

Health Information Technology Systems Profoundly Impact Users: A Case Study in a Dental School

Heather K. Hill, D.D.S., M.B.I.; Denice C.L. Stewart, D.D.S., M.H.S.A.; Joan S. Ash, Ph.D.

Abstract: The purpose of this study was to increase our understanding of the impact of Health Information Technology Systems (HITS) on dental school users when the systems are integrated into chair-side patient care. We used qualitative research methods, including interviews, focus groups, and observations, to capture the experiences of HITS users at a single institution. Users included administrators, clinical faculty members, predoctoral students, support staff, and residents. The data were analyzed using a grounded theory approach, and nine themes emerged: 1) HITS benefits were disproportionate among users; 2) communicating about the HITS was challenging; 3) users experienced a range of strong emotions; 4) the instructor persona diminished; 5) there were shifts in the school's power structure; 6) allocation of end-users' time shifted; 7) the training and support needs of end-users were significant; 8) perceived lack of HITS usability made documentation cumbersome for clinicians; and 9) clinicians' workflow was disrupted. HITS integration into patient care impacts the work of all system users, especially end-users. The themes highlight areas of potential concern for implementers and users in integrating a HITS into patient care.

Dr. Hill is National Library of Medicine Fellow, Department of Medical Informatics and Clinical Epidemiology, School of Medicine; Dr. Stewart is Associate Dean of Clinical Affairs, School of Dentistry; and Dr. Ash is Professor and Vice-Chair, Department of Medical Informatics and Clinical Epidemiology—all at Oregon Health & Science University. Direct correspondence and requests for reprints to Dr. Heather K. Hill, 3181 SW Sam Jackson Park Rd., Mail Code: BICC, Portland, OR 97238-3098; 503-473-6621 phone; 503-494-4551 fax; hillhe@ohsu.edu.

Dr. Hill was supported by National Library of Medicine Training Grant T15LM007088. One of the authors provides consulting services for the electronic software vendor that her institution was paid for, but this author did not take part in data-gathering or coding.

Keywords: attitude of health personnel, attitude to computers, computers, dentists, dental informatics, dentistry, dental education, ethnographic studies, information systems, dental schools

Submitted for publication 8/7/09; accepted 1/13/10

Dental schools are expanding the capabilities of their information systems and integrating the systems more profoundly into patient care and student education.¹⁻⁹ In the 1990s, the function of information systems centered on school financials, including billing and insurance claim processing programs. Since then, the purposes of information systems have evolved to include administrative and clinical aspects, the electronic patient record (EPR), inventory, student grading, oral disease risk assessment tools and quality indicators. In the dental setting, Health Information Technology Systems (HITS) is a comprehensive term that includes the software components of these information systems and their necessary hardware (computers, digital x-ray processors, printers, etc.).

Nearly all dental schools in North America use a HITS in some capacity. While a few schools

use locally developed systems, most depend on commercial dental school software products such as axiUm (Exan, Port Coquitlam, Canada), ICE Dental Systems (Calgary, Canada), Salud (Dublin, Ireland), Software of Excellence International (Henry Schein, Auckland, New Zealand), and Windent (Richardson, TX, USA). Dental schools have embraced the expanded functions of HITS because these systems have improved schools' ability to fulfill their missions of quality patient care, education, and research. Illegible chart notes are no longer a problem for students and faculty members, and users have access to their patients' information ubiquitously. For administrators and faculty members, 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 the faculty to identify students who

need extra attention. In addition, patient databases can be mined to answer research questions.

The factors that influence the success of HITS implementation in the dental setting have just begun to be studied.¹ A survey of end-users of the EPR found faculty members, staff, and students had mixed feelings about its effect on their efficiency, and less than a third of users believed the EPR improved productivity. In the hospital setting, the barriers to realizing the optimal implementation of computerized physician order entry (CPOE) have been studied.¹⁰⁻¹⁵ A successful implementation is not a reflection on the technology alone, but is a combination of personal, organizational, and environmental aspects as well. Furthermore, there is a small body of literature evaluating the impact of clinical systems on medical students and residents. These studies found computerized documentation has created new challenges for students and residents, causing positive and negative repercussions for their clinical practice and education.¹⁶⁻¹⁸

To identify the impact of HITS on dental school users, we conducted a qualitative case study at a dental school located in the western United States. We conducted interviews and focus groups with administrators, faculty members, students, and residents and observed daily activities in the clinic and EPR training. A grounded theory approach to analysis revealed nine themes. The results of this investigation concerning the experience of users in integrating the HITS into patient care should better equip administrators, faculty members, and support staff to manage the impact and any negative repercussions. In conclusion, we offer suggestions for the implementation team to take into consideration to improve their success.

Methods

The School of Dentistry (SoD) where we conducted this study is representative of HITS implementations in dental schools nationwide. The study was conducted one year after a big-bang adoption of EPR by the pediatric clinic and one year into a five-year schoolwide phased adoption of EPR. This study was approved by the university's Institutional Review Board (IRB).

The SoD 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. The PDC is supervised by three full-time faculty members (working three or more days per week) and nine part-time faculty members (working two or fewer days per week). There are eight pediatric dental residents and approximately 140 predoctoral dental students who rotate through the clinic each year. The PDC has approximately fifteen open operator bays to facilitate behavior modeling among child patients and three individual patient care rooms where sedation can be privately administered.

The SoD created an implementation team made up of administrators, faculty members, and staff with experience in the electronic record system to oversee planning and implementation of the HITS. To understand the needs of the department, the team met with department faculty, staff, and residents to determine existing workflows (from first call to recall) and essential information. In addition, the team members observed clinic operations, reviewed the content of existing paper forms and charts, and assessed how forms were used. A comprehensive implementation plan and timeline were then developed by the team and reviewed with key department faculty members and staff. The implementation was designed as an iterative process. As the team developed the electronic forms, it regularly solicited the input of department administrators, faculty members, staff, and residents at formal and informal meetings. Based on the feedback the team modified the forms to ensure the final product met the department's needs. While the team provided suggestions to the department regarding hardware, the department managed hardware selection and installation. The implementation team continues to meet monthly to address user concerns and maintain the HITS.

First, we defined HITS users as individuals who used the HITS in some capacity. The term "user" includes both clinicians and nonclinicians, while "end-user" refers only to clinicians (see Figure 1). The users fell into four groups: 1) administrators who use the HITS to manage school operations and performance; 2) faculty members (full- and part-time instructors) who use the HITS for Department of Pediatric Dentistry supervision, patients' clinical care, and student evaluation; 3) support staff members who build and maintain the HITS; and 4) students (pediatric residents and third- and fourth-year predoctoral students) who use the system for patients'

Administrators (4)

HITS support staff members (3)

End-users (clinicians)

 Department of Pediatric Dentistry faculty members (7)

 Chair

 Graduate program director

 Full-time clinical faculty members

 Part-time clinical faculty members

 Students (44)

 Pediatric residents

 Predoctoral students rotating through the Pediatric Clinic

Figure 1. Users who were interviewed, participated in focus groups, or observed for this qualitative case study

clinical care. 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.¹⁵ Informal interviews were conducted with users during observations when their time and interest allowed.

We decided on three data-gathering techniques: formal interviews, focus groups, and observation. Data collection and analysis occurred concurrently. Study data were collected by the first author, a practicing dentist with informatics and qualitative research training, from July through October 2007, with pilot study data collected the preceding May. Formal interviews and focus groups were conducted, recorded, and transcribed. Field notes taken during observation were jotted by hand and expanded later. The first author coded ninety-nine pages of data with the aid of qualitative research software (NVivo 7, QSR International) and collaborated with the other authors to identify themes. Data were collected until saturation was reached (the point when new data reinforce existing themes but do not produce new themes).

The first and last authors created a semistructured interview guide for the formal 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 with them (see Figure 2).¹⁹ Four predetermined topics were addressed in each interview, including user's computer background, HITS use, training, and concerns. Interviews ranged in length from sixty to

ninety minutes. Four focus group interviews were conducted for a total of five hours. Observations were made in the clinic and classroom (during EPR training sessions). Individual faculty members and students were shadowed for a total of five hours as they completed their clinic tasks.

To code the data, we decided to use the grounded theory approach, in which the codes emerge from the data rather than being listed under preconceived codes.^{20,21} The first author completed all coding. Codes were based on users' words, phrases, or ideas. The resulting twenty-two codes were connected by a process of organizing and discussion to develop patterns that produced nine themes.¹⁹ Internal validity was established by using triangulated data collection methods and multiple data analysts. Trustworthiness was established by using member checking, in which we elicited feedback from users with whom we shared and discussed our themes. External validity was ensured by cross-checking our findings with the published literature.

Results

During analysis of the data, nine themes emerged concerning the impact the HITS users perceived. The nine themes are presented here with commentary and representative quotes from the transcripts (see Figure 3). The themes are listed alphabetically. Subjects were promised confidentiality, so comments that revealed their identity have been edited.

-
- Personal Background
- Tell me about your professional background.
 - Do you enjoy using computers?
- Implementation Background
- How were you involved in the process for the Department of Pediatric Dentistry to convert 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 you work (or your workflow)?
 - How long did it take you to get to the point where you were 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?

Figure 2. Interview protocol for this qualitative case study

1. HITS benefits were disproportionate among users.

Although computers are often touted as helpful, there was a definitive and unequal division of benefits among user groups.

Administrators articulated the most and widest reaching benefits. Prior to the HITS, data had to be collected from surveys of paper charts and/or personal testimonies and experiences; decisions were often based on best estimates. The HITS fundamentally changed the quantity and quality of information that administrators could access and synthesize. From monitoring operations to strategic planning, administrators utilized information from the HITS to make better-informed decisions. These users noted that administrators' work is so tightly coupled to the information they can harness from the HITS that working without the system would be a struggle. One administrator noted, "Now that we have evolved, we couldn't do our work without computers."

The faculty and students had mixed reviews about the advantages of the HITS. For faculty mem-

bers, 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, "Without a computer it would have been a lot harder to manage how much [the students] have done." Some faculty members commented that the HITS did not support their work in the clinic; one said, "The system doesn't help teach; it doesn't help treat [patients]." Students could name several benefits they appreciated: not having to depend on auxiliary staff to access charts and having clinical decision support available for prescription. Yet students commented they perceived the administration as the primary beneficiary of the HITS. "From [the administration's] perspective they love it because it is command and control," said one, "but they're not using it from a clinical standpoint, so there is a divide between how we see it." Since students have always had the HITS available to them in the PDC, they may not realize that the HITS allowed administrators and the faculty to get near-instantaneous

-
1. HITS benefits were disproportionate among users.
 - Administrator: "Now that we have evolved, we couldn't do our work without computers."
 - Faculty member: "One thing I like is the reports I can get on production and collections."
 - Faculty member: "Without a computer it would have been a lot harder to manage how much [the students] have done."
 - Faculty member: "The system doesn't help teach; it doesn't help treat [patients]."
 - 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 divide between how we see it."
 2. Communicating about the HITS was challenging.
 - Faculty member: "A big part of the problem is communication. . . . Everyone has different levels [of familiarity with computers]."
 - Faculty member: "It is a constant back and forth, and trying to change."
 3. Users experienced a range of strong emotions.
 - User: "Computers are the future."
 - Faculty member: "The whole idea with going paperless is to decrease the time we spend on paperwork, so we can spend more time with patients and students . . . and it hasn't happened yet."
 4. The instructor persona was diminished.
 - Faculty member: "I want to teach the students about dentistry and have the patient as the focus [not the HITS]."
 5. There were shifts in the school's power structure.
 6. Allocation of end-users' time shifted.
 - 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."
 7. Training and support needs of end-users were significant.
 - Administrator: "The frustrating part about training is that it goes back between the clinical versus the system. It kind of gets thrown in together."
 - Administrator: "They [the student and faculty member] need help, they have someone in the chair . . . they need it fixed right there."
 8. Users perceived usability problems.
 - Student: "Some of its inefficiency is in the way it is set up; there is not a good flow to it."
 9. Clinicians' workflow was disrupted.

Figure 3. Themes and comments that emerged from interviews regarding HITS use and impact

information about student progress towards clinical requirements.

2. Communicating about the HITS was challenging.

Communication requires a sender, message, receiver, and an understanding of the meaning. Communication that results in mutual understanding is

challenging enough between people, and the HITS adds another level of complexity. Communication occurs most effectively between people who share similar qualities.²² Miscommunication results from a lack of shared vocabulary, empathy, and occasions to share.

Within a user group and especially between user groups, individuals in our study found it difficult to express themselves precisely about the impact of

the HITS. Having a meaningful exchange about the HITS was difficult between users who lack the same vocabulary. Except for the support staff, most users were familiar with computers but lacked any detailed understanding of hardware or software. By default, everything having to do with the HITS (including hardware usability, hardware placement, HITS decision-making process, etc.) was lumped together as a software issue and labeled with the name of the software vendor. A faculty member commented, "A big part of the problem is communication. . . . Everyone has different levels [of familiarity with computers]."

When people represented different perspectives, it took extra effort to empathize with one another's HIT experience. Users were typically quick to identify themselves, and each other, as a certain type of user. These labels tended to fall along two lines: work/education roles and HITS abilities. Common labels included academic, "computer geek," curmudgeon, dentist, director, employee, end-user, informatician, instructor, "old guy," part-time instructor (and continuing to maintain a private practice), purchaser, resident, student, supervisor, technical support, or some combination of the above. Users noted that common roles and/or abilities made communication easier. Comparatively, users with different roles and/or abilities found it challenging to understand each other's message. When users wanted to work together to create a solution, the lack of mutual understanding stifled the rate of progress.

An increase in communication channels and frequency was necessary between user groups to sustain and maximize the HITS. New sender-receiver relationships (i.e., end-user and support staff members, students, and administrators) were necessary to address end-users' needs and utilize information the HITS made retrievable. As the HITS became more integrated into patient care, and as a database of related information was building, user groups kept trying to communicate ways to better match the system to their needs. Students were known to catch the attention of administrators or support staff members in the clinic or the hall to express their concerns about the HITS. In order to utilize the report-generating abilities made possible by the HITS, faculty members needed administrators and support staff to give them an idea of what information could be generated. Likewise, administrators and support staff actively engaged faculty members to better understand what type of information the faculty needed and in what format. One faculty member commented, "It is a constant back and forth, and trying to change."

3. Users experienced a range of strong emotions.

Users articulated an emotional response to the HITS 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 group lines. 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 with the HITS.

Positive emotions, including interest, enthusiasm, and appreciation, were felt across user groups. An optimistic attitude among administrators, faculty, and students frequently stemmed from the belief that users were part of something monumental. "Computers are the future," said one interviewee. Negative emotions, often expressed as disappointment, frequently stemmed from unmet expectations of faculty and students. A common belief among end-users was that the HITS would function similar to, or better than, a paper chart. Furthermore, faculty members anticipated that integrating the HITS into patient care would improve their and their students' efficiency. One faculty member stated, "The whole idea with going paperless is to decrease the time we spend on paperwork, so we can spend more time with patients and students . . . and it hasn't happened yet." Many end-users were disheartened in that they felt the HITS did not make their work easier. Although users tended to entrench themselves in either the positive or negative camp, most interviewees offered at least one ramification of the HITS they liked and another they disliked.

4. The instructor persona was diminished.

Traditionally, the instructor's persona is of an expert and authority on everything related to patient care. However, this perception frequently does not carry over to the HITS because a faculty member is not necessarily the ultimate expert or authority when patient care involved the HITS. Management of the HITS involves a cadre of administrators and IT support staff. In addition, in some clinical situations, the student is more knowledgeable about the HITS than the faculty member. Familiarity often comes with experience. Students use the HITS in some capacity daily, while faculty members (especially part-time faculty members) usually work in the dental school

clinics three or fewer days a week. Students can be so much more skilled with the HITS that the instructor-student role is reversed and instructors depend on the students to locate information within the EPR.

Most hurdles to faculty proficiency resulted from the difficulties of integrating the HITS into workflow, mastering the HITS domain, and ease of use. A few faculty members commented on how integrating the HITS into patient care added another layer of complexity to their jobs. “I want to teach the students about dentistry, and have the patient as the focus [not the HITS],” said one. For faculty members who did not have a thorough understanding of the HITS, clinical instruction could be challenging. Digital radiography was commonly cited as an example of an uncomfortable expanded teaching domain. Faculty members used to working with static film could find the image manipulation process puzzling to master and consequently awkward to teach. Faculty members think of themselves as good with their hands, so when they were “all thumbs” with the HITS keyboard and finger pad, they would be frustrated with the image they perceived themselves projecting.

5. There were shifts in the school’s power structure.

We found all user groups commented on the impact the HITS made on their and others’ control, choices, and decision-making processes. While no one explicitly used the word “power,” interviewees’ comments were rooted in issues involving power. Within this theme, three types of shifts emerged: unclear power, expanded power, and diminished power. Decisions about HITS implementation involved stakeholders with unique and overlapping responsibilities, and this led to unclear power among administrators, support staff, and faculty. It was not always clear which members of these groups should be included in any decision and who had the power to make the final decision. Ultimately, the HITS implementation team (made up of administrators and support staff) gained expanded power over the pediatric department as it led the specification process and interface design. Faculty members believed they had little authority over the implementation of the HITS that impacted how they provided patient care; thus, they considered themselves to be losing power.

6. Allocation of end-users’ time shifted.

Changes in end-users’ time allocation and changes in their workflow were tightly coupled. Some of the new clinical processes developed to utilize the HITS 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 chair-side or at the front office desk. With the HITS, these forms are filled out on a chair-side 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. 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 while in the reception area; the student would then review the form chair-side and place it in the patient chart. The new electronic process required the student to enter the form’s data directly into the system.

Implementation of the HITS affects how faculty members and students spend their time interacting with patients and each other. End-users believed they were spending more time interacting with the HITS than they had with the paper chart, and this resulted in less face-to-face time with their patients. Due to space and operatory configuration that could not be easily changed, computer stations were located behind the operatory chairs, making it difficult for faculty members and students to make eye contact with patients and/or parents while completing or reviewing documentation. In addition, faculty members and students believed they spent less time interacting with each other. One faculty member commented, “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.”

7. Training and support needs of end-users were significant.

Administrators and faculty members were unclear who would best train end-users. Instruction on patient care involving the HITS requires a familiarity with its components, dental terminology, and clinical processes. Because the HIT is an integral component of patient care that relies on information technology, there was not an obvious delineation of who (faculty or administrators) should train end-users and the role

of the support staff members. Commenting on the confusion about 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.”

End-users’ support needs were intense and time-sensitive. End-users wanted faster access to patient information within the HITS (in part the time it took to load software). They wanted different font sizes, buttons, menu options, and screen layouts. In addition, end-users were frustrated with the hardware’s ease of use, location, size, and impact on workflow. Because the HITS 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 HITS support, that support was needed immediately. “They [the student and faculty member] need help, they have someone in the chair . . . they need it fixed right there,” said one.

8. Users perceived usability problems.

Although the users did not explicitly use the term “usability,” their experiences reflected problems with usability. Usability is a term commonly used to describe the ease users experience in interacting with a product, such as a computer or software. The largest developer of standards, the International Organization for Standardization (ISO), defines usability as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.”²³ For the purposes of our study, usability reflects both on software and hardware issues.

Although the electronic patient record resembled its paper precursor, end-users struggled with the limits the HITS electronic format put on how information was captured and displayed. With a paper form, all of the text is visible, but electronically formatted information can be hidden. Challenges in documentation involved list boxes that contracted to the chosen item, text boxes that were too small to contain all of the student’s comments and/or collapsed so only the first line was visible, tabbed electronic forms that layered information inconspicuously, and electronic forms longer than one screen in length that had to be scrolled. Because the presentation of

electronic information was partitioned in ways that not all users found intuitive, they found it challenging at times to grasp what they saw.

The documentation process involved viewing all of a patient’s information on one screen, which was perceived by some users as requiring a high cognitive load and physically awkward. With a paper chart, students and faculty members could access multiples sources of information by flipping from page to page. With film x-rays on a light box and a paper chart in hand, end-users could review the films and use the chart concurrently with little effort. When using the HITS to review digital x-rays, record diagnostic information, generate a treatment plan, etc., an end-user may need to open a variety of independent electronic forms, tabs, and modules. For some students and faculty members, remembering key information while navigating among forms, tabs, and modules required focused concentration and had the potential to be disrupted by the effort required to coordinate the pointer. Maneuvering the pointer with the small 2” x 2” keyboard finger pad that rested on an arm mounted to the wall could be clumsy. (Due to space limitations the implementation team decided not to use mouses at chair-side computer workstations.) One student summed up his experience using the electronic record: “Some of its inefficiency is in the way it is set up; there is not a good flow to it.”

9. Clinicians’ 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 HITS implementation affected how they accomplish their work. This theme is closely linked with issues of time and HITS usability. In evaluating participant comments and the first author’s observations, we found single instances could represent multiple themes.

Some end-users commented that integrating the HITS into patient care and instructor workflow was challenging because it required coordinating new complex tasks that were not intuitive. Workflows that needed to be redesigned with the HITS were accessing a patient’s chart, taking a medical history, creating a treatment plan, gaining informed consent, commencing treatment, and completing a procedure.

Faculty members experienced with the previous paper charts and forms and predoctoral students rotating through other clinics that did not use the chair-side HITS were the most likely to describe their workflow negatively.

A new workflow required by the HITS that could be difficult for faculty members was the student evaluation and faculty approval process. Prior to the HITS, faculty members signed paper forms to approve patient treatment plans, completion of treatment, and student grading. With the HITS, this process is electronic and requires faculty to use a personal electronic badge. Although a card reader is attached to the workstation of every operator, the electronic approval process could be cumbersome for several reasons. One, getting faculty approval required that students locate the faculty member and bring him or her to their operator or a nearby computer, compared to carrying the paper forms to the supervising faculty member. Two, faculty members did not readily learn in which direction to turn approval cards when passing them through the reader, or they passed the cards through so quickly or at such an odd angle that the approval was not electronically registered. This issue resulted in faculty members having to pass the card through the reader multiple times, and it raised the risk that he or she would walk away without confirming that the card had not registered. Three, if faculty members were at a shared workstation, they needed to log off the computer after swiping, which added another step that could be forgotten.

HITS hardware size and location were another workflow issue that impacted students' ability to provide patient care and faculty members' ability to instruct. 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 monitor and the computer workstation pushed against the wall. With this arrangement, the computer workstations took up prime operator space at the head of the dental chair where the students worked on their patients. Ultimately, students had to decide between easy access to a patient's information and more roomy work space. Likewise for faculty, having the keyboard folded against the monitor made it hard to access and view a patient's information without interrupting the working student. Other hurdles in workflow created by HITS integration into patient care were the need to share limited hardware (i.e., signature pads,

digital image scanners) among multiple end-users, institutional enforcement of HIPAA regulations, and incompatible hardware and software.

Discussion/ Recommendations

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

HITS benefits were disproportionate among users. Users do not experience all the benefits of HITS 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 HITS, such as improved quality of care, instruction, and research.

Communicating about the HITS was challenging. Communication is vital to HITS success, so implementers must provide opportunities for communication between user groups, both in frequency and detail. A communication plan should be a component of the HITS planning, implementation, and maintenance plans. Implementers can improve users' ability to communicate by developing a shared HITS-related vocabulary. Formal communication channels that end-users can access easily, such as a helpline or comment box, could be beneficial. Implementers should provide end-users with feedback, such as reporting suggestions users provide

and the resulting changes. To sustain and maximize the HITS, administrators should spend time in the clinic observing the impact of the HITS on end-users. HITS 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. End-users will wrongly anticipate the HITS will be perfect and/or that the system has the ability to make them into "superdentists" who can document faster, make clinical decisions more easily, and deliver improved patient care. As an analogy, one end-user compared what he expected from the HITS to what an amateur photographer could achieve with Photoshop. End-users' expectations can be managed with education about HITS and training, so it is critical that implementers work to create realistic expectations of the HITS. To maintain good will, the implementation team must institute a formal process to handle problems end-users experience with the HITS.

The instructor persona was diminished. The old paradigm of the faculty as those with the most experience and expertise is shifting. To improve faculty members' experience with the HITS, implementers must evaluate how dental clinical education has changed as well as the expertise required of instructors. The variety of perspectives, commitment, and expectations of part-time and full-time faculty members can result in very unique needs. Faculty members require ongoing training and support options. Clinical faculty members should be included on the HITS implementation team.

There were shifts in the school's power structure. Changes in power are a result of HITS implementations.^{24,25} 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. HITS 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. Implementation and maintenance teams do not characteristically contain dentists.² This trend is an oversight. Faculty members, and even students, can contribute greatly to maximizing the benefits of the HITS.⁹ HITS develop-

ment is a never-ending iterative process. Therefore, it is important to solicit end-user input consistently and constantly.

Allocation of end-users' time shifted. Integrating a HITS into patient care changes how faculty members and students spend time with patients and each other. In addition, end-users perceived they were spending more time completing processes via the HITS than in previous processes involving paper. It could be beneficial for all users to identify activities that require an exorbitant amount of time and work to alleviate them. Potential timesinks include medical history intake, new patient exam documentation, digital radiograph interpretation and disease diagnosis, electronic informed consent, and faculty approval. In the medical setting, providers' time can increase with the integration of HITS into physician order entry, ordering tests, and creating prescriptions.²⁶ Yet, these types of integrations have resulted in improvements in the quality of patient care and patient outcomes.²⁷

Training and support needs of end-users were significant. Training and support have a major impact on end-users' experience with the HITS. If end-users perceive training and support as inadequate, interacting with the HITS becomes problematic. Because HITS training involves both technical and clinical components, it requires HITS experts and clinicians. Training needs vary considerably, and an ideal training method is not the same for everyone. It would be wise to make immediate chair-side support, such as that provided by superusers, available to end-users.

Users perceived usability problems. Users must realize documentation may take longer in the HITS system. Implementers must realize training end-users can improve their ability to document, but their capacity is ultimately limited by the quality of the documents' designs and hardware usability.²⁸ To increase usability, vendors and implementers must continuously incorporate user-centered designs that make it easy for clinicians to enter, access, and synthesize information.²⁹ A balance must be struck between maximizing the benefits of an electronic system versus providing opportunities for students to grapple with the system. For example, as a learning experience, the software was configured to require students to convert a patient's weight from pounds to kilograms (even though the functionality existed in the software to do this automatically). However, many students complained the software should convert the weight for them. Implementers

should not underestimate end-users' appreciation of "small" HITS automations, such as age-appropriate odontograms that are used frequently during pediatric exams. Implementers should be aware of the increased cognitive load required from end-users and work with them to create systems that support their thought processes more.³⁰

Clinicians' workflow was disrupted. To limit the disruption of HITS on end-users, implementers must be rigorous in their planning and pre-implementation evaluation.³¹ Implementers must identify how HITS will support end-users' workflow. To facilitate workflow, implementers should evaluate the number and location of hardware, including computers, monitors, printers, signature pads, and x-ray developers. After implementation, implementers should evaluate workflow at both the individual and clinic level to identify possible inefficiencies that need to be reengineered. There could be a place for paper in a "paperless" system, for the medical history, the day's treatment plan, etc. Careful consideration should be given to institutional enforcement of HIPAA time-out regulations that do not meet dental students' needs. Seamless integration of software and hardware can improve end-users' efficiency and effectiveness.³²

Limitations and Future Directions

Data collection and coding were completed by only one author in this study, though the coding scheme was verified by an additional researcher. This work is a case study of a big-bang implementation within one department of one dental school undergoing a five-year phased adoption. The results are not necessarily generalizable, but could be transferable to other dental departments and schools. Factors impacting transferability are composition of the implementation team, details of the evaluation, implementation and maintenance plans, users' expectations and previous HITS experience, clinic workflow design, level of standardization of processes, HITS training and support, and the HITS hardware and software. Although HITS users commented on the previous paper-based system, that system was not studied.

Although HITS have been used in dental environments for over fifteen years, there are few studies evaluating their impact on dental users, so further investigation is needed. To achieve the potential improvements in dental school education, research,

and patient care made possible by integrating HITS chair-side, we must understand how end-users' work is changed. Specifically, we must further explore the effect of HITS on faculty members' ability to manage patients and instruct students and the development of students' patient management skills.

Conclusion

Health Information Technology 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. HITS integration into patient care and student education impacts the experience of end-users in profound and unclear ways. When administrators, faculty members, and students understand the impact of HITS, they can work cooperatively to address any deleterious components. Recognizing the need to address issues around the HITS, 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?" These are questions that implementers should ask end-users before, during, and after HITS adoption.

REFERENCES

1. Walji MF, Taylor D, Langabeer JR, Valenza JA. Factors influencing implementation and outcomes of a dental electronic patient record system. *J Dent Educ* 2009;73(5):589-600.
2. Wrzosek M, Warner G, Donoff RB, Howell TH, Karimbux N. A survey of information technology management at U.S. dental schools. *J Dent Educ* 2003;67(10):1095-106.
3. Atkinson JC, Zeller GG, Shah C. Electronic patient records for dental school clinics: more than paperless systems. *J Dent Educ* 2002;66(5):634-42.
4. Iacopino AM. The influence of "new science" on dental education: current concepts, trends, and models for the future. *J Dent Educ* 2007;71(4):450-62.
5. American Dental Education Association. Competencies for the new dentist. *J Dent Educ* 2007;71(7):926-8.
6. Peterson D, Kaakko T, Smart E, Jorgenson M, Herzog C. Dental students' attitudes regarding online education in pediatric dentistry. *J Dent Child* 2007;74(1):10-20.
7. Finucane D, Nunn JH, O'Connell AC. Paediatric dentistry experience of the first cohort of students to graduate from Dublin Dental School and Hospital under the new curriculum. *Int J Paediatr Dent* 2004;14(6):402-8.
8. Schitteck M, Mattheos N, Lyon HC, Attstrom R. Computer assisted learning: a review. *Eur J Dent Educ* 2001;5(3):93-100.
9. Grigg PA, Stephens CD. A survey of the IT skills and attitudes of final-year dental students at Bristol University in 1996 and 1997. *Eur J Dent Educ* 1999;3(2):64-73.

10. Massaro TA. Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior. *Acad Med* 1993;68(1):20–5.
11. Ash JS, Anderson NR, Tarczy-Hornoch P. People and organizational issues in research systems implementation. *J Am Med Inform Assoc* 2008;15(3):283–9.
12. Ash JS, Gorman PN, Lavelle M, Payne T, Massaro TA, Frantz GL, Lyman JA. A cross-site qualitative study of physician order entry. *J Am Med Inform Assoc* 2003;10(3):189–201.
13. Lorenzi NM, Riley RT. Managing change: an overview. *J Am Med Inform Assoc* 2000;7:116–24.
14. Ash JS, Fournier L, Stavri Z, Dykstra R. Principles for a successful computerized physician order entry implementation. *AMIA Symp Proc* 2003;36–40.
15. Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW, Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. *Health Aff (Millwood)* 2004;23(4):184–90.
16. Mallon WT, Jones RF. How do medical schools use measurement systems to track faculty activity and productivity in teaching? *Acad Med* 2002;77(2):115–23.
17. Embi PJ, Yackel TR, Logan JR, Bowen JL, Cooney TG, Gorman PN. Impacts of computerized physician documentation in a teaching hospital: perceptions of faculty and resident physicians. *J Am Med Inform Assoc* 2004;11(4):300–9.
18. Keenan CR, Nguyen HH, Srinivasan M. Electronic medical records and their impact on resident and medical student education. *Acad Psychiatry* 2006;30(6):522–7.
19. Berg BL. *Qualitative research methods for the social sciences*, 5th ed. Boston: Allyn & Bacon, 2003.
20. Crabtree BF, Miller WL. *Doing qualitative research*. Thousand Oaks, CA: Sage Publications, 1999.
21. McMillan WJ. Finding a method to analyze qualitative data: using a study of conceptual learning. *J Dent Educ* 2009;73(1):53–64.
22. McPherson M, Smith-Lovin L, Cook J. Birds of a feather: homophily in social networks. *Annu Rev Sociology* 2001;27:415–44.
23. International Organization for Standardization. At: www.usabilitynet.org/tools/r_international.htm. Accessed: December 2, 2009.
24. Ash JS, Sittig DF, Campbell E, Guappone K, Dykstra RH. An unintended consequence of CPOE implementation: shifts in power, control, and autonomy. *AMIA Symp Proc* 2006:11–5.
25. Bartos CE, Butler BS, Penrod LE, Fridsma DB, Crowley RS. Negative CPOE attitudes correlate with diminished power in the workplace. *AMIA Symp Proc* 2008;6:36–40.
26. Overhage JM, Perkins S, Tierney WM, McDonald CJ. Controlled trial of direct physician order entry. *J Am Med Inform Assoc* 2001;8:361–71.
27. Menachemi N, Chukmaitov A, Saunders C, Brooks R. Hospital quality of care: does information technology matter? The relationship between information technology adoption and quality of care. *Health Care Manage Rev* 2008;33(1):51–9.
28. Nygren E, Wyatt J, Wright P. Helping clinicians to find data and avoid delays. *Lancet* 1998;352:1462–6.
29. Thyvalikakath TP, Monaco V, Thambuganipalle HB, Schleyer T. A usability evaluation of four commercial dental computer-based patient record systems. *J Am Dent Assoc* 2008;139(12):1632–42.
30. Schleyer T, Spallek H, Hernandez P. A qualitative investigation of the content of the dental paper-based and computer-based patient record formats. *J Am Med Inform Assoc* 2007;14(4):515–26.
31. Irwin JY, Torres-Urquidy MH, Schleyer T, Monaco V. A preliminary model of work during initial examination and treatment planning appointments. *Br Dent J* 2009;206(1):E1.
32. Schleyer T. Why integration is key for dental office technology. *J Am Dent Assoc* 2004;135:4S–9S.