The Impact of a Clinical Information System on Users in the School of Dentistry: A Case Study

by

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CERTIFICATE OF APPROVAL

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ABSTRACT

Objective: To understand the impact experienced by users in the dental school setting of integrating clinical information systems (CIS) into patient care.

Design: We used qualitative research methods, including interviews, observations and focus groups, to capture the experiences of CIS users at a single institution. The data were analyzed using the grounded theory approach.

Results: Nine themes emerged from the data: 1) CIS benefits were disproportionate among users, 2) Communicating about the CIS was challenging, 3) Users experienced a range of strong emotions, 4) The instructor persona diminished, 5) There was variation in how users' time was impacted, 6) The training and support needs of end-users were significant, 7) There were shifts in the school's power structure, 8) Lack of CIS usability made documentation cumbersome, and 9) Clinicians' workflow was disrupted.

Conclusion: By identifying the issues experienced by users as the CIS was integrated into patient care, administrators and faculty will be better equipped to manage their impact on the success of CIS implementation.

INTRODUCTION

Mirroring trends in teaching hospitals, dental schools are expanding the capabilities of their information systems and integrating the systems more profoundly into patient care and student education. (1-4) In the dental setting, clinical information systems (CIS) is the comprehensive term used to describe the software components of these information systems and their necessary hardware (computers, digital x-ray processors, printers, etc.). In the 1990s, the function of CIS centered on school financials, including billing and insurance claim processing programs. Since then, the purpose of CIS has evolved to include administrative and clinical aspects, such as digital image capture, storage and enhancement, the patient-centered electronic oral health record, inventory, oral disease risk assessment tools, and student grading.

Dental schools have embraced the expanded functions of CIS because they have improved the schools' ability to fulfill their mission of quality patient care, education, and research. Illegible chart notes are no longer a problem for students and faculty, and users have access to their patients' information ubiquitously. For administrators and faculty, quality care assessments are not limited to surveys of "pulled charts." The digitalized database makes it feasible to track all patients. Student progress is monitored in real time, which allows faculty to identify students who need extra attention. In addition, patient databases can be mined to answer research questions.

Every dental school in the United States (59) and Canada (10) uses a CIS in some capacity. While a few schools use a homegrown system, most depend on commercial dental school software products such as Salud, Ice and Windent. The most popular CIS is Exan Enterprise's clinical management system, AxiUm, with over 39 clients. Exan has earned the majority of the market by offering customizable features, a modular design that allows for

growth and extensive reporting, and information manager tools. In addition, Exan is continuously soliciting their clients' feedback to guide themselves in updating and creating modules that schools can pick and choose from to meet new needs.

In the hospital and medical school setting, the barriers to realizing the optimal implementation of CIS have been documented. (5-13) Typically these barriers are not a reflection on the CIS itself, but of the organizational environment the CIS is integrated into. CIS implementation is more of an organizational issue than a technical problem.(14) While the impact of CIS on dental professionals could be expected to be as profound as on other health care providers, the effect on users in the dental environment has not been studied.

Dental care and schools have several commonalities with medical care and teaching hospital settings**.** In both settings, predoctoral students and residents are supervised by senior residents, and attending providers or faculty. In layout, dental school clinics closely resemble hospital emergency rooms, with open floor plans that make it convenient for providers to oversee the care of multiple patients but can also compromise patients' privacy. Most dental school treatment appointments involve ambulatory patients seeking routine surgical procedures, to restore teeth and gingiva. Hospital patients' needs span a broader spectrum of diseases and injury (with varying levels of urgency) and include in-patient care. The medications used in the dental school setting are typically limited to anesthetic, fluoride, sedation and pain control, where as in the hospital setting formularies have hundreds of drugs. The dental school care team is relatively small compared to the medical counterpart. Typically, a dental student or residents (overseen by a faculty member) provides direct patient care. On occasion, the dental student or resident may work with a fellow student, a dental assistant or a dental hygienist, or engage a specialist in consultation. Comparatively, medical residents provide patient care as part of a

larger health care team, made up of medical assistants, phlebotomists, pharmacists, nurses, etc. that they write orders to. In the dental and medical school setting students and residents complete documentation that is co-signed by the faculty. In teaching hospitals other members of the health care team are responsible for their facet of documentation.

While the scope of patient information is narrower in the dental patient record, dental health providers depend more heavily on graphics and images. Oral radiographs are a common component of a dental patient record. For routine care the dental care team relies on an "odontogram," a graphic depiction of the status and treatment needs of the 160 surfaces of the 32 permanent teeth and their roots. In addition, an adults' periodontal health is monitored on a periodontal chart, a separate visual representation of a patient's bone and gingival health. For each recording appointment, the periodontal chart can contain up to 192 values for pocket depths (colored coded to reflect the presence of bleeding or purulence) and 192 values for gingival attachment health.

To identify the impact of CIS on dental users, the authors conducted a qualitative case study at a dental school located in the western United States. The authors conducted interviews and focus groups with administrators, faculty, students, and residents, as well as, made observations of daily activities in the clinic and CIS training. A grounded theory approach to analysis revealed nine themes: CIS benefits, communication, emotions, instructor persona, power, time commitment, training and support, usability, and workflow. The purpose of this paper is to elucidate the impact of CIS implementation on users in the dental school setting.

METHODS

Site Selection

We selected the Western School of Dentistry (SoD) (a pseudonym) because it is representative of CIS implementations in dental schools nationwide. The study was conducted two years after a big bang implementation in one dental clinic, the pediatric clinic. This study was approved by the Institutional Review Board (IRB).

Site Description

Founded in the 19th century, the Western SoD is one of 67 dental schools in North America. The SoD is located in a major metropolitan area of two million people. The School provides services to approximately 20,000 adult and pediatric patients a year, within nearly 100,000 visits.

The Department of Pediatric Dentistry (DPD) opened the Pediatric Dental Clinic (PDC) recently in response to a community-identified need for dentists trained in children's care (pediatric dentistry). The PDC is supervised by 3 full-time faculty members (i.e., working 3 or more days per week) and 9 part-time faculty members (i.e., working 2 or fewer days per week). There are 8 pediatric dental residents and approximately 140 predoctoral dental students who rotate through the clinic each year.

The PDC has 15 open operatory bays to facilitate behavior modeling among child patients. This common dental clinic design puts unique constraints on CIS privacy issues. The clinical area is divided into two clinic rooms, one for pediatric dental residents (4 operatories) and the other for predoctoral students (11 operatories). Five single operatory rooms located off the main clinic are used for patients requiring oral or nitrous oxide sedation as part of their dental treatment. Each faculty member oversees 4-6 students and their patients concurrently.

Interviewee Selection

First we defined CIS users as individuals who used the CIS in some capacity. The term "user" includes both clinicians and nonclinicians, while "end-user" refers only to clinicians. The users fall out into four groups: 1) Administrators who use the CIS to manage school operations and performance, 2) Faculty (full and part-time instructors) who use the CIS for the Department of Pediatric Dentistry supervision, patients' clinical care and student instruction, 3) Support staff members who build and maintain the CIS, and 4) Students (pediatric residents and third and forth year predoctoral students) who use the system for patients' clinical care (see Appendix A for a list of user groups and the number and type of user group representatives). We selected formal interviewees using two complementary strategies. The first strategy was to tap representatives from each user group. The second strategy was to gain more depth within each user group by using the snowball sampling technique. This strategy invites interviewees to recommend other users to interview or invite to focus groups. (15) Focus groups were used to build synergistic interaction among users and capture multiple perspectives at one point in time. Informal interviews were conducted during observations whenever users' time and interest allowed.

Data Collection and Analysis

The authors used three data gathering techniques: interviews, focus groups and observation. Data collection and analysis occurred concurrently. The first author, a practicing dentist with informatics and qualitative research training, conducted all interviews and focus groups.

All authors took part in the analysis and interpretation phases of the study. Study data were collected from July through October 2007, with pilot study data collected the preceding May. Formal interviews and focus groups were recorded and transcribed. Field notes were

jotted by hand and expanded later (see Appendix B for a sample of field notes). The authors analyzed 99 pages of data using qualitative research software (NVivo 7, QSR International).

We used a semi-structured interview guide for the interviews and focus groups so questions could be tailored to users' perspectives (for example, administrator versus student) and users could digress on any topic that resonated. (15) Four predetermined topics were addressed in each interview, including user's computer background, CIS use, training, and concerns (see Appendix C for the Interview Guide). Interviews ranged in length from 60 to 90 minutes. Four users were individually interviewed for a total of 8 hours. Four focus group interviews were conducted (with three different user groups, 3-4 members per group) for a total of 5 hours.

Observations were made in the clinic and classroom (during CIS training sessions). Individual faculty members and students were shadowed for a total of five hours as they completed their clinic tasks. During observations, we conducted brief casual interviews. The authors attended two training sessions, one for pediatric dental residents and the other for predoctoral dental students, for a total of 3 hours.

The analysis of the data was an iterative process of coding, connecting and checking. To code the data we used the grounded theory approach, in which the codes emerge from the data rather than being listed under preconceived codes. (16) Codes were based on users' words, phrases or ideas. The resulting twenty-two codes were connected by a process of organizing, linking, listing, and discussion to develop patterns and 9 themes. (15) Internal validity was established by using triangulated data collection methods and multiple data analysts. Trustworthiness was established by using member checking, when we elicited feedback from users with whom we shared and discussed our 9 themes.

RESULTS

During analysis of the data, 9 themes emerged concerning the impact the CIS users perceived. Below, the 9 themes are presented with commentary and representative quotes from the transcripts. The themes are listed alphabetically. Subjects were promised confidentiality, so comments that revealed their identity have been edited. (See Appendix D for a list of themes, subthemes and users' comments designated by their user group affiliation.)

1. CIS benefits were disproportionate among users

Although computers are often touted as helpful, there was a definitive and unequal division of benefits among user groups. The administration described the largest gain, while end-users were more ambivalent about benefits.

Administration articulated the most and widest reaching benefits. Prior to the CIS, data had to be collected from surveys of paper charts and/or personal testimonies and experiences; decisions were often based on best estimates. The CIS fundamentally changed the quantity and quality of information that administrators could access and synthesize. An administrator commented, *"We are collecting objective information, that part I really like,"* and another said, *"We can track things, quicker, faster, better."* From monitoring operations to strategic planning, administrators utilized information from the CIS to make better informed decisions. Furthermore, their work depended on the information they could harness from the CIS. One administrator noted, *"Now that we have evolved, we couldn't do our work without computers."* Another administrator focused on the potential for capturing data electronically for clinical research purposes: *"…things like research are easier to get. Statistically significant sample of something, you can look at a lot of records instead of each one."*

Faculty had mixed reviews about the advantages of the CIS. The more administrative their responsibilities, the more directly they experienced the benefits. A faculty member with administrative responsibilities commented, *"One thing I like is the reports I can get on production and collections."* Another commented, *"I can get data real fast. Without a computer it would have been a lot harder to manage how much…[the students…have done."* Administrators recognized that faculty was not proactive in utilizing the CIS reporting ability*: "It was a long time after we went paperless that we even got asked for reports…it seems like largely the faculty hasn't used it, accept for accreditation."* A dental informatics staff member lamented the lack of faculty understanding about the benefits of the CIS: *"They have had the same response they would have had with a paper chart, 'It's a chart.'"* On the same subject, a faculty member indicated he understood that data could be beneficial but the effort to get them was too great, "*Yes, there is data in there, but it is not easy to use."* Another user commented that while the CIS could be used to get data, additional time to evaluate the data was necessary.

Although students could name several benefits, they considered the benefits to be negligible compared to the cost of using the system. Some features students particularly liked were not having to depend on auxiliary staff to access charts and having the clinical decision support available for prescription. A student shared, *"I like the paperless [system] better than the paper charts it is easier…we don't have to request for charts to come downstairs [from the chart room]."* Yet, students commented that the administration was the primary beneficiary of the CIS. *"From…[the administration's]…perspective they love it because it is command and control … but they're not using it from a clinical standpoint, so, there is a huge divide between how we see it and how they see it."* Since students have always had the CIS available to them in the PDC, they may not realize that the CIS allows administrators and faculty to get near

instantaneous information about student progress meeting clinical requirements. The breadth and availability of this information allows administration and faculty to identify students who need extra attention to succeed. This CIS benefit is especially helpful for struggling students who might fall through the cracks of a decentralized, slow paper grading system.

2. Communicating about the CIS was challenging

Communication that results in mutual understanding is challenging enough between any two people, and the CIS adds another level of complexity. Within a user group, and especially between users groups, individuals found it difficult to express themselves precisely about the impact of the CIS. Miscommunication resulted from a lack of shared vocabulary, empathy, and occasions to share.

Implementing a CIS increases the need for communication and can expose deficiencies. An administrator provided an analogy, "*Implementing a CIS is like the canary in the mine. Implementation reflects the overall communication in the organization."* While that analogy may be true, communication about the CIS adds another level of complexity. Communication requires a sender, message, receiver and an understanding of the meaning. Implementation of a CIS involves a new complex message that can be difficult to understand. There are new and changing sender-receiver relationships, i.e., end-user and CIS support staff members, students and administrators.

Having a meaningful exchange about the CIS is difficult between users who lack the same vocabulary. Except for the support staff, most users are familiar with computers but lack any detailed understanding of hardware or software. By default, everything having to do with the CIS is lumped together under the name of one of the software vendors. An administrator observed, "*We [everyone] don't say 'the electronic health record.'" When we talk about the*

system, we normally don't say 'the clinic information system.'" We normally say [Product X] …If it has anything to do with 'the computer' it is [Product X]. Even if the hardware is messed up it is [Product X], '[Product X] is not working', [Product X] is not printing.' Most users don't make any differentiation at all." One faculty member labeled everything associated with the CIS as "the machine." Commenting on the inability to communicate effectively, an administrator stated, *"It is the classic problem, they [the end users] says 'My computer isn't working!' or 'My file went away!' And the first thing the…[support] person says is, 'What did you do?', and they say, '…I can't tell you what I did!'"*

When people represent different perspectives, it can take extra effort to understand each other's motivation. Users were typically quick to self identify themselves as a certain type user, including that of academic, "computer geek," curmudgeon, dentist, director, employee, end-user, informatician, instructor, "old guy," part-time instructor (and continuing to maintain a private practice), purchaser, student, supervisor, technical support, or some combination of the above. Users found it challenging to empathize with one another's CIS experience. A faculty member commented, *"We don't all think the same way…someone…will walk in here and after they describe it [the problem], you'll wonder, 'Are they looking at the same thing I am?' People don't hear and perceive things the same way. People don't fully understand what people are trying to say."* Administrators purposively spent time in the clinics to learn the struggles end users tried to articulate, *"I think the other thing is for us to go down, like we do, and live in it, try to do it, to experience the frustration first hand."*

When users want to work together to create a solution, the lack of mutual understanding stifles progress. Although some end-users suggested that all of the information problems could be solved if the school returned to paper charts, most users accepted that the transition to the

electronic system was permanent. Nearly everyone was committed to improving the system. A faculty member said, *"If we have to live with it, let's make it better. We don't want it to be painful."* However, they found it challenging to build a consensus around the best methods or goals. A faculty member commented, *"A big part of the problem [around the CIS] is communication…Everyone has different levels [of familiarity with computers]."* Administrators concurred, *"When you ask them [end-users] about the computer problem, they have a hard time describing it in a way that can be understood."*

Frequent communication between user groups was necessary to sustain and maximize the CIS. Unlike paper records, which can be modified by writing in the margins, CIS are configured. CIS rules prevent users from leaving forms blank and dictate how information will be captured. Consequently, users can feel affronted by the limitations imposed on them by the CIS. Thus, the CIS is constantly under revision as user groups work to articulate and better match the system to their needs. A faculty member commented, *"It is a constant back and forth, and trying to change."* The never ending CIS project can be emotionally taxing. It requires that everyone move from focusing on the people involved to concentrate on the problem. An administrator commented, *"You have to get thick skinned and not defensive…It feels personal. You have to let go of that, and that is kind of hard. And say, 'Ok, that doesn't work for you, what would work? Can we figure out a way to fix this?'"*

3. Users experienced a range of strong emotions

Users articulated an emotional response to the CIS implementation that ran the spectrum of positive to negative. Most individuals experienced a wide range of feelings, but the sources tended to fall along user groups. The origins of users' feelings revolved around four issues: the technology, the implementation process, their ability to influence the process, and their ability to

communicate about their experience and the CIS. General comments organized into three subthemes.

Positive emotions, including interest, enthusiasm and appreciation, were felt across user groups. One administrator suggested there is something inherent about being a dentist that predisposes them to liking computers. *"I think dentists as a group are very interested in computers. We [dentists] generally like gadgets. Even if we are concerned it is going to change how we work, or we need to learn something new, overall…we are interested in them [computers]."* An optimistic attitude among faculty and students frequently stemmed from the belief that users were part of something monumental. Over and over again, faculty member and students comments reflected their pride. *"Computers are the future." "I was excited about a 'paperless' system."* Administrators expressed their gratitude for the technology, *"I love them [computers]"* and *"Computers are great, I don't have any problems with using them*."

Negative emotions expressed as disappointment and disillusionment stemmed from unmet expectations, especially among faculty members. It was common for faculty to assume the CIS would function similar to the paper chart. A faculty member stated, *"The [CIS] project was to duplicate what we do [with paper]."* Furthermore, many expected the CIS to be even better than paper. A faculty member stated, *"The whole idea with going paperless is to decrease our time and paperwork, so we can spend more time with patients and students…and it hasn't happened yet."* The incongruencies the faculty perceived were a let down. *"…the computers are not the positive change that I would have imagined when I started." "… it is really frustrating, we are working with it…but it's not perfect…"*

Although users tended to entrench themselves in either the positive or negative camp most interviewees offered at least one ramification of the CIS they liked and another they

disliked. A support staff member recognized the dichotomy of the physical response CIS use can evoke, *"There is a love/hate thing about it [the CIS]."*

4. The instructor persona diminished

Faculty members take great pride in instructing their students well in patient management, clinical techniques and treatment philosophy. Traditionally, the instructor's persona is of an expert and authority on everything related to patient care. However, this perception does not frequently carry over to CIS use because a faculty member is not the ultimate expert or authority when patient care involves the CIS.

When faculty members did not have a thorough understanding of the CIS, they found clinical instruction difficult. Digital radiography was commonly cited as an example of an uncomfortable expanded teaching domain. One faculty member noted, *"…when you [the student] have a problem, I have to figure out what is wrong. You're a student, you don't know, all you know is that when you take a film you hit the enhance button."* One element of digital x-ray interpretation is temporary manipulation of the dental image. An administrator commented, *"…obviously we are not letting go [of] something that is not diagnostic in quality but we have to adjust the image more."* Faculty members used to working with static film could find the image manipulation process puzzling to understand and awkward to teach. One faculty member came to the conclusion that digital images were inferior to film because the images were malleable. *"If we are spending time with every image that is taken, we do the clarifier, the highlighter, and the contrast button, that is telling me, with every [digital image], something is wrong."* A few faculty members concluded that incorporating the CIS into patient care frustratingly shifted their focus as instructors from students to the CIS. *"…I want to teach the students about dentistry, and have the patient as the focus [not the CIS]."*

In some clinical situations, the student is more knowledgeable about the CIS than the faculty member. Familiarity often comes with experience. Students use the CIS in some capacity daily, while faculty, especially those part-time faculty, usually work in dental school clinics three, or fewer days a week at the dental school. A student remarked, *"I think they [faculty] tend to rely on the student or resident. They will say 'this [radiograph] doesn't look good, can you adjust it?' because they [students] are more familiar with it."* Students can be so much more skilled with the CIS that the teacher-student role is reversed. A faculty member may be dependent on a student to enter or locate patient information within the CIS. One student observed, *"I see the…[students]…keep asking the faculty, 'How do I do this? How do I put that in?' The faculty doesn't know. I think the students know more than the faculty because they use it everyday."*

When faculty members perceive themselves as dental care experts, they are uncomfortable with the image they project when they experience difficulty with the CIS. A few faculty members commented on the how the CIS added another layer of complexity to their jobs. *"A third dimension is added on [to patient care and instruction], a lot of things get tied up in this."* Faculty thought of themselves as "good with their hands", so when they were "all thumbs" with the CIS keyboard and finger pad they could be frustrated. An administrator noticed, *"They [many of the faculty members] don't know how to type, they are uncomfortable with it."* Most hurtles for faculty were around perceived CIS usability and skill in using the CIS. Faculty commented that they felt so inept in front of students and patients, they were embarrassed. A faculty member shared what he experienced. *"…we [faculty] get errors…I am 'Not a Known User' or something like that…and I am making...comments to the students because the parents are looking at me like I am really dumb."*

5. There was variation in how users' time was impacted

Some of the new clinical processes developed to utilize the CIS were thought to be more time consuming than replaced paper processes. For example, patient agreement and consent forms used to be filled out and signed chairside or at the front office desk. With the CIS, these forms are filled out on a chairside workstation. Then, due to the limited number of electronic signature pads, the student and parent had to relocate to a centrally located shared computer station to capture the parent's signature. A faculty member noticed, *"If I had the paper [consent] form for you to sign, it would be quicker."* While the paper process might have been quicker, quality control was harder. If no one checked or noticed, required documents could be left unsigned, but the CIS has built-in warnings and triggers that ensure the forms are signed. Other examples are the medical history form and diagnostic data. The previous medical history process was for the patient's parent to fill out the medical history form out while in the reception area, the student would than review the form chairside and place it into the patient chart. The new electronic process required the student to enter the form's data into the system. A faculty member mentioned, *"…it [the process] needs to be more efficient. The … [students]… waste a lot of time typing information in..."* Because the task of typing in diagnostic data was so time consuming compared to writing, to conserve appointment time, some students developed their own paper forms to capture information with the intent to transfer the information later.

Implementation of a CIS affects how faculty and students spend their time interacting with patients and each other. End-users believed they were spending more time staring at the monitor and less face-to-face time with their patients. A few students joked, *"I spend more time on the computer than with patients."* With a paper chart sitting on their laps, students could make constant eye contact with their patients as they filled out forms. Because the clinic's computer

stations are located behind the operatory chairs, it is awkward for faculty members and students to make eye contact with patients and/or parents while completing documentation. In addition, faculty and students believe they spend less time interacting with each other. A faculty member commented, *"I spend over half of my clinic time working with the CIS, as opposed to…how I used to spend my time talking to the students. They're entering things on their computers and I am entering things on computers."*

It was difficult for administrators to recognize how much time to spend engaging end-users in CIS implementation. Faculty and students are primarily focused on clinical care, so asking them to participate in CIS implementation meetings did not seem an efficient use of their time. Walking the thin line between over-involving or under-involving end-users, the administrators chose the latter. An administrator stated, *"Sometimes we try to think up things. We say, 'Hey, would it be helpful to you?' and sometimes we just hand things out to them."* Furthermore, the implementation meetings focus on detailed aspects end-users might find tedious. A support staff member stated, "*They [faculty]…weren't part of the weekly meetings. That was us making those decisions because, if they [faculty] had been involved in that, that would have been too much of a tangled mess."*

Learning how to efficiently use the CIS can be a time intensive process for faculty. In describing the minimum amount of training necessary to get up and running, a faculty member stated, *"…the learning curve is huge."* Some faculty members did not want to make the necessary time investment to learn the CIS as well as they did the paper chart. *"… many of them are…not interested in taking the time to learn a new system."* Consequently, faculty members relied heavily on students to navigate the CIS, *"It [the CIS] is just complicated enough that I will ask the students to help me do it. My education has big holes in it."* An administrator stated,

"We didn't realize the learning curve with the faculty was so wide and they were resistant to the change from paper." However, administrators noticed that faculty who use a CIS in their own clinics made the transition easier. *"If they use it in their private practice, it is not a big deal for them."*

Required use of the CIS changed the balance faculty had between student instruction and evaluation. Faculty felt they shouldered a disproportionate amount of new work and responsibility around student instruction and evaluation. When talking about the magnitude of his responsibilities, one faculty member commented, *"I am sitting here doing five different things at one time. You almost have to be a little ADHD for this job."* Some faculty members perceived they that have to make a choice between student instruction and student evaluation. "*We…are used to spending a lot of time with the students, and now we spend a lot of time going through all this computer work..."*

6. The training and support needs of end-users were significant

End-users commented frequently that their training and support needs were not being met. There were many issues around training and support that were unclear to administrators, faculty and students alike. The list included when, how often, how much, in what format, and by whom the training and support should be handled.

Although end-users were provided training, they did not feel adequately trained. End-users receive a combination of class demonstrations, access to a customized CIS manual, and in-clinic group training. However, most end-users stated they have not learned everything they need to know to succeed. A faculty member recognized, *"I think the trainers did a good job but everything I know I learned in the clinic, the information is so massive I don't think I remembered how to do anything one hour after I left [the training]*." End-users reflected on

their inability to translate what they learned about the CIS into practice. A student commented, *"When you are looking at the computer screen [projected during training,] you're like 'that's easy' and then you go to do it and you're like, 'how did they do that?'"* Another student stated, *"They [CIS trainers] went through it and there was about 100 things to remember. To remember it, I need to see it again and again. I know they can't go through it five times."* A faculty member commented, *"It is better if you sit me down and walk me through it one on one. If I am in the river, throw me a line and keep bringing me back to shore."* To just make it through CIS procedures, end-users, especially students, learned by trying or asking each other. Two students lamented, *"The students are self taught [about the CIS]"* and *"We learn as we go…"* An administrator noted, *"A lot of times the students are asking each other and sometimes they are not getting quite the right information."*

Administration and faculty members were unclear who would best train end-users. Instruction on patient care and the CIS system requires a familiarity with its components, dental terminology and clinical processes. Because the CIS is an integral component of patient care that relies on information technology, there was not an obvious delineation of who should train end-users, faculty or administrators, and what was the role of the support staff members. Commenting on the confusion of who should instruct, an administrator stated, *"The frustrating part about training is that it goes back between the clinical versus the system. It kind of gets thrown in together."* Given the limited lecture time pediatric faculty had with predoctoral students they believed there was insufficient time to adequately cover the CIS and patient care. *"Although we can be part of the training, we don't have enough class time with the students [to do clinical instruction and CIS instruction]."* Furthermore, in the clinic, faculty thought training and support would be best handled by CIS professionals, so they could focus on patient care.

"*The training should be done by [CIS] professionals…I am the end user, I don't have the time in the clinic to deal with computers and software [support].*"

There was also confusion around where, how and when training would best be accomplished. Administrators and faculty commented on the lack of knowledge about the ideal training method for end-users. Should training occur one-on-one, in small groups, in the classroom, in the clinic, or all of these? Using a manual, lecturing, or working on mock patient scenarios? Before clinic begins or during clinic? Frustrated with an in-class exercise, a student stated, "*The way they do it is adequate but it isn't easy to learn…they are trying to project it [on a screen] and you can't learn that way.*" Manuals are available but were rarely seen used. A student stated, "*They did give us a big packet, [but] I didn't have time to go through it.*" Students commented that they appreciated mock patient scenarios completed in unison. Yet, an administrator commented that the simulated CIS exercises completed on fake patients were not enough. "*Even if we have them do exercises, in what we call 'teach me patients,' it seems not to stick until they have to do it for themselves.*" While official training was completed before clinic started, administrators noticed students took training more seriously once they were in the clinics. An administrator said, "*You try to train people right before they need it. Honestly, some of them are pretty apathetic. Then they get into the clinic and they need it, they know they need it and they panic.*" Ultimately, many end-users said they learned from each other and from "trial and error."

End-users' support needs were time sensitive, intense and never ending. Because the CIS was integrated into every aspect of patient care (intake, diagnosis, treatment planning, treatment, etc.) and housed the patient's entire record end-users could not provide care without it. Administrators recognized that when end-users were working with patients and needed CIS

support, that support was needed immediately, *"They [the student and faculty] need help, they have someone in the chair...they need it fixed right there."* The amount of staff necessary to provide that high level of support constantly was not possible. An administrator lamented, *"I know they wish we had somebody [CIS expert] down there full time helping them, everyday. That would be great. I think that would be great, too, but we just don't have enough people to do that."*

Faculty and students had requests for support that were impossible to meet. End-users were frustrated with the softwares' color, font size, load-up time, screen lay out, accessibility, and usability. In addition, end-users were frustrated with the hardware's usability, location, size, and impact on workflow. End-users believed it was the responsibility of administrators and support staff to address and, when possible, solve these problems. One faculty member stated, *"That problem should be really easy to fix…the type of change that can be made in a day, but [apparently] it can't be done."* Because end-users did not understand how the CIS worked, they typically overestimated the control and abilities of the administrators and support staff. Furthermore, the CIS Team made a decision during implementation to create school wide standards and not customize the software to every end-users' preferences (for example, the electronic patient chart always opens to the latest odontogram although some end-users might prefer to see the medical history first). A support staff member commented about end-users' seemingly unrealistic requests, *"Sometimes it is just not a proper understanding of like how the system works."* When describing complaints about the software, a support staff member confessed, *"Truth be told, 90% of those things [end-user complaints] are things we can never do anything about."*

7. There were shifts in the school's power structure

The authors found all user groups commented on the impact the CIS made on their and others' control, choices and decision making processes. While no one explicitly used the word "power," their comments were rooted in issues involving power. Within this theme, three types of shifts emerged: expanded power, diminished power and unclear power.

Decisions about CIS implementation involved stakeholders with unique and overlapping responsibilities and this led to unclear power among administrators, support staff members, and faculty. It wasn't always clear which administrators, support staff members and faculty should be included in any decision, and who had the power to make the final decision. Questions around the CIS are frequently complex. They may involve an administrative, clinical, financial, teaching, or technical component, or some combination of the above. For example, "What should our grading form look like?" or "Which digital film processor is best?" The questions involve multiple perspectives but it can be challenging to solicit timely, informed input. Ultimately, decisions had to be made that did not involve everyone who wanted to be included. An administrator commented, *"We could probably do a better of job of going back to every group and saying, '…What would help you? What would be useful for you to know?'"* Another administrator commented that hardware decisions were made by the department that would have been better if the administration was included.

The CIS Team, made up of administrators and support staff, gained expanded power over the Pediatric Department as they led the specification process. To develop the list of specifications, the CIS Team devised a three step process. First, they worked with the Pediatric Department faculty to evaluate their current procedures and needs. This step gave the administrators an opportunity to critically review the Pediatric Department forms and make

recommendations. A support staff member remembered, *"They [administrators] had some question about their [DPD] forms. There was some redundancy that we tried to eliminate."* Second, the CIS Team evaluated the needs of the Pediatric Department in respect to their own needs and the anticipated need of the school's other departments. Third, the CIS Team created the final specifications. A support staff member noted that the CIS Team retained the final authority because the specifications had to be generalizable to the entire school, *"The majority of the decision making went on in the CIS [Team] meetings because the decisions that were being made in the Pediatric Department had to comply with whatever will be needed in the future for the whole dental school going electronic."*

Clinicians (aka end-users) were concerned that they were losing control over their practice. One faculty member stated, *"We [DPD] didn't have a choice, we were told that 'this is what the school is using'..."* While the CIS Team included two dentists (both administrators, one also a practicing clinician) the Team did not include a faculty pediatric dentist. The faculty was weary of the dichotomy between CIS implementers and end-users. The faculty observed they were held responsible for the care students provided to patients under their supervision. Yet, the faculty had little authority over the implementation of the CIS that impacted how they provided patient care. Furthermore, the CIS Team was not intimately involved in the day-to-day operations of the PC, so end-users questioned whether or not their needs could be well understood. A student stated, *"They [CIS Team members] really aren't familiar with what is going on down here in the trenches."*

The Department of Pediatric Dentistry faculty did not have the power to tailor electronic forms to meet their specific needs. Faculty were excited about the potential the CIS gave them to increase the speed and quality of documentation. However, they were disillusioned by the

hurdles they experienced to creating that change. The process to institutionalize modifications to the paper and electronic forms were identical: suggestions are reviewed and approved by the School's Quality Assurance Committee (QAC). However, with the advent of a school wide CIS, the QAC must, more than ever before, balance the needs and desires of each department against the entire school. An administrator commented, *"Sometimes something [involving the CIS] is developed and it doesn't fit everything."* Thus, the needs and desires of the DPD were sometimes outweighed by others and a compromise that did not satisfy everyone had to be made. For example, some faculty thought the SoD should take advantage of the CIS software's ability to support progress note templates to assist end-users. The CIS Team, in consultation with DPD faculty, decided pre-existing notes were not in the best interest of students' education. The template feature was not utilized. A disappointed faculty member observed, *"Ninety-nine percent of what we [the DPD] do, I could make into a few basic templates…We are not doing a lot of extra fancy stuff."*

8. Lack of CIS usability made documentation cumbersome

Usability is commonly defined as "ease of use." End-users believed a lack of CIS usability resulted in their having to spend more time working with patients' electronic records, compared to paper charts. For the purposes of this paper, usability reflects both software and hardware issues.

When compared to having a chart chairside, initiating the documentation process takes more coordination on the part of the end-user. The old process of locating the paper chart was not always smooth but once the chart was in hand, patient information could be easily located. To get a chart a student was expected to go to the chartroom where they filled out a form to check-out the chart, and after the student had the patient's paper charts in hand, he would carry it

to the PC, where he could open the record to any section. The CIS process different. The record is available from any clinic computer but the end-user has to go through several steps to access patient information. The CIS documentation process involved several steps on the part of end-users to access a patient's record, including identifying an unused computer, ergonomically adjusting the workstations, logging into the software, and uploading opening the needed CIS programs or applications. Faculty comfort and skill in navigating the electronic chart impacted their perception of access to information. While there haven't been any dental emergencies in the clinic where the management was hampered by the CIS, but a faculty member could imagine a scenario where accessing a patient's information via the CIS posed a problem. *"Is he [the patient] epileptic? Is he asthmatic? What kind of medicine did you give him? How much does he weigh? I need to get to that information faster than I think I can."*

Although the electronic patient record resembled its paper precursor, end-users could not transfer the old documentation process to the new electronic record. Faculty and students were not clear on how to enter information in an electronic format. For example, we observed a student who was confused about filling out the electronic odontogram. He asked his supervising faculty member, *"How do we put in current restorations?"* to which the member replied, *"Don't get hung up on that. Write it down on paper and we'll figure out how to enter it later."* With the paper form the student would have had to circle either the letter or number that corresponded to the location of each tooth while the electronic record required the student to click on the default tooth number which then became a letter. Another faculty member was frustrated that electronic forms required completion of new, and what he considered silly, time-consuming questions. As an example he provided: *"Every time you put in a treatment…[into the CIS] you have to make sure you [the student] selects 'PEDO" for every procedure. Well, it's a pedo clinic! Why do*

you have to enter 'PEDO'…if the answer is always 'PEDO?" Because the CIS is used school-wide, end-users have to identify which discipline a proposed procedure is supposed to be completed in when it overlapped with another discipline. For example, tooth restorations have the same clinical procedure codes (as delineated by the ADA and by insurance companies for billing) regardless of whether the restoration is completed on a child or adult. A few end-users thought the CIS should automatically label the procedure based on the patient's age or that the work station was located in the pediatric clinic.

The electronic format of the patient record limited what information was captured. With paper charts end-users could adapt forms to their needs. A faculty member commented, *"If a paper form doesn't work well…, or there is some other thing they [the clinicians] want to do, they just write it in the margin, or they change it. Well, there is no margin to write in, in the electronic record [CIS]."* The CIS standardizes data entry into one of three forms: either drop-down list boxes, option buttons or sized free text boxes. For some students, the required format was not the preferred format. For example, during observation, several students commented that the five options available on the list to classify a pediatric patient's behavior were insufficient (even though the categories were the same as those available on the previous paper forms and were the categories preferred by the pediatric faculty). They said describing their patients' behavior in free text would be much more helpful to them in future appointments. But categorization of data provides easier means of analysis or reporting, which is not always evident or valued by the end-user. The limited size of the free text boxes was also a frustration. A student remarked, *"…some of…[us]…want to add more [information] but the line is only [student makes a small space with index finger and thumb], you can't type over that amount so you choose what words are important and you put down those words."* Ultimately, end-users

concluded the electronic format limited their ability to document with the same richness as the paper chart.

Because the presentation of electronic information was different than on paper, end-users found it challenging to synthesize information. End-users held specific mental models, based on paper forms that framed how recorded information would be presented. (These formats could be common, for example, "CC" for chief complaint, or individual specific.) When the electronic format deviated from the anticipated format, end-users could be confused or unaware of the information. For example, one experienced student used to the traditional presentation of medical alert information as a large red cross located at the top of the medical history form did not appreciate the red rectangle medical alert button located on the toolbar at the bottom of the screen. The student stated stated, *"If they [the patient] had a heart defect, you [the dentist] would never know it from the [CIS] screen."* A faculty member indicated that the electronic format hampered how he flagged himself, *"I want to look at the record and say, 'This is what I did before and this is what I am going to do now' and I want to reference that…with a star...."* Furthermore, with a paper form, all of the text is visible, but electronically formatted information can be hidden. The most work for end-users involved list boxes that contracted to the chosen item, text boxes that collapsed so only the first line was visible and electronic forms longer than one screen in length that had to be scrolled.

9. Clinician's workflow was disrupted

Workflow is defined as the order of a set of tasks performed by various agents to complete a given procedure within an organization. Changes in workflow were the most tangible change for users. Administrators, faculty members, and students found it easy to articulate how the CIS implementation affected how they accomplished their worked.

Consequently, end-users stated they had to rely more on memory with CIS documentation compared to paper.

CIS hardware size and location were obstacles to faculty and students' ability to provide patient care. To create more floor space in the small operatories, the flat screen monitors and keyboards were attached to wall mounted trays that allowed the keyboard to be flipped up against the monitors and the computer work station pushed against the wall. With this arrangement, the computer workstations took up prime operatory space at the head of the dental chair where the students worked on their patients. Ultimately, end-users felt they had to decide between access to patient information and to work space. We observed that reviewing the electronic record chairside was so physically cumbersome for faculty and students they would finish with the CIS before seating the patient for treatment. A student stated, *"I review them [digital x-rays] in the morning but in general I don't review them sitting at my [operatory] chair."* A faculty member stated, *"I would love to sit down with the students and look at the patient's [electronic] chart in the morning…but that is a pain…so I did it before clinic [alone]."* Initial exams required access to the CIS, so students would just make do.

Patient information accessibility impacted the opportunities faculty had to teach students. With a paper chart, patient information was easily accessible, the paper chart would be housed on the counter, and the x-ray films would be on the viewbox. With the computer workstation, the keyboard folded against the monitor made it hard to access and view patient's information without interrupting the working student. A faculty member commented on how the CIS impacted his ability to monitor students. *"There is something about having the films right there [on the viewbox] when a student is working on a patient, that I can look over their shoulder and assess that everything [patient and treatment] is right,"* A faculty member observed this lack of

convenient patient information translated into fewer teaching opportunities, *"It would be nice if I could easily look at the film so we could talk about [treatment] philosophy…"* Furthermore, the CIS provides institutional enforcement of HIPAA regulations (time-out), which protect patients' privacy but impinge on end-user workflow. A faculty member noted, *"… I want to have films up, but they [digital images] will disappear [screen times out] when I am in the middle of discussing something about them with the student."*

Another obstacle of CIS documentation was the limited hardware. Electronic informed consent required digital signature capture pads. There were only three available, and all were attached to the shared workstations at the entrance of the clinic. As a result, students and patients' parents would pair up and form a line at the workstation waiting for an available pad to complete the consent process. An administrator empathized with the parents, *"It is not the type of environment that says, 'Take your time, get all your questions answered.'"* Then, if a patient wanted a copy of the completed forms, he would have to wait for a hard copy to print on one of the two public printers.

The CIS documentation process was physically awkward and required a higher cognitive load. With a paper chart, faculty members and students can have access to multiples sources of information with ease and in some instances simultaneously. For example, the clinician may view the x-rays on the light box (or monitor) while having the patient's chart open to the odontogram, periodontal charting or progress notes. In addition, the end-user can quickly flip between chart sections. When capturing a patient's information in the CIS, the student is expected to open a variety of independent software programs and applications to view a patient's treatment plan, x-rays, etc. The steps required to access the appropriate, and often multiple, components of the CIS were perceived as more cumbersome and time consuming than opening a

patient's available paper chart. Students commented that the process was disjointed because they had to toggle between the software programs and applications, using an awkward 2" x 2" keyboard finger pad while focusing on remembering patient information. One student shared *"…some of its inefficiency on the way it is setup, there is not a good flow to it, it takes me much longer for me to do stuff."*

Since the CIS can enforce completion of electronic forms prior to acceptance, end-users got held up in data entry. The paper documentation process was considered more adaptable, unclear intake questions could be left blank with the intent to answer them at a more convenient time (or never) and comments could be written in the margin. These omissions could never be fully rectified by the quality assurance review because the large quantity of patient encounters that required their audits utilize only samples of charts. Consequently, identification of errors across all records was difficult and clinicians were only modestly regulated. With the CIS, the end-users' completion of all form questions is verified electronically so the end-user does not have the option to leave required questions unanswered; the end-user must provide some type of answer to complete documentation. Thus, when confusion arises, an end-user must decide between finding a resource that will inform him how to answer the question, making his best guess at what the question is asking, or providing an arbitrary answer. Whatever the decision, ultimately end-users' documentation with the CIS had the potential to be more thorough but at the expense of end-users' discretion and workflow.

The faculty and students found the electronic approval process interrupted their workflow. Prior to the CIS, faculty signed paper forms to approve patient treatment plans, completion of treatment, and student grading. With the CIS, this process is electronic and requires faculty use a personal electronic badge. Although a card reader is attached to the

workstation of every operatory, the electronic approval process was awkward for several reasons. One, getting faculty approval required the student to locate the faculty member and bring them to their operatory, compared to carrying the paper forms to the supervising faculty member. Two, it often took multiple swipes before the card registered. We observed faculty members swiping once and walking away from the student's operatory, having incorrectly assumed the swipe had registered. A faculty member stated, *"Every time there is a change or add on, the faculty have to swipe it [card reader], every time you do that there is a couple of swipes to get one patient done, and we have an average seven or eight students to take care of at a time, I don't want to deal with that…"* A student concurred, *"It takes four million swipes to get everything done, it's ridiculous."* If at a shared workstation, the faculty needed to log off after swiping, which added another step they often forgot to execute.

Incompatible hardware and software created new work. Incompatibility issues in documentation hardware made inputting data cumbersome. For example, oral sedation patients were monitored with a pulse oximeter. Prior to the CIS, students were supposed to place the pulse oximeter printouts into the paper chart pocket. With the CIS, the pulse oximeter device could not transmit data electronically to the CIS so the output had to be scanned in manually by support staff. Students would staple data printouts to a "Request to scan form" that they walked to the support staff's inbox. A faculty member stated, "*We have to scan in the pulse oximeter [paper output]... the interface doesn't let you connect it to the computer...*" An example of software incompatibility existed between the dental school and neighboring hospital, where residents with faculty saw children who required general anesthesia. The hospital and dental school CIS could share demographic information but not patient records. Thus, students had to generate hardcopies of patients' medical history forms. A faculty member commented, "*The*

hospital needed a special form for the OR [operating room]. We still have problems [with interoperability between the hospital and dental school CIS].

DISCUSSION/RECOMMENDATIONS

This study evaluated the impact of a CIS implementation on users, including administrators, faculty members and students. The authors conducted interviews and focus groups, and observed end-users in training and interacting with the CIS. Users repeatedly commented on similar issues and experienced related situations in the field. We identified nine themes that represent potential obstacles to a successful CIS implementation. Below, suggestions to mitigate the impact of the hurdles are discussed. These suggestions can be used to improve CIS implementation.

***CIS benefits are disproportionate among user groups*:** Users don't experience all the benefits of CIS equally. Since user groups experience distinct benefits at different times, it is important that the benefits end-users believe administrators receive are trickled down to the end-user. Administrators have the most immediate benefits, at what end users might consider their expense. Some of the better known benefits to end-users are legible records, continuously available patient records, and clinical decision support. Students have instant grading and feedback on their performance. Standardized electronic data can be efficiently mined for clinical decision support and quality assurance. Implementers, and especially trainers, need to give special attention to the benefits end-users might receive. They should reiterate the accomplishments made possible by the CIS, such as improved quality of care, research and instruction.

Communicating about CIS problems was challenging: Communication is vital to success, so implementers should make communication a priority. More communication, both more frequent

and more detailed, is likely necessary than ever before. Implementers can improve users' ability to communicate by developing their CIS-related vocabulary and understanding of CIS and its impact. They can develop formal communication channels that end-users can access easily, such as a helpline or comments box. They can encourage constant two-way communication among all users. They can report on user suggestions and resulting changes. To sustain and maximize the CIS, administrators should spend time in the clinic observing. CIS improvements require that everyone move from focusing on the personalities of the people involved to concentrating on the problem.

Users experienced a range of strong emotions: Because negative emotions stemmed from unmet expectations, implementers should work proactively to capture and correct end-users' expectations to alleviate frustration and anxiety. Some end-users might wrongly anticipate the CIS will make them into a "SuperDentist" with the instant ability to document faster, make clinical decisions easier and improve patient care. One user expected the CIS to improve his abilities similar to the abilities amateur photographers achieve with Photoshop. Implementers must understand that end-users' expectations can change with education**.** It is impossible to build a perfect CIS, but you can build a better process to handle CIS imperfections.

The instructor persona diminished: The old paradigm of faculty as those with the experience and expertise may be dead. To improve the faculty's experience with the CIS, implementers need to address the changes the changes a CIS makes to the clinical education and expertise needed as an instructor. Faculty members require ongoing training and support options. Implementers must evaluate how dental clinical education is changing and what that means for faculty training, and faculty representatives should sit CIS implementation team.

There was variation in users' time commitments: How faculty and students spend time with patients is changing. End-users may need to spend more time on the CIS then previous paper processes. It could be beneficial for all users to identify timesinks and work to resolve them. Potential time sinks include medical history intake, new patient exam documentation, digital radiograph interpretation and disease diagnosis, electronic informed consent, and faculty approval. Implementors should evaluate workflow at both the individual and clinic level to identify possible inefficiencies.

Training and support needs of users were significant: Training and support has a major impact on end-users experience with the CIS focus on training and support. If end-users perceive training and support as inadequate, interacting with the CIS is problematic. Because CIS training involves both technical and clinical component, it requires CIS experts and clinicians. Training needs vary considerably, and an ideal training method is not the same for everyone. Training is time consuming. Introducing the CIS in the simulation or preclinical setting will familiarize students with the system so that by the time they reach the clinic, they are comfortable. End-user training should be tailored around end-user workflow, not CIS functions. Train super users within the department to act as frontline support. Make immediate chair-side support available to clinicians.

There were shifts in the school's power structure: While some users considered CIS implementation to affect the delineation of power positively, others considered the effect to be negative. For most, an increase in power was beneficial and a loss of power was detrimental. For some, the shifts in power improved patient care and student education, while others believed the shifts were a deterrent. Unclear power was especially frustrating for all involved. CIS implementation creates new work and someone must determine who is responsible for that work.

Implementers must delineate clear lines of responsibility for evaluation, purchasing, training and support. They should involve end-users (clinicians) as much as possible. CIS development is a never ending iterative process. Solicit end-user input consistently and constantly. Implementers should convince users that standardization can lead to improved patient care quality.

Lack of usability made documentation burdensome: Users must realize documentation may take longer, especially when they are learning the system. To increase usability, implementers should continuously incorporate user-centered designs that make it easy for clinicians to enter and access information, and avoid "too many clicks" and the "scrolly-ollies." A balance must be struck between maximizing the benefits of an electronic system and providing educational opportunities, for example, requiring students to enter both a patient's weight in kilograms and pounds, instead of automating it. Implementers shouldn't underestimate end-users appreciation of "small" CIS automations, such as age appropriate odontograms or "PEDO" classification. As appropriate, implementers should give end-users the ability to personalize documentation. The benefit of electronically formatted data is that it can be easily evaluated for quality control and research.

Clinician's workflow is disrupted: Implementers should recognize what processes should be standardized, and, if possible, try to standardize processes prior to implementation. They should identify how CIS implementation will support end-users. There could be a place for paper in a "paperless" system, such as, medical history, the day's treatment plan, etc. After implementation, implementers should look for workflow bottlenecks (such as, faculty approval, chart review, diagnosis) that need to be addressed by either a change in process or the CIS. To identify unclear questions consider adding an option of "I don't know." Implementers should evaluate the number and location of hardware, including, computers, monitors, printers,

signature pads and x-ray developers. Careful consideration should be given to institutional enforcement of HIPAA time-out regulations that do not meet dental students' needs. They must recognize when information is presented in a different format, cognitive processes are disrupted.

FUTURE DIRECTIONS

Although CIS have been in used in dental environments for over 15 years, this is the first study evaluating their impact on dental users so further investigation is needed. Since the majority of work evaluating the impact of CIS (and their components) has focused on the medical setting, especially academic hospitals, it could be mutually beneficial to evaluate the similarities and differences between the two. In comparing their respective environments, users, systems and impact, we might better understand the intrinsic qualities of CIS integration in the patient care setting. To achieve the improvements in education, research and patient care, dental schools must explore the challenges CIS impose on faculty members' ability to manage patients and instruct students. Furthermore, it would be wise to study how chairside CIS integration affects the development of students' patient management skills.

LIMITATIONS

This work is a case study of a big bang implementation within one department of one dental school. The results are not necessarily generalizable, but could be transferable to other dental departments and schools. Although CIS users commented on the previous paper-based system, the system was not studied. Coding was completed by only one author, though the coding scheme was verified by additional researchers.

CONCLUSION

Clinical information systems are becoming standard in North American dental schools because of their many advantages over paper-based systems; yet, their impact is not well

understood. CIS integration into patient care and student education impacts the experience of users in profound and unclear ways. When administrators, faculty and students understand the impact of CIS, they can work cooperatively to address any deleterious components. Recognizing the need to address issues around the CIS, one user stated what he would like to be asked and what he would like to ask others. *"Ok, that doesn't work for you, what would work? Can we figure out a way to fix this?"*

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APPENDENDIX A ■ Users

i. Administrators (4)

ii. CIS Support Staff Members (3)

iii. End-users (aka Clinicians)

1. Faculty (7)
    a. Pediatric Department Chair
    b. Graduate Program Director
    c. Full-time Faculty
    d. Part-time Faculty
2. Students (44)
    a. Pediatric Residents
    b. Predoctoral Students

APPENDIX B ■ Field Notes

Location: School of Dentistry, Pediatric Department, Predoctoral Clinic

Observer: HKH

Date: 10/05/2007

Time: 9:00-10:00am

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This is the first day for third year dental students in the pedo clinic. Students are paired. One student is the clinician and the other is the assistant. There are 11 operatories and approximately 18 students. There are four instructors, two faculty members and two pediatric residents. The atmosphere is disorganized.

The space is tight. The operatories vary in size. Some of the operatories do not have a comfortable amount of room for two students and a patient. The operatory computers are attached to walls. The computers are at various heights. The students are anywhere from short to tall. The computers aren't necessarily at a comfortable height for all the students. The students can adjust the heights but they don't know how to operate the workstation arms. When a student could not keep the computer arm keeping from constantly rising up he grabbed the attention of an assistant walking by who called support team. Within 10 minutes a support staff member arrived and fixed it. One student cries out jokingly as the workstation arm swings back, *"I'm stuck. I'm locked in back here."*

There are bags around all of the workstations. No one has a mouse, they are using keypads. The workstations are not ergonomic in that they have space to rest their hand

A student came up to me and says:
"What are we suppose to be doing? We didn't get a very good orientation."

Students were confused on what to do, one asks, "How do we put in current restorations?"
An instructor answers, "Don't get hung up on that. Write it down on paper and we'll figure how to enter it later." The student responded, "You guys have paper down here?" Another student responded, "I have my notebook."

An instructor doesn't have his swipe card. He has to go look for it. Only one of the four instructors has their swipe card.

APPENDIX C ■ Interview Guide

Personal Background

Tell me about your professional background?

Do you enjoy using computers?

Implementation Background

How were you involved in process for the pediatric department to convert over to CIS?

Training

What type of training was available to you?

Did you feel the training met your needs?

How could the training be improved?

Implementation Experience

Describe what it is like to use the CIS?

How did the CIS change the way your work (or your workflow)?

How long did it take you to get to the point where you efficient with the CIS?

How could the implementation process be improved?

Evaluation, Feedback and Improvements

How do you provide feedback?

How could evaluation, feedback and improvement processes be improved?

Wrap-Up

Is there anything we didn't cover that you think would be helpful for me?

Appendix D ■ Comments from Users

Theme	Comments from Users
1. CIS benefits were disproportionate among users.	**A. Administration articulated the most and widest reaching benefits.** **Administrator:** *"We are collecting objective information, that part I really like."* **Administrator:** *"We can track things, quicker, faster and better."* **Administrator:** *"Now that we have evolved, we couldn't do our work without computers."* **Administrator:** *"…things like research are easier to get. Statistically significant sample of something, you can look at a lot of records instead of just one."* **B. Faculty had mixed reviews about the advantages of the CIS.** **Faculty Member:** *"I can get data real fast. Without a computer it would have been a lot hard to manage how much…[the students]…have done."* **Faculty Member:** *"One thing I like is the reports I can get on production and collections."* **Faculty Member:** *"… I want to have films up, but they [digital images] will disappear [screen times out] when I am in the middle of discussing something about them with the student."* **Administrator:** *"It was a long time after we went paperless that we even got asked for reports...it seems like largely the faculty hasn't used it, accept for accreditation."* **Support Staff Member:** *"They [Faculty] have the same response they would have had with a paper chart. 'It's a chart."* **Faculty Member:** *"Yes, there is data in there, but it is not easy to use."* **C. Although students could name several benefits, they considered the benefits to be negligible compared to the cost of using the system.** **Student:** *"I like the paperless [system] better than the paper charts… it is easier… we don't have to request for charts to come downstairs [from the chart room]."* **Student:** *"From…[the administration's] …perspective they love it because it is command and control … but they're not using it from a clinical standpoint, so, there is a huge divide between how we see it and how they see it."*
2. Communicating about the CIS was challenging.	**A. Implementing a CIS increases the need for communication and can expose deficiencies.** **Administrator:** *"Implementing a CIS is like the canary in the mine. Implementation reflects the overall communication in the organization***."** **B. Having a meaningful exchange about the CIS is difficult between people who lack the same vocabulary.** **Administrator:** *"We [everyone] don't say "the electronic health record". When we talk about the system, we normally don't say "the clinic information system". We normally say [Product X] …If it has anything to do with "the computer" it is [Product X]. Even if the hardware is messed up it is [Product X], '[Product X] is not working', [Product X] is not printing.' Most users don't make any differentiation at all."* **Administrator:** *"It is the classic problem, they [the end users] say 'My computer isn't working!' or 'My file went away!' And the first thing the… [support] person says is, "What did you do?', and they say, "…'I can't tell you what I did!"* **C. When people represent different perspectives it can take extra effort to understand each other's motivation.** **Faculty Member:** *"We don't all think the same way… someone… will walk in here and after they describe it [the problem] you'll wonder,' Are they looking at the same thing I am?' People don't hear and perceive things the same way. People don't fully understand what people are trying to say."* **Administrator:** *"I think the other thing is for us to go down, like we do, and live in it, try to do it, to experience the frustration first hand."* **D. When users want to work together to create a solution the lack of mutual understanding stifles progress.** **Faculty Member:** *"If we have to live with it, let's make it better. We don't want it to be painful."* **Faculty Member:** *"A big part of the problem [around the CIS] is communication…Everyone has different levels [of familiarity with computers]."* **Administrator:** *"When you ask them [end-users] about the computer problem, they have a hard time describing it in a way that can be understood."* **E. Frequent communication between user groups was necessary to sustain and maximize the CIS.** **Faculty Member:** *"It is a constant back and forth, and trying to change."* **Administrator:** *"You have to get thick skinned and not defensive…It feels personal. You have to let go of that, and that is kind of hard. And say, 'Ok, that doesn't work for you, what would work? Can we figure out a way to fix this?"*
3. Users experienced a range of strong emotions.	**A. Positive emotions, including interest, enthusiasm and appreciation, were felt across user groups.** **Administrator:** *"I think dentists as a group are very interested in computers. "We [dentists] generally like gadgets. Even if we are concerned it is going to change how we work, or we need to learn something new, overall …we are interested in them [computers]."* **Faculty Member:** *"Computers are the future."* **Faculty Member:** *"I was excited about a 'paperless' system."* **Administrator:** *""I love them [computers]"* **Administrator:** *"Computers are great, I don't have any problems with using them."* **B. Negative emotions expressed as disappointment and disillusionment stemmed from unmet expectations, especially among faculty members.** **Faculty Member:** *"I thought the [CIS] project was to duplicate what we do [with paper]."* **Faculty Member:** *"The whole idea with going paperless is to decrease our time and paperwork, so we can spend more time with patients and students…and it hasn't happened yet."*

	Faculty Member: *"…the computers are not the positive change that I would have imagined when I started,"* **Faculty Member:** *"… it is really frustrating, we are working with it…but it is not the perfect system…"* **C. Most interviewees offered at least one ramification of the CIS they liked and another they disliked.** **Support staff member:** *"There is a love/hate thing about it [the CIS]."*
4. The instructor persona diminished.	**A. When faculty members did not have a thorough understanding of the CIS they found clinical instruction difficult.** **Faculty Member:** *"… when you [the student] have a problem, I have to figure out what is wrong. You're a student, you don't know, all you know is that when you take a film you hit the enhance button".* **Administrator:** *"… obviously we are not letting go [of] something that is not diagnostic in quality but we have to adjust the image more."* **Faculty Member:** *"If we are [CIS] project was to duplicate spending time with every image that is taken, we do the clarifier, the highlighter, and the contrast button, that is telling me, if you have to do that with every film, something is wrong."* **Faculty Member:** *"…I want to teach the students about dentistry, and have the patient as the focus [not the CIS]."* **B. In some clinical situations, the student is more knowledgeable about the CIS than the faculty member.** **Student:** *"I think they [faculty] tend to rely on the student or resident, they will say 'this [radiograph] doesn't look good, can you adjust it?' because they [students] are more familiar with it."* **Student:** *"I see the … [students] … keep asking the faculty, 'How do I do this? How do I put that in?' The faculty doesn't know, I think the students know more than the faculty because they use it everyday".* **C. When faculty members perceive themselves as dental care experts, they were uncomfortable with the image they project when they experience difficulty with the CIS.** **Faculty Member:** *"They [many of the faculty members] don't know how to type, they are uncomfortable with it."* **Faculty Member:** *"A third dimension is added on [to patient care and instruction], a lot of things get tied up in this."* **Faculty Member:** *"…we [faculty] get errors…I am 'Not a Known User' or something like that…and I am making...comments to the students because the parents are looking at me like I am really dumb."*
5. There was variation in how users' time was impacted.	**A. There was variation in how users' time was impacted.** **Faculty Member:** *"If I had the paper [consent] form for you to sign, it would be quicker."* **Faculty Member:** *"…it needs to be more efficient. The …[students]… waste a lot of time typing information in, and they have to type the same information in several places…"* **B. Implementation of a CIS effects how faculty and students spend their time interacting with patients and each other.** **Student:** *"I spend more time on the computer than with patients."* **Faculty Member:** *"I spend over half of my clinic time working with the CIS, as opposed to…how I used to spend my time talking to the students. They're entering things on their computers and I am entering things on computers."* **C. It was difficult for administrators to recognize how much time to spend engaging end-users in CIS implementation.** **Administrator:** *"Sometimes we try to think up things. We say, 'Hey, would it be helpful to you?' and sometimes we just hand things out to them."* **Support staff member:** *"They [faculty]… weren't part of the weekly meetings. That was us making those decisions because, if they [faculty] had been involved in that, that would have been too much of a tangled mess."* **D. Learning how to efficiently use the CIS can be a time intensive process for faculty.** **Faculty Member:** *"…the learning curve is huge."* **Faculty Member:** *"… many of them are… not interested in taking the time to learn a new system."* **Faculty Member:** *"If they use it in their private practice, it is not a big deal for them."* **Administrator:** *"If they use it in their private practice, it is not a big deal for them."* **E. Required use of the CIS changed the balance faculty had between student instruction and evaluation.** **Faculty Member:** *"I am sitting here doing five different things at one time. You almost have to be a little ADHD for this job."* **Faculty Member:** *"We…are used to spending a lot of time with the students, and now we spend a lot of time going through all this computer work..."*
6. The training and support needs of end-users were significant.	**A. Although end-users were provided training, they did not feel adequately trained.** **Faculty Member:** *"I think the trainers did a good job but everything I know I learned in the clinic, the information is so massive I don't think I remembered how to do anything one hour after I left [the training]."* **Student:** *"When you are looking at the computer screen [projected during training] you're like 'that's easy' and then you go to do it and you're like, 'how did they do that?"* **Student:** *"They [CIS trainers] went through it and there was about 100 things to remember. To remember it, I need to see it again and again. I know they can't go through it five times."* **Faculty Member:** *"It is better if you sit me down and walk me through it one on one. If I am in the river, throw me a line and keep bringing me back to shore."* **Student:** *"The students are self taught [about the CIS]"* **Student:** *"We learn as we go…* **Faculty Member:** *"A lot of times the students are asking each other and sometimes they are not getting quite the right information."* **B. Administration and faculty members were unclear who would best train end-users.** **Administrator:** *"The frustrating part about training is that it goes back between the clinical versus the system. It kind of gets thrown in together."* **Faculty Member:** *"Although we can be part of the training we don't have enough class time with the students [to do clinical instruction and CIS instruction]."* **Faculty Member:** ,*"The training should be done by [CIS] professionals…I am the end user, I don't have the time in the clinic to deal with computers and software [support]."* **C. Furthermore, there was confusion around where, how and when training would best be accomplished.** **Student:** *"The way they do it is adequate but it isn't easy to learn…they are trying to project it [on a screen] and you can't learn that way."* **Student:** *"They did give us a big packet, [but] I didn't have time to go through it."* **Administrator:** *"You try to train people right before they need it. Honestly, some of them are pretty apathetic. Then they get into the*

	clinic and they need it, they know they need it and they panic." **D. End-users' support needs were time sensitive, intense and never ending.** **Administrator:** *"They [the student and faculty] need help, they have someone in the chair...they need it fixed right there."* **Administrator:** , *"I know they wish we had somebody [CIS expert] down there full time helping them, everyday, that would be great, I think that would be great too, but we just don't have enough people to do that. "* **E. Faculty and students had requests for support that were impossible to meet.** **Faculty Member:** *"That problem should be really easy to fix …the type of change that can be made in a day, but [apparently] it can't be done."* **Support Staff Member:** *"Sometimes it is just not a proper understanding of like how AxiUm works."* **Support Staff Member:** *"Truth be told, 90% of those things [end-user complaints] are things we can never do anything about."*
7. There were shifts in the school's power structure.	**A. Decisions about CIS implementation involved stakeholders with unique and overlapping responsibilities and this lead to unclear power among administrators, support staff members, and faculty.** **Administrator:** *"We could probably do a better of job of going back to every group and saying, ''… What would help you? What Would be useful for you to know?"* **B. The CIS Team, made up of administrators and support staff, gained expanded power over the Pediatric Department as they led the specification process.** **Support Staff Member:** *"They [administrators] had some question about their [DPD] forms. There was some redundancy that we tried to eliminate***."** **Support Staff Member:** , *"The majority of the decision making went on in the CIS [Team] meetings because the decisions that were being made in the Pediatric Department had to comply with whatever will be needed in the future for the whole dental school going electronic."* **C. Clinicians (a.k.a end-users) were concerned that they were losing control over their practice to the CIS Team.** **Faculty Member:** *""We [DPD] didn't have a choice, we were told that 'this is what the school is using'..."* **Student:** *"They [CIS Team members] really aren't familiar with what is going on down here in the trenches."* **D. The Department of Pediatric Dentistry faculty did not have the power to tailor electronic forms to meet their specific needs**. **Administrator:** *"Sometimes something [involving the CIS] is developed and it doesn't fit everything."* **Faculty Member:** *"Ninety-nine percent of what we [the DPD] do I could make into a few basic templates…We are not doing a lot of extra fancy stuff."*
8. Lack of usability made documentation cumbersome for end-users.	**A. When compared to having a chart chairside, initiating the documentation process takes more coordination on the part of the end-user.** **Faculty Member:** *"Is he [the patient] epileptic? Is he asthmatic? What kind of medicine did you give him? How much does he weigh? I need to get to that information faster than I think I can."* **B. Although the electronic patient record resembled its paper precursor, end-users could not transfer the old documentation process to the new electronic record.** **Faculty Member:** *"How do we put in current restorations?"* to which the member replied, *"Don't get hung up on that. Write it down on paper and we'll figure out how to enter it later."* **Faculty:** *"Every time you put in a treatment plan [into the CIS] you have to make sure you [the student] selects 'PEDO" for every procedure. Well, it's a pedo clinic! Why do you have to enter 'PEDO'…if the answer is always 'PEDO?"* **C. The electronic format of the patient record limited what information was captured.** **Faculty Member:** *"If a paper form doesn't work well …, or there is some other thing they [the clinicians] want to do, they just write it in the margin or they change it. Well, there is no margin to write in, in the electronic record [CIS]."* **Student:** *"… some of… [us]… want to add more [information] but the line is only [student makes a small space with index finger and thumb], you can't type over that amount so you choose what words are important and you put down those words."* **D. Because the presentation of electronic information was different than on paper, end-users found it challenging to synthesize information.** **Student:** *"If they [the patient] had a heart defect, you [the dentist] would never know it from the [CIS] screen."***."** **Faculty Member:** *"I want to look at the record and say, 'This is what I did before and this is what I am going to do now' and I want to reference that… with a star...."*
9. Clinicians' workflow was disrupted.	**A. CIS hardware size and location were obstacles to faculty and students' ability to provide patient care.** **Student:** *"I review them [digital x-rays] in the morning but in general I don't review them sitting at my [operatory] chair".* **Faculty Member:** *"I would love to sit down with the students and look at the patient's [electronic] chart in the morning …but that is a pain… so I did it before clinic [alone]."* **B. Patient information accessibility impacted the opportunities faculty had to teach students.** **Faculty Member:** *"There is something about having the films right there [on the viewbox] when a student is working on a patient, that can look over their shoulder and assess that everything is right,"* **Faculty Member:** *It would be nice if I could easily look at the film so we could talk about [treatment] philosophy …"* **Faculty Member:** *"… I want to have films up, but they [digital images] will disappear [screen times out] when I am in the middle of discussing something about them with the student."* **C. Another obstacle of CIS documentation was the limited hardware.** **Administrator:** *"It is not the type of environment that says, 'take your time, get all your questions answered."* **D. The CIS documentation process was physically awkward and required a higher cognitive load.** **Student:** *"…some of it's inefficiency on the way it is setup, there is not a good flow to it, it takes me much longer for me to do stuff."* **E. Since the CIS can enforce completion of electronic forms prior to acceptance, end-users got held up in data entry.** **F. The faculty and students found the electronic approval process interrupted their workflow.** **Faculty Member:** *"Every time there is a change or add on, the faculty have to swipe it [card reader], every time you do that there is a*

	couple of swipes to get one patient done, and we have an average seven or eight students to take care of at a time, I don't want to deal with that…" **Student:** *"It takes four million swipes to get everything done, it's ridiculous."* **G. Incompatible hardware and software created new work.** **Faculty Member:** *"We have to scan in the pulse oximeter [paper output]... the interface doesn't let you connect it to the computer..."* **Administrator:** *"The hospital needed a special form for the OR [operating room], we still have problems [with interoperability between our and their system]."*