AHRQ Final Report

1. TITLE PAGE

Project Title:	Decision Support to Improve Dental Care for Medically Compromised Patients
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2. STRUCTURED ABSTRACT (250 word maximum)

Purpose. eDental Guides is a clinical decision support (CDS) system that integrates dental and medical records with clinical guidelines to improve the quality and safety of dental care for medically complex patients. The purpose of this study was to evaluate the efficacy of different strategies within the CDS to alert providers at the point of care to improve care for patients with medically complex conditions.

Scope. The 3 different alerts for provider activation included; 1) active pop-up alert in front of electronic dental record(EDR), 2) passive alert in schedule, or 3) flashing alert in the EDR as a control.

*Methods.*15 dental clinics from HealthPartners with 252 dental providers were randomized to one of the three CDS arms to evaluate the impact of different alerts on dental provider's use of CDS, the specific patient's medical history summary, and personalized recommendations to minimize complications. The 3 alerts were compared for utilization overall, medical summary usage, care recommendation usage, and guideline access.

Results. Over the 12 months of the study, there was an increased utilization of eDental guides regardless of the alert. Overall the pop-up alert triggered the most use of the CDS at 44% of providers, while the schedule and EDR alert triggered 25% and 22% of providers respectively. However, the schedule alert was the most preferred by dental providers due to less intrusiveness. The medical summary was used (43% of providers) more than the personalized action plan (2% of providers) or the general guidelines part of the webpage (<1% of providers).

Key Words. Informatics; information dissemination; electronic dental records; electronic medical records; medical conditions; medical history; complications, clinical decision support; randomized controlled trials; practice guidelines; quality of care.

3. PURPOSE (Objectives of the study)

Congruent with AHRQ PAR-08-270 Utilizing Health Information Technology to Improve Health Care Quality (R18), the *overall goal of this study* was to use health information technology (HIT) to improve the quality and safety of dental care for medically compromised patients. Conditions such as diabetes, heart disease, and pulmonary disease impact the quality and safety of dental care.[1-13] Improving care for these patients depends upon two key factors: identification and action. Providers must be aware of their patients' condition(s) and understand how to alter care. Clinical guidelines have been developed, but often fail to change practice.[14-16] Clinical decision support (CDS) embedded within electronic dental records (EDRs) and electronic medical records (EMRs) offers a power alternative method of informing and activating providers and change clinical protocols for patients with medical conditions and provide personalized evidence based recommendations. [17-23]

We had completed prior research as supported by AHRQ RFA-HS-07-006: Ambulatory Safety and Quality Program (R18 HS017270) to set up this study. [24] This randomized clinical trial (RCT), set in HealthPartners (HP), a large multi-specialty setting with both dental and medical clinics explored the efficacy of such an innovative CDS strategy toward improving dental care for medically compromised patients including diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease, and xerostomia (dry mouth). It was one of the first studies to integrate EDR and EMR data and enrolled 109 dental providers and 7500 patients across 17 dental clinics over a 3-year period. The results demonstrated the use of an EDR-embedded CDS, e-Dental Guides, increased the use of personalized clinical guidelines by 440% and significantly improved point-of-care procedures compared to a control group. However, despite this success, the study also revealed two key shortcomings. First, the CDS system was passive and only triggered a response by, at most, 20% of all dental providers. Second, eDental Guides was reliant upon the integrated database of this closed HP medical group and was not easily transferable to community dental clinics. Thus, there remains a critical need to identify what additional CDS components will increase the level of dental provider activation and design CDS that is generalizable and scalable to all dentists. Until these needs are met, the use of CDS toward improved chronic disease management in all dental practices will remain a theoretic possibility lacking broader application.

Thus, the purpose of the current study was to address these issues with 2 novel solutions: 1) evaluate new methods of provider activation and 2) create a format and technology for the database that allows integration of the eDental Guides CDS within the health information exchange efforts**.** This would eventually allow immediate access to medical information from any community sources and facilitate use of health information exchange by community dentists. This study determined what CDS components best increased provider activation using a 3-arm, 2-year prospective, group-randomized clinical trial. The 3 different alerts for provider activation included; 1) active pop-up alert in front of electronic dental record (EDR), 2) passive alert in schedule, or 3) control group with a flashing EDR alert.

The following specific aims were achieved:

Aim 1 - Determine the impact that the 3 alerts strategies have on increasing the use of and adherence to evidence based guidelines. *Our primary working hypothesis* was that Active and Passive Alert mechanisms would be associated with *significantly more frequent* review of and adherence to evidence-based guidelines.

Aim 2 - Determine the impact of the 3 alerts strategies upon improve dental care utilization and reducing emergency visits due to adverse events. Our *working hypothesis* was that the Active and Passive Alerts would improve hygiene visits and reduce the frequency of dental-related adverse events and emergency care utilization.

Aim 3 - Develop strategies to integrate the e-Dental Guides CDS within community-based health information exchange (HIE) formats to allow use by community dentists. Our *working hypothesis* is that the community HIE systems would be able to provide accurate and timely information to the eDental Guides CDS regarding identified patient chronic conditions.

HealthPartners Institute for Education and Research was an ideal environment to address both issues simultaneously and generalize the use of the CDS to all community dental providers. HP dentists belong to the NIH-NIDCR funded Dental Practice Based Research Network (U01 DE016747). Our study team has proven experience employing CDS systems in dental and medical settings and working with health information exchange efforts within a diverse population of people in Minnesota employing National Health Information Network (NHIN) standards.[25-26]

4. SCOPE (Background, Context, Settings, Participants, Incidence, Prevalence)
Chronic illnesses such as heart disease, diabetes, cancer, and lung disease comprise most illnesses that present to physicians as well as dentists; and as the population ages, the prevalence of these conditions is increasing. Patients with these chronic medical conditions have significant dental care implications that include not only the increased risk of dental problems such as periodontal disease and caries but also the possibility of medical complications that arise during or after treatment. Baum (2007) recently reviewed the importance of dentists' understanding of medical conditions and the problems associated with the current lack of training in medicine in dental schools.[6] He states that dentists' training is lacking in the understanding of "enough medicine to treat their patients who have chronic illnesses, a population that continues to increase in size." Only five of the current dental schools spend more the 1% of their instructional time on general medical emergencies, and little time in these curricula is focused on how to manage medically compromised patients.[6] This has led to problems for dentists in identifying medical problems during routine dental care as well as modifying their dental care to take these conditions into account.

Both the *1995 Institute of Medicine Report on Dentistry* and the *U.S. Surgeon General's 2000 Report on Oral Health in America* call for more links between dentistry and medicine and the need to better train dentists on special considerations in managing patients with medical conditions.[1-2] The 1995 report concludes that "dental practitioners will use more medical knowledge in the future and will need to work more closely with other health professionals. Meeting the needs of an aging population with more complex health problems will require that dental professionals have more comprehensive medical knowledge…and that the dental profession will and should become more closely integrated with medicine and the health care system on all levels: education, research, and patient care."[1-2,28] They also highlight the important interactions between oral disease, particularly periodontal disease and oral infections, with diseases such as coronary heart disease, bacterial pneumonia, diabetes, and stroke.

Clinicians and organizations who want to improve the quality of care and reduce health care costs rely on evidence-based clinical practice guidelines to reduce variation in practice patterns and the gap between evidence and practice to improve patient outcomes and costs. Studies have found that review of medical conditions in the dental record is associated with more frequent dental exams and changes in the dentist's care for these patients. For example, in a study comparing diabetes patients with controls on self-perceived oral health and oral self-care, Sandberg et al[11] observed that 85.1% of diabetic patients had regular dental visits, while 95.1% ($p<.05$) of the controls had regular visits. When asked, only 47.7% of the diabetes patients felt that their dentist was aware of their diabetes. In an investigation of caries among diabetes patients by Rush et al at HealthPartners, with at least one exam, the mean number of exams for the patients identified with diabetes in the dental record was 2.1, while for the unidentified diabetes patients, the mean number of exams was 1.3 ($p<0.0001$).[9] Among these patients, only 49.2% had the presence of diabetes recorded in their dental record. Thus, identification of diabetes in the dental record is associated with more frequent dental exams and related considerations in their dental care.

Practice guidelines can be both the engine and the vehicle for improving health care.[13-16] However, distributing and promoting clinical practice guidelines alone does not ensure a change in clinical practice.[10] A review of 59 published evaluations of clinical guidelines in medicine concluded that guidelines could improve clinical practice, but the use of the guidelines and the size of the improvements in performance varied considerably.[11] Bero and colleagues examined

systematic reviews of strategies for the dissemination and implementation of research findings to identify evidence of the effectiveness of different strategies and to assess the quality of the systematic reviews.[16] The reviews examined suggest that the **passive** dissemination of information (e.g., publication of consensus conferences in professional journals, the mailing of educational materials) is *generally ineffective or results in only small changes in practice.* These passive approaches represent the most common ones adopted by researchers, professional bodies, and health care organizations. Thus, the use of **active** strategies to implement research- based recommendations is necessary to change practice, and the more intensive efforts to present clinical guidelines to alter practice are generally more successful.[16]

The Innovative Use of Health IT to Increase Use of Clinical Guidelines in Dental Care. Dentists are confronted with patients with chronic conditions and have significant challenges in assimilating the large body of scientific evidence into clinical knowledge to facilitate improvements in the quality and safety of patient care. A review of the published reports of the use of computer-based guidelines in medicine reveals that mixed success and strategies to increase efficacy have developed. In 1999, Shiffman et al, conducted a systematic review of the functionality and effectiveness of computer-based guideline-implementation systems.[22] Guideline adherence improved in 14 of 18 systems in which it was measured. Documentation improved in four of four studies. In another report, the investigators studied clinical guidelines embedded in an EMR that were previously determined to improve the quality while lowering the cost of care.[42] They implemented this same system in the emergency department for the care of young children with febrile illness, and the intervention markedly improved documentation but had little effect on the process of care or costs.[43] These results underscore the need for further research on implementation methods tailored to specific clinical problems. Feifer and Ornstein tested a multi-method intervention similar to that suggested in this proposal to help practices improve primary and secondary prevention of cardiovascular disease and stroke in a nationwide practice-based research network of small primary care practices that use the same EMR.[44] They reported a positive effect on outcomes and process of care from an intervention that included training with the use of tools in the EMR to improve use of guidelines.

Usable summaries readily available to the dentist are the basis for "evidence-based dentistry."[37-39] However, having access to the current best evidence is not sufficient to change behavior.[16] Strategies must also take into account the systems in which providers work and how both dentists and patients can be educated and activated toward change. The success of efforts in evidence-based dentistry depends on efficient transfer of information into easily interpreted and applied guidelines adapted into existing clinical systems in a user-friendly manner. *The evaluation of different CDS implementation strategies facilitating effective use of clinical guidelines is critical to understanding how to improve the quality and safety of dental care.*

Innovations in CDS in Dentistry. The emergence of EDRs in dental offices offers new opportunities for improving communication and access to information.[46-49] The integration of health information from EMRs to EDRs adds even more potential for improved HIE, enhanced communication, and quality and safety of care, particularly for patients with chronic illnesses. However, although medical informatics has accumulated a considerable body of research evaluating the use of the EMRs as a tool to improve the delivery of medical care, this is in sharp contrast to the lack of corresponding activities in dentistry. Thus, we believe this study is highly innovative because it develops and evaluates the use of CDS that integrates medical and dental information from both EDRs and EMRs and, thus, is of critical importance to dentistry, dental providers, and patients.

CDS tools including paper-based scoring systems, chart flags, and computerized programs, have been developed to facilitate the process of clinical decision making in many disciplines.[17-19] Such tools have been shown to improve prescribing practices, reduce medication errors, improve clinical practice, and enhance adherence to recommended care standards.[50-56] For example, a meta-analysis of several controlled trials concluded that computer reminders improved preventive practices compared with the control condition for vaccinations, breast

cancer screening, colorectal cancer screening, and cardiovascular risk reduction but not cervical cancer screening or other preventive care.[53] Sequist and colleagues evaluated the impact of an integrated patient-specific electronic clinical reminder system on diabetes and coronary artery disease (CAD) care and to assess physician attitudes towards this reminder system. Baseline adherence rates to all quality measures were low.[52] The results showed that, while electronic reminders increased the odds of recommended care for diabetes and CAD, the impact of individual reminders was variable. Three of nine reminders effectively increased rates of recommended care for diabetes or CAD. Most physicians (76%) felt that reminders improved quality of care. [52]

In Dentistry, some CDS tools have also been developed to assist daily practice, such as histopathologic diagnosis of salivary gland neoplasms, orthodontic diagnosis and treatment planning, oral radiology, and partial denture design.[48-49] However, compared with medicine, use of CDS systems in dental practice is minimal. Our review of the literature failed to find any data examining the use of clinical reminders and guidelines in the EDR. Due to lack of information, clear clinical guidelines and point-of-care CDS, dental care for medically compromised patients are mostly based on the individual experience of clinicians and is therefore somewhat arbitrary. This arbitrary and variable dental care model may significantly impact clinical outcomes and quality of care for these patients. It is also a potential source of iatrogenic errors. For instance, many medically compromised patients, including those with severe CHF, are in class IV according to the American Society of Anesthesiologist (ASA) Classification; therefore, aggressive and stressful surgical procedures are not appropriate for these patients. However, due to poor oral hygiene and impaired physical function, risks of infective oral disease are high, greatly increasing the need for invasive and emergency dental and medical treatment.

In a recent review of the literature on CDS systems, Kawamoto et al[21] found that there were four important factors that made for successful CDS: (1) the automatic provision of support as part of the regular work flow, (2) the delivery of support when decisions occurred, (3) provision of specific actionable recommendations and (4) use of the computer to generate CDS. They concluded that “an effective CDS system must minimize the effort required by clinicians to receive and act on system recommendations.” Barriers and facilitators to the effective use of clinical reminders were determined by observing nurses and physicians as they interacted with clinical reminders embedded in an EMR. Optimally using the clinical reminder system for its intended purpose was impeded by (a) lack of coordination between nurses and providers, (b) using the reminders while not with the patient, impairing data acquisition and/or implementation of recommended actions, (c) workload, (d) lack of clinical reminder flexibility, and (e) poor interface usability. Facilitators included (1) limiting the number of reminders at a site, (2) strategic location of the computer workstations, (3) integration of reminders into workflow, and (4) the ability to document system problems and receive prompt administrator feedback.[21] A similar list of barriers and facilitators is likely to exist for the EDR; however, dentistry and medicine have important differences, and we can expect barriers and facilitators unique to dentistry to be present.

These findings provide a background for the significance and innovation of this study. Our previous CDS system, the eDental Guides, was a **Passive CDS** that notifies providers and makes available personalized evidence-based guidelines base on the patient’s medical condition. It demonstrates both the potential of such a system toward improving care for medically compromised patients and its key shortcoming, provider activation. This study determined if enhancing the eDental Guides system with alternative methods of provider activation, specifically and Schedule Alert CDS or a Pop-up Alert CDS can address that limitation.

4. SETTING AND PARTICIPANTS

The setting and participants of the study are members of HealthPartners (HPs), a large upper Midwestern integrated health system that consists of a dental group, a medical group (including hospitals), a medical plan and a dental plan. HealthPartners medical group serves more than 1

million patients and the HealthPartners dental group serves over 200,000 patients and is the largest consumer governed non-profit health care organization in the country, and the parent company to a number of other organizations. Included under HealthPartners' umbrella are Regions Hospital (a tertiary care hospital located in the center of St. Paul), HealthPartners Medical and Dental Group, the Institute for Medical Education, and HealthPartners Institute. HealthPartners is an integrated health care system with the mission of improving the health of its members, patients, and community. The study included patients who had an upcoming dental visit in the HP Dental Group and had at least one or more of four medical conditions including diabetes mellitus, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), or risk of infective endocarditis (IE) as identified by their EMR. The medical conditions for this study were selected based on their prevalence, potential for dental complications, the need to modify treatment to improve quality and safety of care, and the interest among dental providers.[7,8,18-22] The study used privacy and security methods that were approved by the HealthPartners institutional review board and consistent with the Health Insurance Portability and Privacy Act[17] and federal guidelines. To be eligible for the study, patients must have an established diagnosis of one of four targeted medical conditions based on two or more ICD-9 diagnosis codes for diabetes, CHF, COPD, and risk of infective endocarditis. These conditions were identified according to electronic algorithms using data from HeathPartners' medical group and claims pharmacy data. All dental providers at HealthPartners Dental Group clinics were included in the study. Dental providers were masked to the group they are in. There are currently 47 eligible dentists and 134 total dental providers at 17 clinics, with a total of about 83,125 adult patients (1,768 patients per dentist). Each dentist cares for at least 88 patients (5%), with at least one of the targeted medical conditions. Thus, each of the three study arms will include about 15 dentists with an average of about 2,500 patients for analysis in each arm, or 7,500 total patients, including the control group. A continuing education course was provided to familiarize them with the evidence based guidelines.

5. METHODS (Study Design, Data Sources/Collection, Interventions, Measures, Limitations)

Study design. A three-arm 12-month prospective, randomized clinical trial within the HealthPartners Dental Group (HPDG) was used to compare the impact of three strategies to alert dental providers to improve quality and safety of dental care for those with medically complex conditions. HPDG is part of a large multi-specialty integrated health care delivery system that includes dental clinics, medical clinics, and hospitals with separate EMRs and EDRs system that do not share data. Thus, a system was needed to provide a quick reference to both medical and dental data and alert dental providers of any special characteristics of the patient. The fifteen dental clinics in the HPDG were randomly assigned to one of three CDS alert groups: 1) Pop-up Alert group, 2) Schedule Alert group and 3) Control Alert group. The study was designed to answer the following question: "What is the most effective alert to activate dental providers to utilize patient-specific care recommendations at the point of care?"

HPDG has 17 dental clinics, and only 15 were eligible for the study because one clinic provides specialty care and the second has patient demographics very different than the other clinics and could not be matched. The study used privacy and security methods that were approved by the HealthPartners institutional review board and consistent with the Health Insurance Portability and Privacy Act[17] and federal guidelines. The study determined what CDS components best increased provider activation using a 3-arm, prospective, cluster-randomized clinical trial. Three arms in the study are defined based on both the type of alert, and when and by whom in the work-flow it is triggered. Table 1 summarizes each component of the different groups and alerts.

Table 1. Different groups are defined by the types of alerts provided and when and by whom during the work flow they are activated and used. (Fig. 1)

Type of alert	Task where alert is seen	When in work flow does task occur	When is alert activated by review of EMR	Who can see alert when logged in

Fig 1a. **Red cross** on top of EDR (Control)	DDS review of schedule	Morning or night before	The day before the visit	DDS, DA, RDH
Fig 1b. **ASA status** in schedule and red cross	Huddle with all DDS and staff	Morning or night before	The day before the visit	Front desk, DDS, DA, RDH
Fig 1c. **Pop-up** in patient chart and red cross	Chair-side with DA, RDH and, then, DDS	After patient checks in	The day before the visit	DDS, DA, RDH

Figure 1a. EDR Control Alert (The red cross flashes in heading of the EDR)

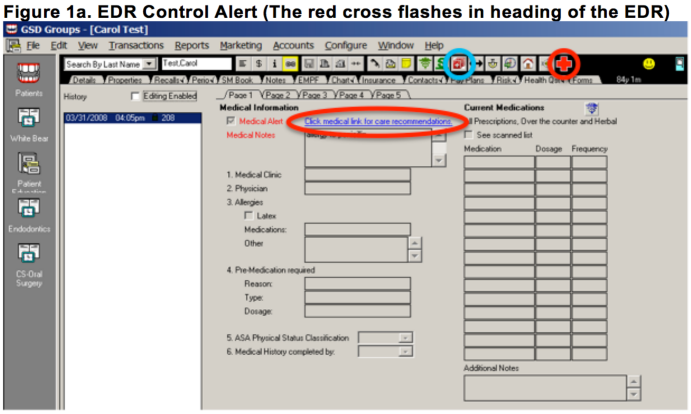


Figure 1b. Schedule Alert (The ASA status displayed in schedule)

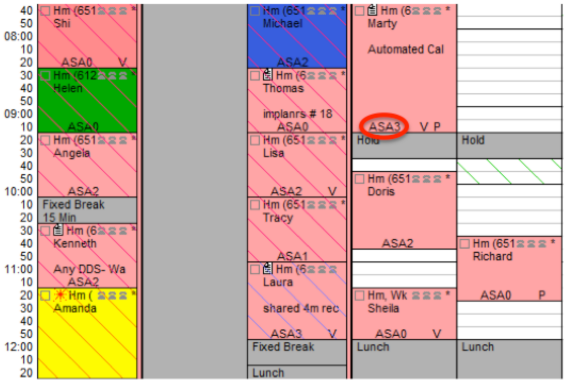
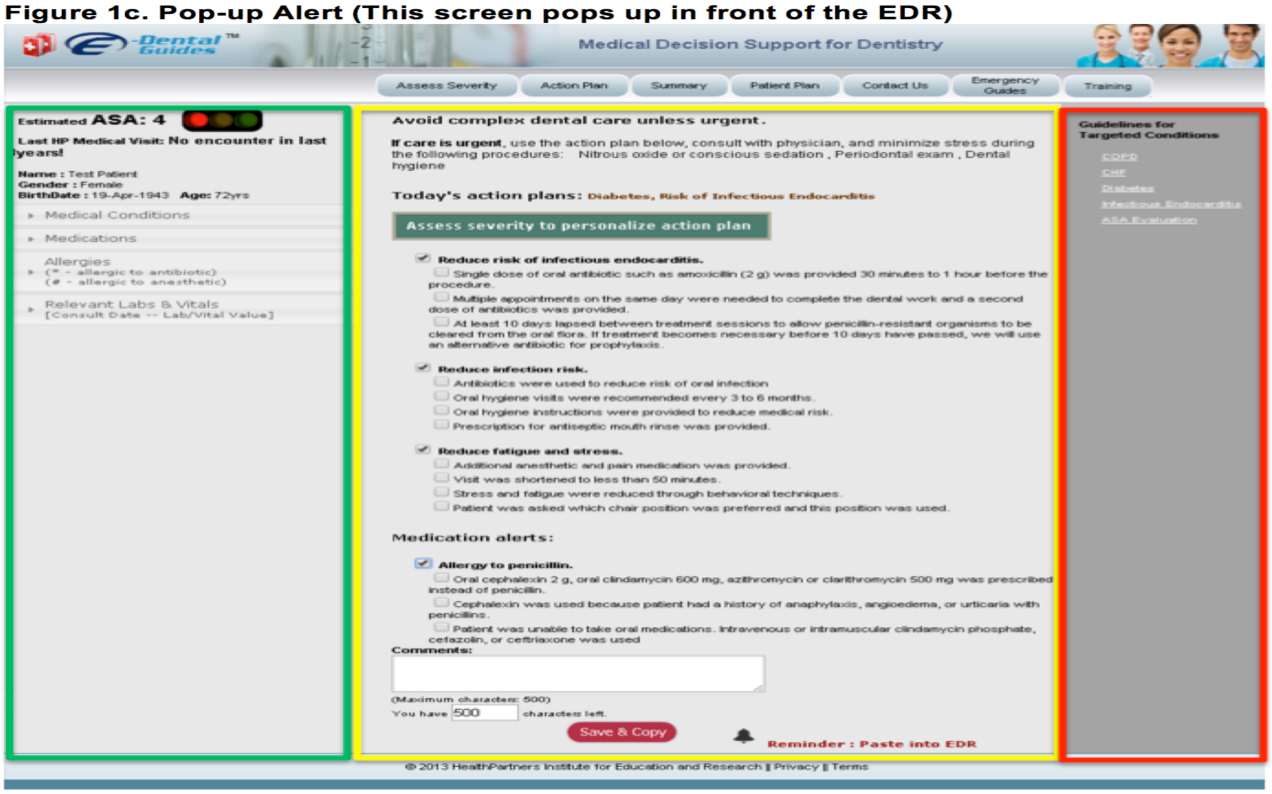


Figure 1c. Pop-up Alert (This screen pops up in front of the EDR)



Data Sources/ Collection. Data sources included the electronic medical and dental records from HealthPartners Medical and Dental Group. To be eligible for the study, patients from HPDG must have an established diagnosis of one of four targeted medical conditions based on two or more ICD-9 diagnosis codes for diabetes, CHF, COPD, and risk of infective endocarditis.

Intervention. eDental Guides is a clinical decision support (CDS) system that integrates dental and medical records with clinical guidelines to improve the quality and safety of dental care for medically complex patients. *Figure 1c* illustrates the 3 components of the data available in

eDetal Guides. The three main components to the eDental Guides website included: medical summary (left side), recommendations (middle), and general guidelines (right side). We designed the website so the user would need to click on a header in order to know something meaningful about the patient's medical condition.

a. Medical Summary (left side): This section requires the users to click one of the four drop downs to display the following information: 1) Medical conditions display the EMR problem list. 2) The medications display the EMR listed medications. 3) Allergies display the EMR listed allergies. 4) Labs display the EMR recorded blood pressures, HbA1C, and INR values over the last two years.

b. Recommendations (middle): The middle part of the eDental guides webpage provides tailored recommendations at the patient level only utilizing EMR data due to the difficulty of extracting EDR data. Thus the recommendations were implemented at the patient level, independent of dental procedure type. The three main components were: 1) Severity Assessment – since not all assessments can be done through extracting EMR data, the software developed assessment questions from the gold standard in managing medically complex dental patients, and these were used to refine the Action Plan. 2) Action Plan – this recommended actions assuming the most severe condition, and following severity assessment, refined the recommended actions. 3) Summary – develops a summary of the Severity Assessment and Action Plan that can be copy and pasted into the electronic dental record.

c. General Guidelines (right side): The right side of the webpage has general guidelines for managing congestive heart failure, chronic obstructive pulmonary disease, diabetes, and risk of infective endocarditis for dental procedures.

CDS Alerts. The interventions involved three different provider alert activation strategies designed to alert the dental providers to use personalized clinical care guidelines for patients with the identified complex medical conditions (Fig. 1). In all three interventions, the dental provider could access eDental guides at any time by clicking on the "red medical alert" icon in the EDR. All groups had access to the EDR control alert.

a. Control Alert group (Fig. 1a). Patients in the control group were presented with a blue link in the health questionnaire of the EDR and a flashing red-cross alert icon in the EDR when the EMR found the patient had diabetes, CHF, COPD, or risk of IE.

b. Schedule Alert group (Fig. 1b.). The schedule alert group was alerted by each patient being assigned an estimated ASA status in the dental schedule. Estimated ASA was assigned 0 (insufficient data), 1, 2, 3, 4 based on a validated ASA algorithm. If the provider wanted to view eDental guides for that patient, the provider would open that patients chart and click on the "red medical alert" icon.

c. Pop-up Alert group (Fig. 1c). The pop-up alert involved overlaying the EDR with the first webpage of eDental guides for patients identified by the HealthPartners EMR as having diabetes, CHF, COPD, or risk of IE. The dental provider could switch back to EDR by simply closing or minimizing the eDental Guides webpage.

Patients with upcoming dental appointments who had one or more of the four targeted medical conditions had one of these 3 alerts triggered in the EDR depending on the clinic they were in. By clicking the "red medical alert" icon, dental care providers in each group had immediate access to a patient's EMR-generated medical summary, recommendations (personalized care guidelines using EMR data and a severity assessment), and general clinical care guidelines (Figure 1c). The alerts encouraged the dental care providers to review the medical summary, conduct a severity assessment and implement a personalized action plan that outlined specific steps recommended by clinical guidelines to minimize complications for patients with diabetes, CHF, COPD, or risk of IE.

The new care guidelines were introduced in a newsletter to dental care providers informing them that they were available to all clinics. All providers in all three intervention groups were aware of the alerts but were not aware of the study protocol and other alerts in other

intervention groups. Because each intervention was implemented in different clinics and few dentists or hygienists crossed over to other clinics, cross-over was limited to 1.3 dentists is 17 for all providers.

Clinical care guidelines. The recommendations for modifications in the care of dental patients who had one of the four medical conditions were based on the clinical guidelines of the American Academy of Oral Medicine Guidelines Committee.[7,8] The American Academy of Oral Medicine's clinical guidelines integrate scientific evidence with clinical experience. Table 2 provides a summary of the clinical care recommendations. In addition, the complete general care guidelines include an overview of the medical condition, the effect of the conditions on systemic health and oral health, and what to do in case of emergencies were accessible through the eDental Guides website. The care guidelines needed to be brief enough to implement at the point of care but specific enough to have a meaningful effect on care. Once completed, they were reviewed carefully and edited by the HPDG Records Committee and approved for implementation in the HPDG's EDRs. Specific recommendations to each dentist were based on the clinical guidelines and focus on each of the following condition specific recommendations as noted in eDental Guides. They are;

a. Changes in chair-side dental procedures to minimize complications.
   All patients with a chronic medical condition were identified through the EMR with an alert placed in the EDR at the time and point of care. The dentist needs to review the medical history of the condition identified and the recommended chair-side procedures needed to address the medical condition as part of dental care treatments. The outcome is to document in the EDR the medical history and that action has been taken to minimize complications during the dental procedure.
b. Changes in frequency of oral hygiene visits.
   Each patient with the selected medical conditions has increased risk of complications from periodontal disease and caries. The dentist needs to evaluate the status of the patient's oral hygiene program and make recommendations to achieve at least the standard 6-month or less frequency of oral hygiene visits. The outcome to achieve is to have the patients have at least one oral hygiene visit every 6 months.
c. Closer follow-up visits to monitor outcomes.
   All patients with an identified medical condition are at risk of post-operative complications from delayed healing or compromised immunity. It was recommended to follow them up in person or by phone with these patients at a standard 1 day after treatment to intervene if needed. An alert was provided, and the outcome to be achieved is to have the patient contacted 80% of the time.

Table 2. Medical conditions selected as part of the study described in background and a summary of the interventions for each condition.

Disorder	Summary of interventions
All targeted medical conditions	Three changes are recommended for all conditions: 1) Changes in chair-side dental procedures to minimize complications, 2) Changes in frequency of oral hygiene visits, 3) Closer follow-up visits to monitor outcomes. In addition, condition-specific changes are also recommended, as noted below in this table.
Diabetes	Evaluation for oral infections, review glucose monitoring, monitor medication side effects
Congestive heart failure	Shorter visits, in morning, adequate pain control, possible prophylactic antibiotics, monitoring signs of cardiac distress with blood pressure readings, pretreatment blood pressure
Chronic obstructive pulmonary disease	Shorter visits, less reclined, monitoring signs of respiratory distress, medication side effects, avoidance of gagging procedures
Xerostomia from medications or systemic conditions	Measure salivary flow, prescribe saliva substitute, self-care, good oral hygiene, use saliva medication

Training. Training involved 1) an explanation in the HPDG's weekly e-newsletter to all dental staff and 2) visiting each of the clinics over lunch for the staff. In the e-newsletter, there was an explanation of eDental guides purpose with a screen shot of the three components of the webpage (medical summary, care recommendations, and general guidelines). The clinic visit training included a discussion of eDental guides. The majority of the staff attended all of the clinic visits, providing the opportunity to understand their individual alert, learn how to best utilize the interface, and ask questions.

Health Information Exchange Formats. As noted, the CDS system in each group identified a schedule in the HP dental clinics of patients with one of the targeted chronic medical conditions. This occurred through the network, of which HP is a member, to inform the CDS of presence of a medical condition in the appointed patient and need for triggering access to the clinical guidelines. The advantage of using a HIE format is that, not only can dentists in the community be involved, but medical information about a specific patient who sees medical providers outside of HP can be included in the future. Minnesota HIE efforts include most participating health systems and plans and represents a large, diverse national population of more than 3 million people in the Minneapolis-St. Paul metropolitan area within which to identify patients for the study. *National Health Information Network (NHIN)* standards and NHIN Connect are being employed to ensure that federal standards are met and that we are able to translate HIT from this project into national efforts. NHIN is a national initiative driven by the Office of the National Coordinator for Health Information Technology to build a "network of networks" for HIE.[26] The core capability of the NHIN infrastructure includes 1) patient lookup across HIEs without a national patient identifier, 2) summary patient records (in a continuity-of-care document (CCD) format query and retrieval, 3) secure communication and notification, 4) audit logging and error handling for data access and exchange, 5) audit log querying, allowing security officers and consumers to review audit log data, and 6) support of consumer-defined preferences, including (opt-in/opt-out) between HIEs.

Measures. Outcome measures include clinical outcome measures; system-level process measures; measures of efficiency, provider, satisfaction; patient safety; and implementation costs. The outcome measures are designed to follow the goals of the RFA, reflect changes supported by the interventions, and use nationally recognized clinical and process measures. Three primary outcomes were examined: 1) frequency of accessing guidelines for identified patients; 2) frequency of condition-specific medical review and appropriate action at dental visit, 3) frequency of utilization of emergency care for adverse events such as pain and side effects. A secondary related outcome is to determine the degree of acceptability of the CDS interventions to dentists. Table 5 describes the outcome measures, benchmarks, estimated current status of dentists and patients meeting the benchmark, and expected behavior after the intervention.

a. Frequency of accessing the guidelines. The three primary outcomes include hits on Web site for all patients, percentage of unique providers who access the guidelines, and levels of acceptability and satisfaction of the CDS qualitative and quantitative survey and focus group approach. Dental providers were asked about a standard list of questions to rate the features in each CDS with regard to their functionality, usefulness, and acceptability. In the focus groups of three to five dental providers, the features were also be reviewed and scenarios developed to "stretch" the boundaries outside of an average or inexperienced user and challenge the system's features. Content testing ensured that each word and image on the system is appropriate, spelled correctly, and used as intended. Suggested modifications to the infrastructure were discussed with the whole investigative team. Dentists and their staff in the experimental groups were asked to complete a survey on the acceptability of the CDS. Questions regarding it's use, intrusiveness into workflow, clarity of recommendations, and how it influenced their care was asked. In addition, we held focus groups to discuss the CDS and how it can be improved.

b. Dental Provider Actions. Our analytic focus was frequency and proportion of encounters in which the eDental Guides website was accessed by dental providers for patients with one or more of the study conditions. We collected the outcomes for 12 months after implementing the

intervention and compared the 3 groups. It is important to note that the intervention and alerts were directed at the dental team including the dentist, dental hygienist, and dental assistant and, thus, the eDental Guides intervention and outcomes were not assigned to only one provider. The primary outcomes were as follows:

- Total use: the overall frequency with which providers in each group accessed any feature of eDental Guides web site for any patient;
- Medical Summary use: the proportion of encounters in which Medical Summary items in eDental Guides were accessed for any patient at the point of care.
- Recommendations use: the proportion of encounters in which different aspects of the personalized care guidelines in eDental Guides were accessed for any patient at the point of care.

c. Patient Outcomes. Two primary outcome measures including 1) oral hygiene visits and 2) emergency follow-up visits for adverse events are being analyzed. Oral hygiene care rates are one of the main dependent variables of interest because they are consistently recommended by the guidelines. It is expected that the alerts encouraged patients to meet recommended oral hygiene visits as noted in the EDR and, thus, improve oral hygiene and the potential for complications from oral infections. Oral hygiene care is coded for each patient as a 0 (met criteria for adequate care) or 1 (did not meet criteria for adequate care). To be classified as meeting criteria for care, the patient must be seen by the hygienist at least a mean of twice per year. For utilization data, we measured the actual number and type of visits for dental care (excluding hygiene visits) during the 2-year period through the EDR claims data and whether it is for emergency reasons. Emergency follow-up visits for adverse events provided a measure of resource use associated with dental care and complications from the medical condition. Specific ER visits to the dentist and medical providers are derived from HP's dental administrative claims system.

Overview of Analytic Approach. This study concerns the construction of an integrated CDS system linking an EDR and EMR via a health information exchange portal built to NHIN health information exchange standards. Thus, evaluation of this aim involved collecting and systematically processing the qualitative information that was be gained through focus groups and partnerships. Aims 2-4 of this study comprise a cluster- randomized control trial that posits a CDS employing an integrated EDR/EMR system can be leveraged toward improved care delivery for medically compromised patients. This was tested by block randomizing HPDG clinics into one of three study arms: Arm A (Schedule Alert CDS), Arm B (Chairside Alert CDS), and a Arm C (control arm). We examined a group of medically compromised patients with one or more of the following conditions: diabetes mellitus, CHF, COPD, and xerostomia. The primary outcomes to be analyzed are: frequency of accessing patient-specific, evidence-based guidelines, frequency of condition-specific medical review and action, and the frequency of hygiene and emergency care services. Although the specific analytic models used for each hypothesis test in support of the aims varied in terms of covariates, independent and dependent variables, there are several criteria that were be consistent across analyses.

The characteristics of providers and the volume of services provided (that is, specific procedures coded by each dental care provider) among intervention clinics were compared to ensure that goals for randomization were met. The data are presented according to frequency distributions and means (± standard deviation). A multi-level analysis was used to account for the cluster randomization design by clinics. We evaluated whether the trend of using eDental guides over time differed between arms by including a time-arm interaction. We fit a generalized linear model with Poisson distribution and a log link for frequency outcomes (rate ratio [RR]) and fit a binomial distribution with logit link for the use over time (odds ratio [OR]). We tested intervention sustainability by evaluating the intervention during each month of the six- to 12-month post-implementation period in relation to the control group. In all of the proposed analyses, we tested a null hypothesis of no statistical relationship between the independent and

dependent variables of interest at α = .05. (e.g., center around mean, include interaction terms) or reconsidered its inclusion.

6. RESULTS (Principal Findings, Outcomes, Discussion, Conclusions, Significance,Implications)

Principal Findings. Among 85,045 HPDG patient visits during the 12-month period of tracking, we identified 6,389 patients (7.5 percent) who had one or more of the four medical conditions (identified from the EMR using specific criteria) and had a dental visit at HPDG during the study period (Table 3).

TABLE 3. Characteristics of study population*

Characteristic	Pop-up Alert	Schedule Alert	Control Alert
No. of Dental Clinics	7	3	5
Number of Providers (N = 252)†			
Dentist (59)	33	10	16
Hygienist (78)	39	19	20
Dental Assistant (115)	61	23	31
Range in number of dentists per clinic	5-8	5-8	4-11
Total number of patients seen during study period (n = 85,045) ‡	43,845	16,185	25.015
No. (%) of Patients Seen With Medical Condition During 6-Month Study			
• Any medical condition (n= 6,389)	3037 (18.4%)	1419 (16.1%)	1,933 (20.4)
• Diabetes mellitus (n= 4,456)	2,167 (7.5%)	988 (6.9%)	1,391 (8.1)
• Risk of Infective Endocarditis (n=688)	317 (11.7%)	159 (10.1%)	212(13.1)
• Chronic obstructive pulmonary disease (COPD) (n=1175)	561 (2.4%)	267 (2.1%)	347(3)
• Congestive heart failure (n=889)	407 (1.3%)	215 (1.1%)	277 (1.8)

*6,389 (7.5 percent) of 85,045 patient visits scheduled during the study period were eligible.
† Unique dental care providers participated in pop-up, schedule, and control groups
‡ Patients were counted multiple times when treated at more than one dental clinic.

The condition identified most frequently was diabetes (n = 4,456) followed by COPD (n = 1,175), congestive heart failure (n = 889), and risk of infective endocarditis (n=688). Many patients had more than one of these conditions (n = 2,818, 25.8 percent). These patients were cared for by a total of 566 dental providers including dentist, dental therapist, dental hygienists, and dental assistants. Characteristics of the 252 dentist and dental hygienist care providers and volume of services delivered were similar among the providers in each of the three groups.

Fig. 2. mean number of website hits per provider in the active pop-up alert group, passive schedule alert group and control group over time.

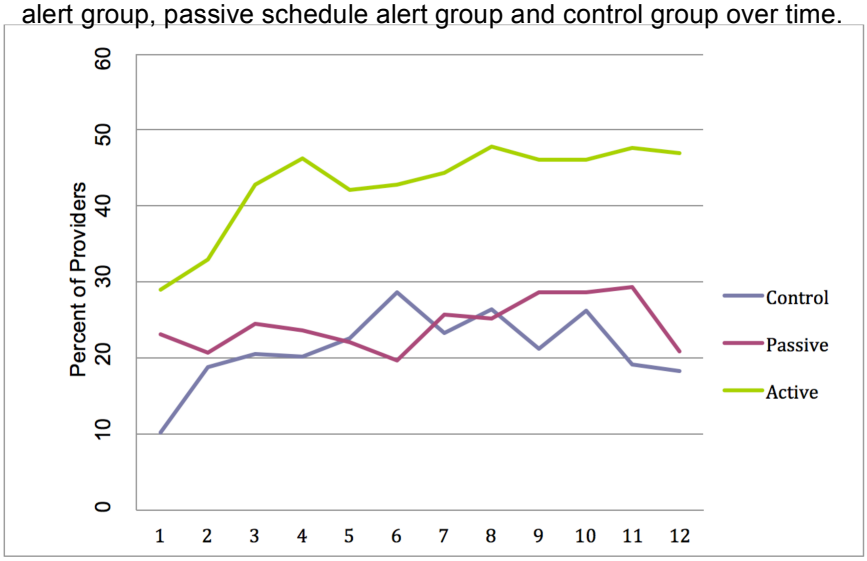


Figure 2 presents the mean number of website hits per provider in the pop-up alert group, schedule alert group and

control group over time. This illustrates the frequency of eDental Guide use of any type by any dental provider for any patient increased over time. There were nodifference between arms in the change over time (p=0.20). We observed a 2.7 percent increase per month in use of eDental Guides within all three intervention arms (RR: 1.027; 95%CI 1.01, 1.04 p<.0001) suggesting the CDS was gaining greater interest over time.

Table 4 shows that the intervention-period effect of the pop-up alert resulted in an increase in the number of hits to open the eDental Guides website during the twelve months of CDS activation compared to the schedule or control alerts. Although the pop-up alert group automatically opened eDental Guides, the table displays only when the user clicked something in the window as to not count the user just closing the window after it pops up. This group also reflects the maximum utilization one could expect from eDental Guides due to its obvious presentation of information to the user. The schedule alert also had higher accessing of the sections but not by as much as the pop-up alert. Both were improved over the control alert in the EDR. The highest utilization within eDental guides was the medical summary on the left side.

Table 4. Utilization of different components of eDental guides for each unique patient encounter. This includes number of unique patient with at least 1-click on eDental Guides for those patients who have an encounter. Total # of encounters (n=18,974) included Pop-up (n=10,638), Schedule (n=3,434), Control (n=4,904)**.**

Groups	Pop-up Alert (n= 4699)		Schedule ASA Alert (n= 843)		Control EDR Alert (n=814)		Pop-up vs EDR Control	Schedule vs. EDR Control	Pop-up vs. Schedule
	%	N	%	N	%	N	P-value	P-value	P-value
Accessed eDental Guides for any reason (n=6,563)	44%	4669	25%	842	22%	1052	<.0001	NS	<.0001
Opened eDental Guides to view medical summary[2] (n=6,489)	43%	4599	25%	840	21%	1050	<.0001	NS	<.0001
Opened eDental Guides to view personalized action plan[3] (n=261)	2%	192	1%	41	1%	28	NS	NS	NS

[1] Some patients had multiple visits during study period
[2]Includes problem list, medication, allergy, laboratory data
[3]Includes severity assessment, action plan, summary, patient plan data
ASA American Society of Anesthesiology (ASA) medical status, HQ-health questionnaire

Table 4 presents the utilization of eDental guides as measured by the total number of website hits for the CDS system per dental service type. The eDental guides system was used almost twice as much during preventive services such hygiene prophies and periodontal visits compared to restorative visits. This may be due to the more active participation by the dental hygienist compared to dental assistants. In both service types, the pop-up alert triggered more use by the dental providers.

Table 4. Utilization of eDental guides medical history items and personalized guidelines for targeted patients at each type of encounter. Total # of Patients (n=10,638) included Pop-up Alert (n=5,826), Schedule Alert (n=1,889), and EDR Health Questionaire Alert (n=2,629)

Groups	Pop-up (n= 5826)		Schedule (n= 1889)		Control EDR (n=2629)		Pop-up vs EDR Control	Schedule vs EDR Control	Pop-up vs. Schedule
	%	N	%	N	%	N	P-value	P-value	P-value
Part of preventive services including prophy and periodontal visits (total N)									
Accessed eDental Guides for any reason (n=6,563)	60%	2890	45%	696	32%	718	<.0001	NS	<.0001
Open EMR medical history [2] (n=6,489)	59%	2836	45%	695	32%	718	<.0002	NS	<.0001
Open personalized action plan[3] (n=261)	3%	146	2%	36	1%	12	NS	NS	NS
Part of restorative services including restoration, prosthodontics, extraction (total N)									
Accessed eDental Guides for any reason (n=6,563)	31%	1779	8%	146	13%	334	<.0001	NS	<.0001
Open EMR medical history [2] (n=6,489)	30%	1763	8%	145	13%	332	<.0002	NS	<.0001
Open personalized action plan[3] (n=261)	1%	46	0%	5	1%	16	NS	NS	NS

[1]Some patients had multiple visits during study period
[2]Includes problem list, medication, allergy, laboratory data
[3]Includes severity assessment, action plan, summary, patient plan data
ASA American Society of Anesthesiology (ASA) medical status, HQ-health questionnaire

Project Outcomes. This study evaluated the rate of reviewing the eDental Guides clinical decision support website and its care recommendations for patients with medically complex conditions by 256 dental care providers who were provided different types of alert mechanisms– pop-up, schedule, and control alerts. The results showed that the pop-up alert was more effective and perhaps more efficient and predictable— in encouraging providers to review medical history from the EMR compared to schedule alert or health questionnaire alerts in the electronic dental record. Care recommendations were not used. In addition, there was a learning curve since providers in all three groups had increased the use of the website over the 12 months of the study. In addition, the study found that the use during type of visit also differed with periodontal visits having a higher use than restorative visits. Because all providers had access to only one alert and not the alerts in other groups, we can attribute this effect to the CDS alert type.

Discussion. Meeting the needs of an aging population with more complex health problems requires dental care professionals to have more comprehensive medical knowledge. In addition, Dentistry needs to become more closely integrated with medicine and the health care system on all levels: education, research and patient care.[1-6] In 2007, Baum[6] explored the problems

associated with the lack of education about medical conditions in dental schools. He stated that "dental students need to know enough medicine to treat their patients who have chronic systemic illnesses, a population that continues to increase in size." [6]

However, few accredited U.S. dental schools spend more than 1 percent of instructional time on managing general medical emergencies, and little time is devoted to teaching students how to care for patients with medically complex conditions.[2] This has led to challenges in identifying medical problems during routine dental care, as well as in modifying dental care to account for these conditions. Complex medical conditions such as diabetes and heart disease can affect the quality and safety of dental care if they are neglected.[18-21] For example, diabetes increases the risk of developing periodontal disease, and patients with congestive heart failure need special treatment during dental care to prevent a cardiac event (Table 1).

Clinical care guidelines have been developed to support evidence-based dentistry and improve implementation of care guidelines.[8,22] However, distributing and promoting guidelines alone does not ensure a change in clinical practice.[9,10] Van Wijk and colleagues[10] reviewed 59 published evaluations of clinical guidelines in medicine and concluded that although guidelines could improve clinical practice, their use and the extent of improvements varied considerably. Bero and colleagues[12] examined systematic reviews of strategies for disseminating and implementing research findings.

Furthermore, the use of clinical decision support systems--interactive computer systems that help doctors make clinical choices--can reduce errors in drug prescribing by offering real-time alerts about possible adverse reactions. But health care professionals often suffer "alert fatigue" caused by excessive numbers of warnings about items such as potentially dangerous drug interactions. As a result, they may pay less attention to or even ignore more vital alerts, thus limiting these systems' effectiveness. Designers and vendors often limit the flexibility and ability to modify alert systems because of liability fears if they permit removal of a warning that could have prevented a harmful error in care.

Conclusion. This study found that 3 different types of alerts each can activate dental providers to review their care for patients with medically-complex conditions. The Pop-up alert was more effective in triggering use but had higher alert fatigue and lower acceptability. Even reminding dental care providers of the need to review medical conditions in the patient's dental record can be associated with changes in the dentist's treatment of these patients.[14-16] However, it is important to recognize that improved government regulation of clinical decision support systems and development of international practice guidelines is needed to limit liability to customized alert systems.

Significance. Meeting the needs of an aging population with more complex health problems will require that dental care professionals acquire more comprehensive medical knowledge. In addition, the dental profession needs to become more closely integrated with the medical profession and the health care system on all levels: education, research and patient care. The significant research findings support the use of specific strategies for implementing CDS systems by dental care providers. The study results showed that pop-up alert was more effective in encouraging providers to review the care recommendations than was the schedule or control alerts in the electronic health record. Providers increased the use of the website over the 12 months of the study. Future dental care delivery systems and EDRs should expand the use of CDS that integrated medical and dental data with clinical guidelines at the point of care to help dental care professionals integrate medical knowledge into routine clinical practice.

Limitations. There are several study limitations. We did not have the medical chart for all the patients so that the conditions algorithm from the EMR may be different as displayed from the EDR. In addition, we did not have a balanced design in the number of clinics in each arm because of variation in the implementation.

The peak use of the CDS was less than expected. Despite the increase in use of the CDS, dental providers opening and using eDental guides peaked at 47.6% in the Pop-up alert group. This was still modest during the 12 months despite the continued presentation of alerts and availability of the medical summary and care guidelines. This suggests that dental providers

either did not feel the need to continue to review the medical history and clinical care guidelines or the alerts became less effective as a result of alert fatigue. Since the dental assistants and dental hygienists alerted the dentist of medical history red flags, it is possible that they relied more on the self-report medical history in the electronic dental record than the CDS.

The CDS was also used differently than expected. eDental Guides was used more for medical history from EMR data and not recommendations or clinical guidelines. In addition, nearly half of the hits on the eDental guides website occurred during appointments with patients who were not in the study. Both of these findings suggests that they were using the tool to view electronic medical record data. There also may have been crossover of a few patients between clinics, which might have influenced the outcomes. However, in analyzing the data, we found that these scenarios occurred infrequently. Thus, we believe that most dental care providers in this study used the CDS as it was intended.

There was low use of the CDS action plan. Dental providers' use of the care recommendations and guidelines, regardless of the intervention group, was low during the entire study. Since most dental providers were already familiar with the clinical care guidelines, suggests that they did not need to repeatedly review the care guidelines to understand and implement them. They may also have developed "alert fatigue," which can occur when one becomes accustomed to seeing flashing alerts and pays less attention to them.

There is a time-based learning curve for providers in using CDS. Although eDental guides triggered an increase in dental providers' use of the care recommendations with a response rate of nearly 49 percent of all dental care providers, the detailed review of the personal web pages was limited, perhaps, due to time-limitations in the clinic setting. This increased over time suggesting that some learning curve is needed regarding use of care recommendations

Implications. We need to determine which additional CDS components such as EDR-embedded office notes and scripts and personalization that may result in a higher engagement and application to improve care while maintaining a high level of acceptability with regard to work-flow and different dental providers. It is possible that by alerting front desk staff of high risk patients ahead of time will allow scheduling more time to review medical history and personalized recommendations. Furthermore, automatically embedding guidelines into progress notes in the EDR may increase use and sustainability. These are possible topics for future research.

We also need to point out that an increased review of care guidelines will not necessarily result in changes in care or in improved clinical outcomes, such as decreased complications and improved periodontal and dental status. Further analysis is required to evaluate changes in care and the effect of CDS on patient-centered outcomes.

Meeting the needs of an aging population with more complex health problems will require that dental care professionals acquire more comprehensive medical knowledge. In addition, the dental profession needs to become more closely integrated with the medical profession and the health care system on all levels: education, research and patient care. Our research findings support the use of CDS systems by dental care providers. The study results showed that pop-up alert was more effective in encouraging providers to review the care recommendations than was schedule or control alerts in the electronic health record. Providers increased the use of the website over the 12 months of the study. Future dental care delivery systems and EDRs should expand the use of CDS at the point of care to help dental care professionals integrate medical knowledge into routine clinical practice.

7. LIST OF PUBLICATIONS and PRODUCTS (Bibliography of Outputs from the study)

a. Fricton JR, Rindal DB, Rush WA, Flottemesch TJ, Vazquez G, Thoele MJ, Durand EC, Enstad CJ, Rhodus N. The effect of electronic health records on the use of clinical care guidelines for patients with medically complex conditions. J Am Dent Assoc 2011: 142(10):1133-42.(Preliminary data paper)
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f. Grant. Fricton, JR Robert Wood Johnson. Project Title: Integrating Medical and Dental Data to Improve Safety and Quality of Dental Care. Application I.D.: 37302 HealthPartners Institue for Education and Research. Submitted, not funded.

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