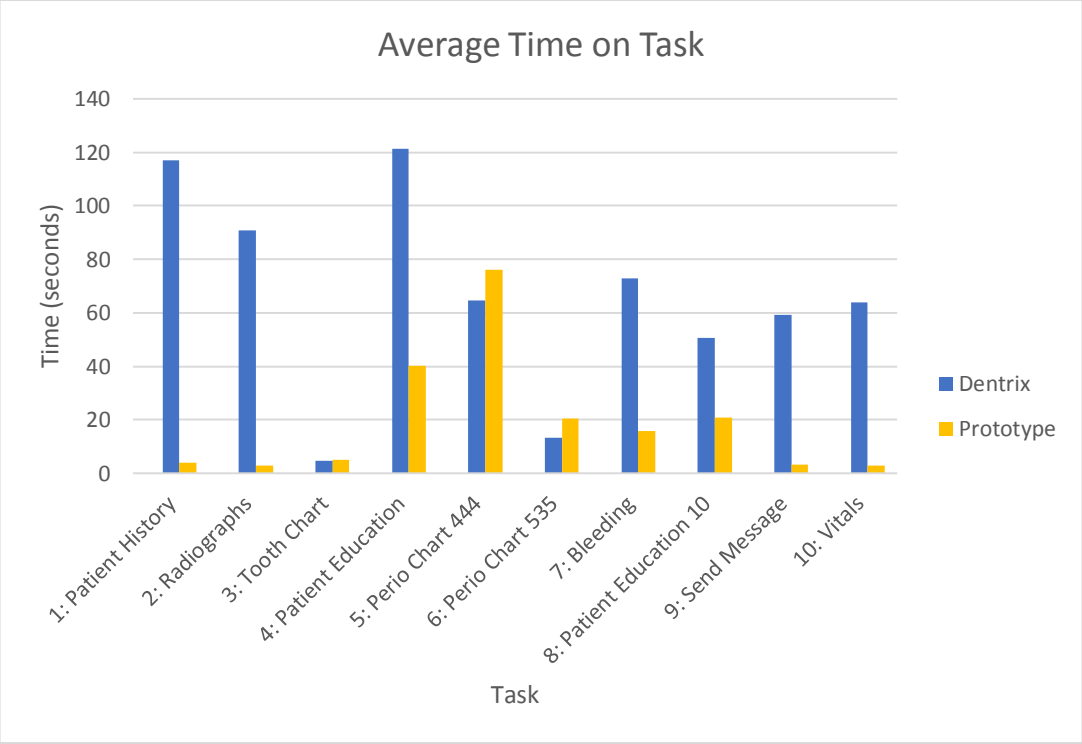


Figure 24. Average Time to Completes Tasks on the Prototype and Dentrix

Notably, task 5 – entering probe depths into the periodontal soft tissue chart for the first time – took the most time to complete on the prototype, averaging 75.93 seconds. This could be attributed to the fact that the dental hygienists were used to inputting data in the EDR using a mouse and/or keyboard, and the prototype was a touchscreen, requiring the use of a finger or pen-stylus. However, upon looking at task 6, which was to update numbers on the periodontal soft tissue chart, the average time to complete the task was much faster than the previous task, which can both be seen in **Figure 24**. This proves that, as with all new systems, there exists a learning curve, and the dental hygienists were faster at inputting the data once they learned how to do it. Moreover, most tasks were completed faster on the prototype than on Dentrix. In a real patient setting, completing data review, retrieval, and entering inputs in a faster, more efficient manner, allows more time to be spent on educating the patient on oral and systemic conditions.

The 10 tasks that were used during the usability testing sessions were developed based on common practices that the dental hygienists use, and they were developed with Neilson's five basic components of usability[48] in mind (learnability, efficiency, memorability, errors, and satisfaction), as seen in **Table 11**. The time to complete the data entry tasks (5 and 6) showed the rate of learnability, efficiency, and error by having a faster completion time on both: Dentrix (64.78 and 13.1 seconds, respectively) and the prototype (75.93 and 20.52, respectively). Moreover, task 4 (finding patient education) had the dental hygienists learn to locate something within both Dentrix and the prototype, while task 8 (reviewing patient education) was a recall task to test the learnability and memorability of this feature. On both systems, task 8 (reviewing patient education) was completed faster than task 4 (finding patient education), as seen in **Tables 8** and **10**.

Table 11. Tasks and Neilson's Five Components of Usability[48]

	Task:	**Usability Element Tested**
Task 1	Click on where in the system you would look to view patient history	Learnability, efficiency, memorability
Task 2	Click on the radiographs	Learnability, efficiency
Task 3	Find out how to access the hard tissue chart and click on it	Learnability, efficiency
Task 4	Click on the patient education component of the system	Learnability, efficiency
Task 5	On the periodontal chart, record pocket depths for tooth 10 on the facial side as 444	Learnability, efficiency
Task 6	Change the recorded pocket depths of the facial side of tooth 10 to 535	Learnability, efficiency, error
Task 7	On the periodontal chart, record tooth 18 as having bleeding	Learnability, efficiency
Task 8	Review the patient's education regarding tooth 10	Learnability, efficiency
Task 9	Click on where you would go to send a message to a patient or colleague	Learnability, efficiency, memorability
Task 10	Click on where you would view vitals	Learnability, efficiency

While completing tasks related to patient education (1 and 4) on the prototype, all four dental hygienists commented with positive remarks on the patient education feature. The patient education feature gives a graphical representation of probed pocket depth from a previous dental visit compared to the current dental visit, as seen in **Figure 20**. Task 4, finding the patient education feature, took more time to locate on average in Dentrix than it did in the prototype as seen in **Figure 25**. However, this task took the second-most amount of time to complete on the prototype, as shown in **Figure 26**. This can be attributed to the fact that 75% (3/4) of dental hygienists did not realize the tabs on the prototype scrolled, and that there were more tabs "hidden" that were not shown on the screen. Once the dental hygienists learned there were more tabs, the time to complete tasks on "hidden" tabs, like patient education, as shown in **Figure 24**, was drastically reduced.

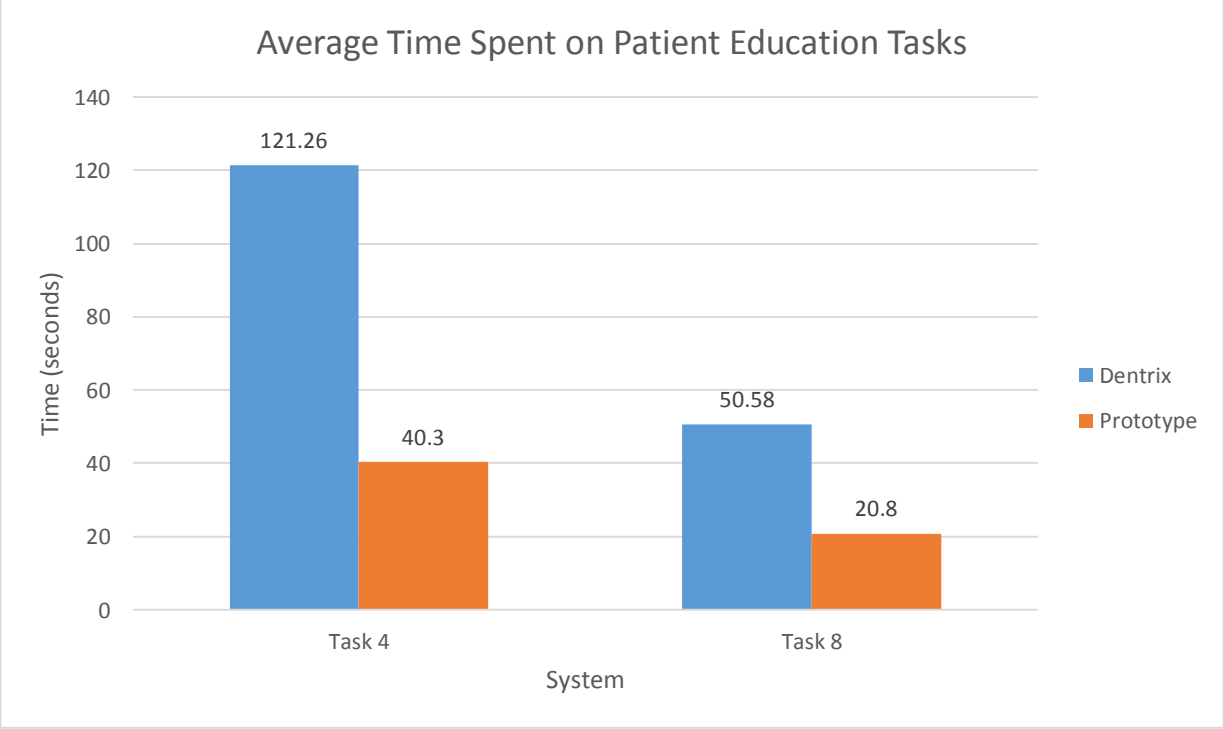


Figure 25. Average Time Spent on Patient Education Task (4 and 8) on Dentrix and the Prototype

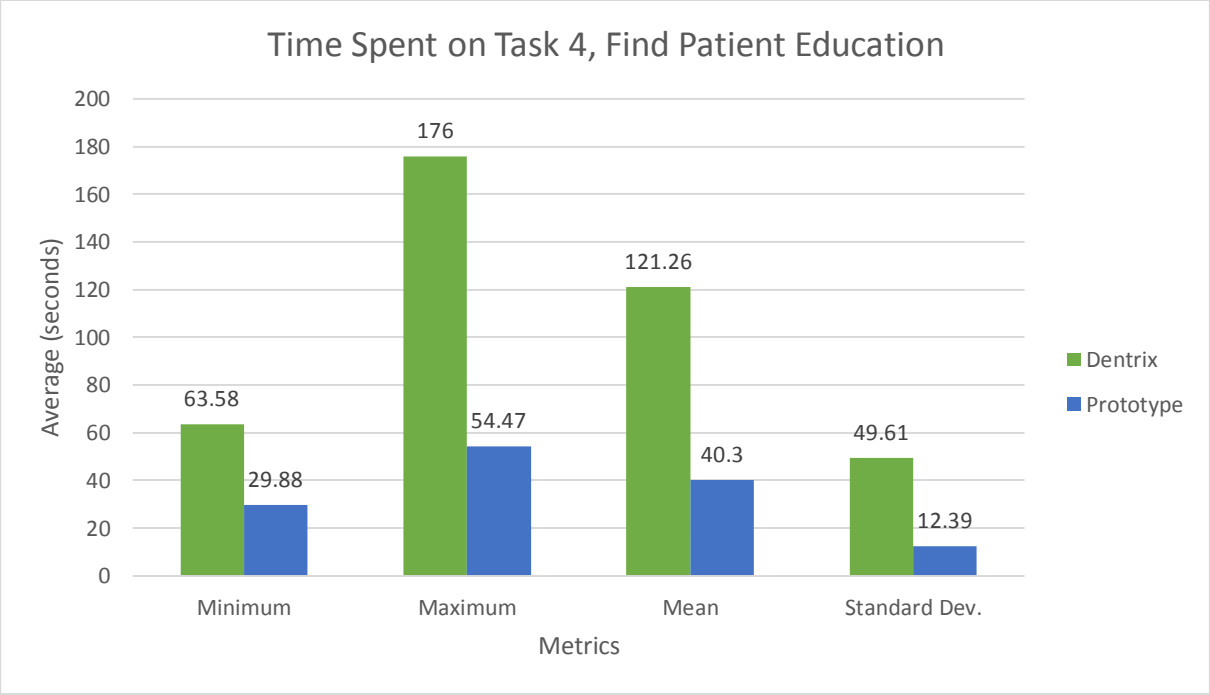


Figure 26. Comparison of Dentrix and the Prototype on Task 4: Find Patient Education

Task completion rate was higher on the prototype than on Dentrix. Seven-and-a-half percent (3/40) of tasks were not completed even with assistance from the moderator on Dentrix. This differed from the prototype, as all tasks on the prototype were completed either successfully, 92.5% (37/40) or successfully with assistance, 7.5% (3/40). This reinforces the exit interview comments that claimed the prototype was easy to use and that Dentrix's layout was difficult to maneuver.

Future Directions

Further revisions should be made to the prototype during the future iterative development process. For example, upon review by the dentist, surfaces of the gums within the periodontal soft tissue chart that had bleeding did not show up in red colored font. Dentists review periodontal soft tissue charts very quickly while seeing patients. Therefore, bleeding surfaces need to "pop out," thus, red colored font should be used.

Additionally, the dental hygienists are used to using a mouse and/or keyboard to enter information. It would be useful to create the prototype for a laptop or desktop computer so that a mouse and/or keyboard could be used (unless one is purchased separately and tested for the iPad). The use of the iPad 2 for the prototype brings about a new aspect of infectious control. While a dental hygienist's hands are in a person's mouth alongside bacteria, using the hands to input data afterward on a touchscreen device is not sanitary. Therefore, different protocols for cleaning the device between patients would need to be implemented.

This prototype features a recommended interface for a periodontal soft tissue chart to be used by dental hygienists. It is not a completely functioning system on its own, and it does not store data. EDR developers should use this layout in implementing new versions of EDRs in order to help them meet the dental hygienists' wants and needs. The current approach of using Numbers for Mac for the prototype could eventually be made into a fully functioning system if all necessary pieces were created, as well as a backend database.

Limitations

Although the dental hygienist is a part of the dental care team, they are not the only member of the team that uses the EDR to input data. All roles of the dental care team should provide input into the design and development of future EDRs, but this study only focused on the dental hygienists. Furthermore, well over 40 hours were spent working directly with the 10 dental hygienists throughout this study. The number of participants would need to be greater to generalize the results for the entire dental hygienist population. Moreover, the prototype was not a fully functioning interface as is Dentrix. The prototype had limitations on functionality, as well as limited backend data storage. However, this study does provide a starting point for future development of EDR systems, specifically periodontal soft tissue charts, to be used by dental hygienists, and conducts a complete wants and needs analysis for practicing dental hygienists.

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APPENDICES

APPENDIX A:

Recruitment and Focus Group Testing Documents

Research Study Information Sheet for Dental Hygienists
Dental Hygienists' Information Needs Assessment in Periodontal Soft Tissue Charting

PI: Timothy Patrick, PhD, University of Wisconsin- Milwaukee

SPI: Kelsey Schwei, MS

Study Objective

The objective of this study is to assess the information needs of dental hygienists. The objective of the study will be achieved by four different methodologies: a) direct observation (shadowing), b) cognitive task analysis (CTA), c) focus groups, and d) usability testing.

Significance

The data we collect will be able to be generalized to all dental hygienists and periodontal soft tissue charts. Our results will be used to improve the design and functionality of future versions of periodontal soft tissue charts to make them more effective for the end users of the system (participants).

Research Design and Methods

Participants will need to participate in portions a, b, and c of the study. Part d of the study will only involve a smaller number of participants and not all participants are required to participate.

a) Direct observation (shadowing) of the dental hygienists' workflow to understand and assess clinical activities like soft tissue and patient charting in context to patient examination, treatment planning, and patient communication. Observation sessions will be focused on dental hygienists while they interact with the patients in the dental centers. Dental centers using paper-based and computer-based health records will be considered for the observation sessions. The data collected will be ethnographic in nature and the researchers will only take notes regarding the workflow/activities of the dental hygienist. The study will not collect any patient identifiers or

health information either in the paper-based or computer-based health records. These sessions will last for a maximum of 1 hour and be the first data collection method.

b) A CTA will be conducted to identify the dental hygienists' cognitive process (concepts, goals, contextual cues, and strategies) that aid in the clinical activities such as data entry and retrieval during patient examination, diagnosis, treatment planning, patient education and communication, all while examining a fictitious patient.

Fictitious patient data will be presented one at a time to the hygienists in random order to prevent sequential bias. Additional information regarding the patient will only be given if the hygienist specifically asks for it. The hygienists will be asked to verbalize the situation with the patient, what information they desire about the patient, and what they are thinking while examining the patient and entering information.

Each CTA session will take approximately 30 minutes and will take place following the focus group. During the CTA sessions, the dental hygienists will be asked to use a think aloud protocol as to how they would go about examining a patient that presents with symptoms based off of the fictitious patient data that is provided and observations will be noted.

c) Focus groups will be conducted with dental hygienists to understand the information needs, workflow, challenges, and regarding periodontal soft tissue chart prototype. These sessions will last for maximum of 1 hour, following the observational sessions and will have all participating dental hygienists from the specific dental center present.

d) Usability testing session will be conducted to compare a prototype periodontal soft tissue chart with an existing commercial periodontal soft tissue chart. These sessions will last a maximum of 1 hour and will be the last data collected method. Participants will be asked to complete a series of task on a prototype periodontal soft tissue chart, as well as complete the same tasks on an existing periodontal soft tissue chart. Participants will be asked questions relating to opinions and give feedback. This part will not be done by all participants.

Dental hygienists will be recruited for the purposes of a) observational sessions, b) CTA sessions in this study, c) focus groups, and d) usability testing.

Potential Benefits to Subjects

Results inform new periodontal soft tissue chart design considerations. All the data collected will eventually be used to improve the design of a periodontal soft tissue chart and also provide recommendation for general Electronic Dental Record system design. The results of the study will be published in journals and will be made available to the participants.

Costs for Participation

There is no financial obligation to participate in this study.

Payment for Participation
No incentives will be given.

Confidentiality

The results of this study may be presented at scientific meetings or in scientific publications; however, your identity will not be disclosed.

Consent

Verbal consent will be obtained from the participants prior to completing the data collection. Participants are able to terminate their involvement in the study at any time and without any reason. All of the previously collected data form the participants will be destroyed immediately upon participant withdrawal.

Potential Risks and Discomforts

There is minimal risk in participating in this study. a) In any observational study, there is a hypothetical risk of the observer seeing an inappropriate action by a staff. There is a small risk of patients being embarrassed by the presence of the observer. It is also possible for the observer to simply "get in the way" of normal activities. Risks to study participants are minimal as the study is non-invasive, will not disclose identifying information on individual participants, and does not include sensitive information. All participation is voluntary.

Study Contacts

For more information about this research or you may contact:
Kelsey Schwei, SPI
schult46@uwm.edu

Melissa Spadanuda, IRB Manager
414-229-3173

Moderator Script

Focus Group: Location_____ Date:_____ # of Hygienists:_____

Hello, thank you for agreeing to participate in my study. I am Kelsey Schwei and I am a PhD student in biomedical and healthcare informatics from the University of Wisconsin- Milwaukee. This portion of the study is the focus group. I will be reading off of a scrip today to ensure that all information that I tell participants is the same. As a reminder, your participation is voluntary and you can stop at any time. Please let me know if you are uncomfortable or if you need anything during the course of the study.

I am working on my dissertation project that involves defining the needs of dental hygienists while working with an electronic periodontal soft tissue chart. The goal for today is to help me gain a better understanding of your current process and to hear any recommendations that you may have regarding periodontal soft tissue charting. Is it alright if I audio record the session so that I can fill in the gaps in my notes later?

Do you have any questions before we begin?

I'm going to ask you a series of several questions. Feel free to be as honest as possible when answering.

- Do you currently use paper or digital soft tissue charting? Do you use both?
    - What specifically is paper still used for?
    - What specifically is electronic?
    - If paper charting is used, have you ever used digital charting previously?
    - If digital charting is used, have you ever used paper charting previously?
    - What system is used?

    - What other systems have you used?

- Did you use electronic charting during your schooling?

- What point during the appointment do you enter information into the soft tissue chart?

- How do you do data entry?
    - Does someone help you with data entry or do you do it on your own?
    - If done on your own, how do you do it while examining the patient?

- What is the process that you take when a patient enters your operatory?
    - Do you have a routine of steps that you follow for each patient?
        - If yes, why is this your routine?
    - If yes, is this routine standard throughout your dental clinic?

- What would be your ideal layout for your soft tissue chart?
    - Would you like to have a link to radiographs from within the periodontal soft tissue chart?
    - Would you like to have an educational component to the periodontal soft tissue chart?
    - Other needs?

- Is there anything on your current soft tissue chart that you feel is missing?
- Any other comments for me?

The next steps: I will work with your manager to schedule a 30-minute individual session with each of you to do the cognitive task analysis. This session will involve me giving you some fictitious patient data and then thinking aloud, so that I can hear your thought process. I will then be creating a prototype periodontal soft tissue chart based on the results of the results from my observations, focus groups and the cognitive task analysis sessions. The final phase of my study is comparing my prototype with an existing commercial system. Would any of you be willing to participate in a usability evaluation comparing my prototype with Dentrix?

Name: _____ Contact:_____

Name: _____ Contact:_____

Thank you all very much for participating!

APPENDIX B:

Ethnographic Observation Testing Documents

Observation: Location_____ Date:_____ Hygienists #_____

1. **What type of soft tissue chart is being used?**
   Electronic Paper

1. **Which EDR? _____**

2. **Is there an assistant to the hygienist in the room?**
   Yes No

3. **Is probing done?**
   Yes No

4. **How many probe depths do the hygienists record at a time?**
   1 2 3 4 5 6 quadrants other_____

5. **What order is the following information recorded?**
   a. MGJ_____
   b. Gingival Margin_____
   c. Furcation Grade_____
   d. Mobility_____
   e. Other_____

6. **Is bleeding noted?**
   Yes No

   a. At what point is bleeding noted?
   After bleeding is seen on each tooth After all other teeth are looked at

7. **Do they use the quadrant system or go through all the teeth in the arch?**
   Yes No

8. **Which quadrant do they start probing in?**
   First Second Third Fourth

9. Which arch do they start with?
Bottom Top

10. How do they move through the mouth?
Distal to proximal (#1-8) Proximal to distal (#8-1)

11. When is periodontal type determined?
Before probing During probing Conclusion of probing Never done

12. Is patient education given?
Yes No

13. Is the periodontal chart used as a teaching tool for the patient?
Yes No

14. How is data entered?
Voice Keyboard Mouse By assistant

15. Is plaque presence recorded before or after probing?
Before After

16. Is bone loss based on what they see before or after probing?
Before After

17. When are notes recorded?
At the end of the appointment Throughout the appointment

18. What surface is probing started on?
Facial Lingual

19. Is the tooth chart ever consulted when recording soft tissue data?
Yes No

20. Is the medical history ever consulted when recording data soft tissue data?
Yes No

21. Are visual aids (radiographs etc.) consulted when recording soft tissue data?
Yes No

22. Is there "flopping" between programs?
Yes No

23. Are previous periodontal health records used to start from

Yes No

Notes:_____

_____

_____

APPENDIX C:

Cognitive Task Analysis Testing Documents

Moderator Script

Hello, _____. Thank you for letting me come in today and for participating in my study.

I will remind you that your participation is voluntary and you can stop at any time for any reason or no reason at all. Let me know if you are feeling uncomfortable or if you need anything during the course of the study.

The goal for today is to gain an understanding of your thought process as you evaluate a patient. Specifically, I want to learn the manner and workflow in which you chart a patient's soft tissue data during a patient exam. This will hopefully provide insight into the design of an efficient periodontal charting interface.

- During the study, I will present you with three fictitious patient profiles (individually). I will not speak unless there is a problem or study methods question; I will only hand you data cards. Additional information will be given only when asked for by you.
- I will also ask you to "think aloud" while you are completing the tasks today. Just say what is at the top of your mind, where you would go to look for something, things that are confusing you, and things you like or don't like. Thinking aloud comes more naturally to some than others, so I might remind you to tell me what you are thinking about.
- Be assured I am not evaluating your knowledge of dentistry. I am trying to deduce your thought process and needs.
- I will be here throughout the study to answer any questions that you may have.

Here is how the session is going to work.

- I have a series of three fictitious patient profiles for you to review.
- First, you will be handed a card describing the patient's chief complaint and demographics. Please read the card aloud and then think aloud as you interpret this information.
- If you encounter a problem or have a question, I will do my best to provide you with an answer. Otherwise, I will not speak and only hand you the cards when you request them.

- I will be taking notes on the thoughts that you dictate to me.

Before we begin, let's practice thinking aloud. So I'm going to pretend to pick out what I am going to wear to work today. I'm standing in my closet looking at my clothes that are hanging up. I decided to wear by black dress pants because I wore my brown ones yesterday and I decide to wear a thicker sweater because it is supposed to be cold tomorrow. Now I want you to try, only instead of picking out clothes, I'd like you to think aloud to me while you count the number of windows in your home.

Do you have any questions or need anything before we begin?

- Ok let's begin with our first patient. Here is the patient's chief complaint and demographics. Please think aloud and describe to me how you would process this patient.
    - (Give them additional cards when/if they ask for them).
- Now let's move on to our second patient. Here is the patient's chief complaint and demographics. Please think aloud and describe to me how you would process this patient.
    - (Give them additional cards when/if they ask for them).
- Now we will conclude with our last patient. Here is the patient's chief complaint. Please think aloud and describe to me how you would process this patient.
    - (Give them additional cards when/if they ask for them).

Thank you for your time today. I really appreciate it. Thank you again for participating in my study.

APPENDIX D:

Usability Testing Documents

Moderator Script

Moderator Script:

Introduction:

Thank you for agreeing to participate today. I will be reading off of a moderator script to ensure that all information that I tell to participants is the same. Have you ever participated in a usability evaluation before? Today I am going to ask you to look at the user interface of Dentrix/prototype electronic dental record (EDR). We want to find out what you think about the design and functionality of the system.

Verbal Consent:

Being in this study is voluntary and confidential. Please do not discuss this study with anybody outside of this testing room. I will be nearby while you complete the user tasks o if you need assistance or wish to stop at any time, please just let me know. I will be recording the screen on the computer for later analysis. Do you have any questions before we begin?

Application Introduction:

As I mentioned, you will be looking at the user interface of Dentrix/prototype EDR. Some of the areas may not be intuitive to you to get the task done in the most efficient and effective manner. If you run into any difficulty, I will help guide you if necessary.

Evaluation Introduction:

The purpose of today's evaluation is to collect information about how easy or hard the software is to use. I will present you will specific tasks to completed. Once you think you have completed a task, please tell me that you are "done." I would like you to use a think aloud protocol while you are working to complete the tasks. Specifically, I'd like you to tell me why you are making specific selections, when you run across things that you don't understand, or about thinks you like or dislike. When you are reading information on the screen, I'd also like you to read that out loud. That will help me to understand where you are looking and what you are doing. I may remind you to think aloud if you become quiet for more than 15 seconds. It is important for you to understand that this is not an evaluation of you or your computer skills, but rather an evaluation of the product. We want to gather information about how people like you really might use the software so we can make good decisions about its design. If something on the site doesn't work for you, chances are someone else will have similar problems too.

Tasks:

As I mentioned, you will be asked to complete some tasks on Dentrix/prototype. Please read the task aloud in its entirety before you start the task on the computer. Please do not rush; spend as much time as you would if you were do these same tasks on your wok. Do you have any questions before we begin?

Start Morea Recorder and Reflector 2

Net Promoter Score (NPS)

How likely is it that you would recommend Dentrix/prototype to a friend or Colleague?

0 = Not at all Likely 5- Neutral 10=Extremely Likely

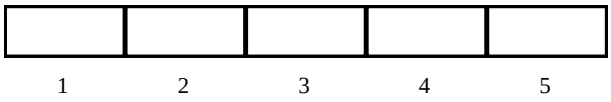
0 1 2 3 4 5 6 7 8 9 10

System Usability Scale (SUS) Survey

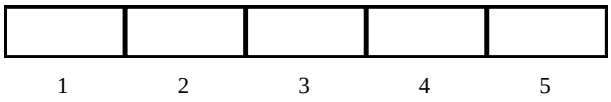
© Digital Equipment Corporation, 1986.

	Strongly disagree	Strongly agree

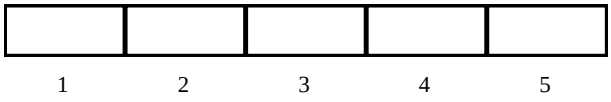
1. I think that I would like to use this system frequently



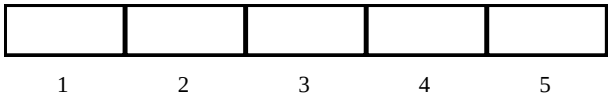
2. I found the system unnecessarily complex



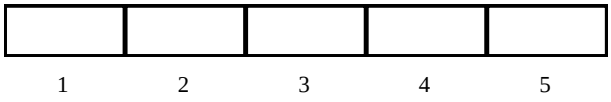
3. I thought the system was easy to use



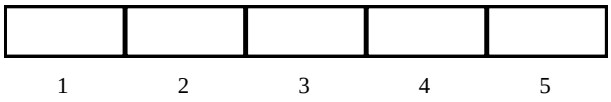
4. I think that I would need the support of a technical person to be able to use this system



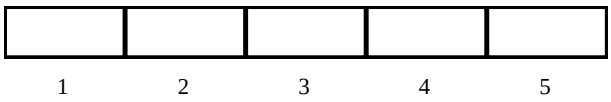
5. I found the various functions in this system were well integrate



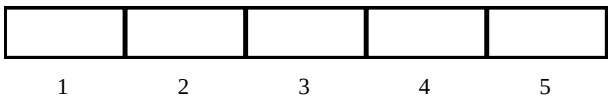
6. I thought there was too much inconsistency in this system



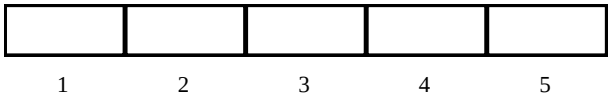
7. I would imagine that most people would learn to use this system very quickly



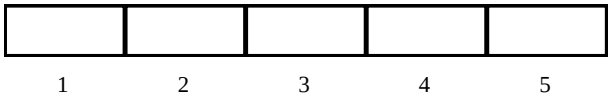
8. I found the system very cumbersome to use



9. I felt very confident using the system



10. I needed to learn a lot of things before I could get going with this system



Desirability Exercise

Please select at least 5 words from the list below that describe your feelings and emotions towards Dentrix/prototype.

Accessible	Creative	Fast	Meaningful	Slow
Advanced	Customizable	Flexible	Motivating	Sophisticated
Annoying	Cutting edge	Fragile	Not Secure	Stable
Appealing	Dated	Fresh	Not Valuable	Sterile
Approachable	Desirable	Friendly	Novel	Stimulating
Attractive	Difficult	Frustrating	Old	Straight Forward
Boring	Disconnected	Fun	Optimistic	Stressful
Business-like	Disruptive	Gets in the way	Ordinary	Time-consuming
Busy	Distracting	Hard to Use	Organized	Time-Saving
Calm	Dull	Helpful	Overbearing	Too Technical
Clean	Easy to use	High quality	Overwhelming	Trustworthy
Clear	Effective	Impersonal	Patronizing	Unapproachable
Collaborative	Efficient	Impressive	Personal	Unattractive
Comfortable	Effortless	Incomprehensible	Poor quality	Uncontrollable
Compatible	Empowering	Inconsistent	Powerful	Unconventional
Compelling	Energetic	Ineffective	Predictable	Understandable
Complex	Engaging	Innovative	Professional	Undesirable
Comprehensive	Entertaining	Inspiring	Relevant	Unpredictable
Confident	Enthusiastic	Integrated	Reliable	Unrefined
Confusing	Essential	Intimidating	Responsive	Usable
Connected	Exceptional	Intuitive	Rigid	Useful
Consistent	Exciting	Inviting	Satisfying	Valuable

Controllable	Expected	Irrelevant	Secure	
Convenient	Familiar	Low Maintenance	Simplistic	

CURRICULUM VITAE

Kelsey M. (Schultz) Schwei

Place of birth: Neenah, WI

Education:

B.S., Texas A & M University, May 2010
Major: Health Sciences, Allied Health

M.S., University of Wisconsin – Milwaukee, May 2012
Major: Healthcare Informatics

Dissertation Title: Dental Hygienists' Cognitive Process in Periodontal Soft Tissue Charting

Awards

National Legion Scholarship, 2006-2007;

Hartford Athletic Training Scholarship, 2006-2007;

Chancellor's Graduate Student Award Medical Informatics, 2012-2013;

College of Engineering and Applied Sciences Dean Scholarship, 2013-2014;

Chancellor's Graduate Student Award HealthCare Informatics, 2014-2015;

Biomedical Health Informatics Research Graduate Award, 2014-2015;

Experience

2012 to present Research Specialist, MS – Informatics, Institute for Oral and Systemic Health, Marshfield Clinic Research Foundation, Marshfield, Wisconsin

2014 to present Lecturer, College of Health Sciences, University of Wisconsin – Milwaukee, Milwaukee, Wisconsin

2011 to 2012 Dental Informatics Research Assistant, Biomedical Informatics Research Center, Marshfield Clinic Research Foundation, Marshfield, Wisconsin

2011 Biomedical Informatics Intern, Biomedical Informatics Research Center, Marshfield Clinic Research Foundation, Marshfield, Wisconsin

Professional Activities

Member, Dental Informatics Online Committee, 2012- present;

Member, American Medical Informatics Association (AMIA), 2012 –Present.

Professional Committees

Work Group Member, American Medical Informatics Association's Dental Informatics (AMIA), 2012-Present;

Planning committee member, Regional Oral & Systemic Health Conference, 2012;

Planning committee member, Oral & Systemic Health Conference, 2013;

Reviewer, American Dental Education Association, 2013;

Reviewer, American Medical Informatics Association, 2014, 2015.

Co-Chair Elect, American Medical Informatics Association (AMIA) Dental Informatics Work Group (DI-WG), January 2014- December 2014;

Co-Chair, American Medical Informatics Association (AMIA) Dental Informatics Work Group (DI-WG), January 2015 – Present.

Mentoring

Mentor, Lauren Janes, Marshfield Clinic Research Foundation Summer Internship, May 2012 – August 2012;

Mentor, Adam Sorenson, Marshfield Clinic Research Foundation Summer Internship, May 2013 – August 2013;

Mentor, Nicolette Klucas, Wisconsin's Statewide Area Health Education Center (AHEC) Community Health Internship Program (CHIP); May 2013 – August 2013;

Mentor, Kaitlyn Skrzypcak, Wisconsin's Statewide Area Health Education Center (AHEC) Community Health Internship Program (CHIP); June 2014 – August 2014;

Mentor, Macy Huettl, Wisconsin's Statewide Area Health Education Center (AHEC) Community Health Internship Program (CHIP); June 2014 – August 2014;

Mentor, David Kirkhoff, Marshfield Clinic Research Foundation Summer Internship, May 2014 – August 2014;

Mentor, Samantha Wong, Wisconsin's Statewide Area Health Education Center (AHEC) Community Health Internship Program (CHIP); June 2014 – August 2015.

Publications

Flynn P, Schwei K, VanWormer J, Skrzypcak K, Acharya A, "Assessing dental hygienists' communication techniques with low oral health literacy patients," Journal of Dental Hygiene, 2015.

Publications Pending Review

Chyou P, Schroeder D, Schwei K, Acharya A, "A simple, novel and cost-saving survey approach," Survey Methodology, 2015;

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Schwei K, Cooper R, Mahnke A, Ye H, Acharya A, "Workflow analysis of dental clinicians and support staff: a time and motion study," Applied Clinical Informatics, 2015.

Abstracts

Schultz K, Acharya A, "Marshfield Enhanced Charting and Code Acquisition (MECCA) Terminology for Dental Procedures", AMIA 2012 Annual Symposium Proceedings, Pg 1901;

Polzin L, Long E, Schultz K, Engler S, Moritz R, Chyou P, Acharya A, Understanding Medical Providers' Information Management Strategies; Accepted at American Medical Informatics Association, Illinois, November 2012;

Janes L, Schwei K, Kayastha J, Acharya A, "Development of Patient Friendly Education Modules Focusing on the Oral-Systemic Connection"; Accepted at Oral-Systemic Health Conference, Wisconsin, September 2012;

Gaasedelen J, Schultz K, Acharya A, "Data Model for Health Information Exchange"; Accepted at Healthcare Information and Management Systems Society, Louisiana, March 2013.

Janes L, Schultz K, Kayastha J, Acharya A, "Development of Patient Friendly Education Modules Focusing on the Oral-Systemic Connection", J Dent Educ. 2013; 77:185-243;

Schroeder D, Schwei K, Rottscheit C, Schneider C, Chyou PH, Acharya A, "Adoption of Health Information Technology among Dental Practices in the United States", AMIA 2013 Annual Symposium Proceedings, Pg 1248;

Schwei K, Shimpi N, Bartkowiak B, Ye H, Glurich I, Acharya A, "Clinical Decision Support Use in Dentistry: A Review of the Literature", AMIA 2013 Annual Symposium Proceedings, Pg 1260;

Sorenson A, Schwei K, Mahnke A, Acharya A, "Usability Evaluation of a Novel Touch-Based Dental Too Charting Application"; Accepted at Human Factors and Ergonomics Society, Illinois, March 2014;

Klucas N, Schwei K, Reul J, Stensberg T, Acharya A, "Development and Evaluation of a Diabetes-Periodontal Disease Educational Video Module", J Dent Educ. 2014; 78:263-314;

Schwei K, Shimpi N, Bartkowiak B, Ye Z, Glurich I, Acharya A, "A Review of Clinical Decision Support Products in Dentistry", AMIA 2014 Annual Symposium Proceedings, Pg 1577;

Acharya A, Glurich I, Schwei K, Shimpi N, Jansen M O'Brian J, Kleutsch T, Penniman E, Nycz G, Developing Medical-Dental Integrated Care Models (ICM) to Manage Diabetes, Wisconsin Research and Education Network (WREN) 2015 Convocation on Developing a Road Map for Optimum Patient-Centered Chronic Condition Management, Oshkosh, Wisconsin, October 14-16, 2015.

Presentations

Schwei K, "Marshfield Clinic Informatics Opportunities"; Invited talk at the University of Wisconsin, Milwaukee, Wisconsin, May 2013;

Schwei K, "Dental Informatics Research and Education Program at Marshfield Clinic"; Invited talk at University of Wisconsin, Madison, Wisconsin, March 2012;

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Gaasedelen J, Schultz K, Acharya A, "A Data Model for Health Information Exchange", HIMSS 2013 Annual Conference and Exhibition, New Orleans, Louisiana, March 5, 2013;

Janes J, Schultz K, Kayastha J, Acharya A, "Development of Patient Friendly Education Modules Focusing on the Oral-Systemic Connection", ADEA 2013 Annual Session and Exhibition, Seattle, Washington, March 20 - March 23, 2013;

Schroeder D, Schwei K, Rottscheit C, Schneider C, Chyou PH, Acharya A, "Adoption of Health Information Technology among Dental Practices in the United States", AMIA 2013 Annual Symposium, Washington, D.C., November 16 -20, 2013;

Schwei K, Shimpi N, Bartkowiak B, Ye H, Glurich I, Acharya A, "Clinical Decision Support Use in Dentistry: A Review of the Literature", AMIA 2013 Annual Symposium, Washington, D.C., November 16 -20, 2013;

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