Factors Influencing Implementation and Outcomes of a Dental Electronic Patient Record System


Abstract: Implementation of clinical information systems is often difficult and costly. Little is known about how to implement electronic patient records in a complex dental school environment. The purpose of this study is to report how such a system was implemented at the University of Texas Health Science Center at Houston Dental Branch and to provide insights that may be useful for other institutions. To identify success factors and barriers, we reviewed project documents, interviewed key individuals on the implementation team, and surveyed end users before and after implementation. Eight critical issues were identified after extensive interviews with the project team. Surveys of students, faculty, and staff before and after implementation indicated that users had mixed feelings about the system in terms of efficiency and time required compared with paper charts. After using the system, many users felt that the electronic patient record improved patient care and that they would recommend such a system to dentists starting a new practice. By sharing lessons learned and knowledge about the science of implementation, we hope to reduce failures and costs for dental schools embarking on large-scale information technology implementations.

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Implementations of health information technology (IT) systems are notorious for costing more than budgeted, taking longer than anticipated, and sometimes failing altogether.\textsuperscript{1-3} In some cases, IT implementations have actually resulted in increased patient mortality in medicine.\textsuperscript{4} There is an increasing realization that a carefully planned implementation approach is critical for successful installations.\textsuperscript{5-7}

Dental schools have recently begun an ambitious goal of converting undergraduate, graduate, and faculty clinics from paper to electronic patient records (EPRs). The functional requirements of EPRs in dental schools are different from those in medicine and nursing.\textsuperscript{8} Patient clinics are typically housed in and owned by dental schools, and clinical experiences and productivity of students are tracked meticulously as part of an academically focused system. The users of these systems include students, staff, and faculty. In more advanced systems, even patients have access to parts of the record or the ability to make requests such as appointments. While students are typically the heaviest users, faculty members may be less technically savvy than their student counterparts and pose additional challenges to adoption and user training.

The implementation of an EPR requires a large capital expenditure and human resource effort that includes infrastructure, software, hardware, system configuration, documentation, user training and support, report writing, and maintenance of the new system.\textsuperscript{9} Other secondary costs include retraining and reassignment of existing staff, ongoing hardware and software costs, compliance, and addition of support staff. The costs of failure or suboptimal implementations are high and can result in less effective patient care, frustration among faculty, students, staff, and patients, and wasted resources.

There are significant opportunities to reduce the rate of failed implementations, costs, and time frame of implementation if experiences are shared among institutions.\textsuperscript{10} In this article, we seek to systematically review the implementation history of an EPR at our institution, the University of Texas Health Science Center at Houston Dental Branch (UTDB). At implementation, the EPR consisted of two primary applications: clinic management/patient record and
digital imaging. We will describe the implementation process, identify characteristics of the implementation that were deemed favorable and those that posed challenges, report the results from end user surveys, and generate recommendations based on lessons we learned that will be useful for other institutions.

**Methods**

We adopted a process evaluation perspective, seeking to determine how the implementation occurred, if milestones were met, what challenges were encountered, and how they were overcome. We used both qualitative and quantitative techniques including interviews, document analyses, and two surveys—one before and one after implementation. A qualitative approach is particularly well suited to answer our research questions and to explore why implementation strategies were successful or not. Institutional Review Board (IRB) approval was received from our university to conduct the research as part of a larger protocol seeking to conduct a comprehensive evaluation of the EPR.

Approximately three to four months after the EPR was fully implemented, we conducted in-depth interviews with four key personnel involved in the implementation. Interviews were conducted with each individual separately, and each lasted approximately sixty to ninety minutes. These individuals, who served on the implementation team and were selected based on their involvement with the project from its inception, were the executive associate dean (who served as project leader), the associate dean for patient care, the clinical IT manager, and the director of patient services.

A semistructured interview instrument was developed for this project using a systematic process of defining the goals and objectives of the research and developing open-ended questions to address them (see Figure 1). Three interviewers (MW, DT, JL) participated in the sessions. The questions were used more as a guide than as a strict protocol during the interview process, so the interviewers and interviewees could fully explore issues that arose. All interviews were audiotaped after receiving consent from the interviewees. A commercial transcription company independently transcribed the audiotape. The transcribed interviews were checked for accuracy by the investigators. Two of the interviewers evaluated each transcript and provided a summary of the account with key points and emerging themes based on the research questions. A grounded theory approach was followed, in which the interviewers independently read the transcripts and identified key phrases, descriptions, and themes.

The findings were then shared between the two interviewers, and any discrepancies or differences were resolved by consensus after review of the transcripts.

For the document review and analysis, key project documents were obtained from members of the implementation team and subsequently analyzed. The documents were the project budget, project plan, project timeline, testing plan and log, and workflow diagrams. These documents were used to help reconstruct the implementation process.

Two surveys were conducted with faculty, staff, and students. The first (pre-implementation) survey was conducted approximately four months before implementation of the EPR, and the second (post-implementation) was conducted approximately six months after implementation.

1. What was your role in the EPR implementation?
2. What goals or objectives did you want to meet by implementing the EPR?
3. What were some of the expected benefits of implementing the EPR?
4. How successful was the EPR implementation?
5. What were some of the major challenges you faced?
6. In hindsight, what would you have done differently?
7. What other functionality can be provided to improve the EPR system?
8. What other suggestions or feedback can you provide regarding the EPR implementation?

Figure 1. Interview questions that were used to elicit feedback from implementation team members
months after full implementation. The surveys were administered online, using the Zoomerang zPro survey software system. Responses were anonymous, and no identifying information was collected. The pre-implementation survey contained twelve questions designed to gather users’ demographic data and attitudes regarding electronic patient records. An email announcement was sent in May 2006 to approximately 700 individuals (faculty, residents, staff, and students) of UTDB, and seventy-eight responses were received over a period of four weeks for a response rate of approximately 11 percent.

The post-implementation survey included the same twelve questions from the pre-implementation survey, plus four questions to determine the users’ experience with the new EPR; it also added free-response (open-ended) questions so users could describe their experience with and recommendations about the EPR. The post-implementation survey also included a question asking respondents if they had used the EPR. This survey was launched in early December 2007 and closed in late January; there were 138 responders, for a response rate of approximately 20 percent. Eight of these 138 responders indicated that they had not previously used the EPR and were subsequently excluded from the analysis. At least half of the 130 responders that were included in the final analysis provided at least one text comment.

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### Results

#### Implementation History and Timeline

After an extensive planning phase that included in-depth discussions among faculty and staff, market research, and site visits to other schools, the UTDB EPR implementation began in May 2005 with the selection of a vendor to provide the clinic management/patient record software. The vendor for the digital imaging system was selected in October 2005. By design, the committee tasked with selection of the digital imaging system proceeded at a pace just behind the EPR selection committee. This was due to the fact that the clinic management/patient record system would be foundational to the digital imaging application and to ensure successful compatibility and integration of the two applications. Table 1 shows the overall sequence of implementation with key milestones documented. The project was conducted with a particular focus on creating a participatory and ownership atmosphere in which key stakeholders and users were engaged throughout the project’s life cycle. All clinics, with the exception of the off-site Graduate Pediatric Dentistry Clinic, had the EPR system installed and utilized by 100 percent.

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<table>
<thead>
<tr>
<th>Milestone</th>
<th>Date Complete</th>
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<tbody>
<tr>
<td>1. Clinic management/patient record software vendor selected</td>
<td>May 05</td>
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<td>2. Clinic management/patient record software and related infrastructure and hardware installed</td>
<td>Aug 05</td>
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<tr>
<td>3. Clinic management/patient record software installed by vendor</td>
<td>Sep 05</td>
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<tr>
<td>4. Digital imaging vendor selected</td>
<td>Oct 05</td>
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<tr>
<td>5. Digital imaging related infrastructure installed</td>
<td>Dec 05</td>
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<tr>
<td>6. Computer hardware installed in pilot site (GPR clinic)</td>
<td>Jan 06</td>
</tr>
<tr>
<td>7. Digital imaging software installed by vendor</td>
<td>Jan 06</td>
</tr>
<tr>
<td>8. Additional IT employee hired</td>
<td>Apr 06</td>
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<tr>
<td>9. Graduate clinics workflow defined</td>
<td>Apr 06</td>
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<tr>
<td>10. Go-live: pilot rollout of clinic management/patient record software and digital imaging (GPR clinic)</td>
<td>Apr 06</td>
</tr>
<tr>
<td>11. Undergraduate clinics workflow defined</td>
<td>Jun 06</td>
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<tr>
<td>12. Go-live: clinic management/patient record software installed in graduate clinics</td>
<td>Jul 06</td>
</tr>
<tr>
<td>14. Go-live: clinic management/patient record software and digital imaging installed in faculty practice</td>
<td>Sep 06</td>
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<tr>
<td>15. Go-live: digital imaging installed in radiology</td>
<td>Nov 06</td>
</tr>
<tr>
<td>17. Go-live: digital imaging installed in undergraduate clinics and graduate clinics</td>
<td>Jun 07</td>
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</table>
of the faculty, students, and staff by June 2007, approximately twenty-five months after the project was initiated.

All but two of the original project milestones were met. The first milestone not met on time was the rollout of the digital imaging system, which was originally planned to occur at the same time as the clinic management/patient record application. This part of the implementation was postponed due to technical problems discovered during the pilot phase, which was conducted at the offsite General Practice Residency (GPR) Program Clinic (Table 1, Milestone 10). Following the “go-live” for the pilot program and progress made in resolving technical problems, the digital imaging system was then rolled out in subsequent phases, first to the Faculty Practice Clinic (Table 1, Milestone 14), followed by the Radiology Clinic, and then to an offsite Oral and Maxillofacial Surgery Clinic. As the digital imaging system demonstrated stability and reliability, the implementation team deployed the application on an enterprise-wide basis, i.e., to the remaining undergraduate and graduate clinics (Table 1, Milestone 17). Once the digital imaging system was in full production, the implementation phase of the project was complete because all designated clinics had met the minimum functionality goals originally planned as shown in Table 1.

Regarding the second unmet milestone, the implementation team decided to postpone the implementation of the EPR to the offsite Graduate Pediatric Dentistry Clinic until permanent leadership was in place (the department had both an interim chair and program director during the implementation process).

**Perspectives of the Implementation Team**

The following themes emerged as critical issues from the extensive interviews with the four members of the implementation team relating to implementation of the EPR.

**Makeup of implementation team.** The participants noted the importance of having an implementation team with the appropriate mix of technical, clinical, and project management experience and who fully understood both the workings of a university dental clinic and the technical complexities of implementing a mission-critical information system. The makeup of the team was determined by the dean and key personnel from the school’s clinical, IT, and administrative departments, and members were selected to ensure appropriate representation from patient care, clinical education, operations, and technology. The role of a clinician champion, who served as the project leader for the entire implementation, was highlighted as especially important. The clinician champion was a faculty dentist experienced with the workings of the clinical environment and who had a strong grasp of both IT and project management. The clinician champion was trusted by the clinical faculty and staff and also garnered respect among the IT and operations teams. The ability to converse in both the clinical and IT languages proved to be a great facilitator.

Sharing responsibility with the project leader was an experienced clinical IT manager with many years of experience in computing in dentistry and medicine and an additional, newly hired IT staff member with a computer programming background. On the clinical side, the role of the associate dean for patient care was essential, as this person was intimately familiar with the actual workings of the clinic and possessed the administrative authority to effect change. Finally, the director of patient services, who manages patient records, patient accounts, and support staff (many of whose roles would change dramatically), provided an insightful perspective on clinical operations for the implementation team.

The team met weekly to manage the project and also utilized email, web-based conference calls with the vendor, and ad hoc meetings. In addition to the core team, several working groups were formed to analyze the number and content of forms and map out clinical workflow in undergraduate and graduate programs.

**Understanding clinical workflow.** Members of the implementation team anticipated that moving from a paper-based system to an EPR would dramatically change the clinical workflow of faculty, students, and staff. To address these changes, a workflow analysis task force (WATF) was created for the undergraduate programs, while representatives of each graduate program met individually with the project leader to describe and document its own workflow. All workflow groups were comprised of key clinic faculty members, staff, and students and were tasked to analyze and document the existing pre-EPR workflow in detail. They were also charged to determine and document the changes in workflow that would have to occur in order to best use the EPR—or, vice versa, how components of the EPR might be designed to support an existing process. Meeting weekly over the course of several months,
the workflow groups carefully examined the work of the clinic and prepared numerous flowcharts. For example, the undergraduate workflow group produced an overview flowchart of the entire clinic operation and twelve detailed charts of specific suboperations. This workflow exercise and the resulting documents had immediate value: examination and documentation of the workflow brought to light at least forty instances of inefficiencies and inequities in the system that could be confronted and corrected before the new technology was installed. There was much discussion about the history and thinking behind many policies, and several were changed on the spot. New workflow documents ultimately served as references for configuration of the EPR application, training session content, “how to” training documents, and revision of job descriptions for appropriate staff. Finally, activities of the workflow groups were also credited with actively engaging key stakeholders, instilling support, and creating understanding and ownership of the implementation.

Despite the efforts of the workflow groups and the implementation team to extensively document work processes and understand the impact of the EPR, some unanticipated workflow anomalies were discovered. For example, the team uncovered a puzzling lack of financial documentation from one graduate clinic. Further investigation revealed that providers sometimes forgot to document a patient visit for cases in which patients had paid in advance; therefore, no charge was generated for subsequent visits. In the old paper-based workflow, an encounter form was generated regardless of whether a charge was needed, and this form served as a physical artifact to remind the provider to document the visit.

Other unexpected workflow issues included the following: 1) bottlenecks in radiology due to the conversion to digital imaging, as students, staff, and faculty members adapted to phosphor storage plates and sensors instead of film; 2) digital images not being available outside the clinic in which they were captured, such as endodontics, unless they had been saved to the main storage server; and 3) “cross-over” of procedure coding and fees between adult and pediatric dentistry clinics. In hindsight, implementation team members reported that more simulation and diatric dentistry clinics. In hindsight, implementation of procedure coding and fees between adult and pediatric dentistry clinics. In hindsight, implementation team members reported that more simulation and digital imaging software applications. Consideration of the best platform for the end user workstations received extensive discussion, and the university IT department led several fact-finding sessions, including site visits to various hardware and software vendors. Ultimately, a “thin client” solution using “blade” technology was selected for approximately 250 of the 350 added workstations. In this platform, a workstation port (thin client) with a monitor, keyboard, and mouse connects to a centrally located, remote PC (blade) system, which delivers the EPR, Internet, and other applications to the end user. The thin client/blade solution was selected for the following reasons: its small size, making it ideal for operatory use; the ease of making changes to the blades as a group; the absence of a local (hard) drive or CPU in the thin clients; and the ability to manage thin clients and blades remotely. The remote management was a significant feature for the university IT department as it did not need to increase its staffing support to the dental school as a result of the implementation. The implementation team, however, reported the following drawbacks with the thin client/blade platform: difficulty at times with thin clients connecting to blades; slower response than PCs; and inability to capture patient signatures directly on screen (using touch screen monitors).

Pilot-testing. Implementation team members credited pilot-testing of the EPR as another key to success. Without pilot-testing, the school would have been forced to “live in two worlds”—both paper and electronic—until conversion to the new EPR was completed. The offsite GPR clinic was chosen as the pilot site for two primary reasons: implementing the
new EPR there had no impact on the current dental school clinic information system (CIS) since the GPR clinic used a separate, stand-alone system; and the faculty and staff at the GPR were seen as early adopters eager to embrace the EPR and other new technology.

The pilot phase allowed the implementation team to identify problems early and refine the configuration and workflow issues associated with EPR implementation (Table 1, Milestone 10). As a key example, piloting provided firm evidence supporting the decision to postpone rollout of the digital imaging system. During the pilot, serious technical problems surfaced with the digital imaging software, primarily configuration, user-friendliness, and system stability. These problems resulted in delaying enterprise-wide implementation of the imaging system for almost a year. Other technical and application issues, such as thin client/blade configuration, server performance, electronic storage, system configuration, and end user training needs, were resolved during this period, both by the vendor and the implementation team.

**Implementation approaches.** From the earliest stages of planning, the implementation team debated whether to take a phased implementation of the EPR versus a “big bang” or all-at-once launch. This question could be further broken down into two related decisions: 1) whether to deploy both the clinic management and patient record features of the EPR or to start with clinic management and then add electronic patient records later; and 2) whether to deploy digital imaging at the same time as the electronic record. While those involved in the discussion recognized the colossal challenge of a “big bang” approach, the majority of the team members felt that implementing in phases—and thus being forced to juggle a combination of electronic and paper-based patient records—was less desirable. With this in mind, the decision was made to implement all phases of the EPR simultaneously.

As implementation proceeded, implementation team members uniformly expressed their growing concerns with the documented technical problems in the digital imaging system in the pilot GPR clinic. Although postponing implementation of the digital imaging system was considered a setback, in hindsight it simplified the process of user adoption and training. During this time, implementation team members perceived a need for more time to test and configure the imaging system than originally planned, and part of the delay was due to waiting on the vendor for bug fixes and enhancements to the software. The team’s consensus was that a more mature digital imaging product would have improved the process.

**Data conversion.** The implementation team initially hoped to convert and make available all the existing patient-related data from both the existing paper and electronic systems to the new EPR. However, it soon became clear it was no trivial task to convert ten years of billing and transaction data from the old CIS to a format compatible with the new system. One team member described it as “an absolute chore” that made for difficult days and nights. The implementation team reluctantly decided that much of the existing data (such as appointment history and treatment plans), while potentially valuable in the new EPR, would not be converted. Instead, students would be required to enter existing treatment plans and future appointments into the new EPR after the “go-live” date. This decision enhanced training as it allowed students and faculty to gain experience on the new system. This exercise was also an important prerequisite for simulated patient encounters during the go-live week as part of provider training.

The reality of limited time and resources forced other alterations in the original plan. For example, all paper-based records were to be scanned into the new EPR, but time, cost, additional electronic storage needs, and the cumbersome nature of the scanning process were too great. The implementation team ultimately devised a hybrid system in which existing paper charts would be available in hard copy for the first two years after implementation in order to maintain continuity of care. Also, any paper documents from the paper record would be scanned if requested by patients or providers, such as for medical consultations. Although this hybrid system was not an ideal solution for viewing historical patient data, team members suggested that this resulted in a reasonable compromise, given available resources.

**Consensus on electronic forms for data collection.** A forms committee was created and charged with three tasks: reviewing all existing paper patient record forms, defining the required data elements (content), and determining the number of forms to be used with the new EPR. Although the EPR application had some standard pre-built data elements by default, it provided great flexibility and the ability to customize. The implementation team sought consensus from the forms committee on key forms, such as medical and dental health histories. Although consensus was eventually achieved, the end result was that many of the new electronic forms were lengthy
and new forms had a learning curve of their own. The consensus medical history form contained approximately 150 questions. There was also debate on the benefits and costs of using “free response” answer fields versus input fields using structured terms. Both the forms committee and implementation team were successful in designing most forms with structured format responses, which greatly facilitates data retrieval and analysis. Many forms were structured to allow providers to make more detailed responses using clinical notes where appropriate.

**Communications and user training.** From prior experience with technology innovations, the implementation team felt that building awareness and support for the project among key users was essential. A communications plan evolved with a focus on educating users about the benefits of an EPR and how it would change their workflow and patient interaction. The first step was to create a separate “identity” for the new system, one that would decidedly differentiate it from the old Clinic Information System, or “C-I-S.” Therefore, “electronic patient record” or “E-P-R” was selected as the name to replace the CIS, which had been in place since 1996, and establish a new identity for the new system. At the same time, implementation team members were aware of the dangers in overstating or “hyping” benefits of electronic records. They were careful to moderate expectations by explaining that the transition from paper records to the EPR was likely to slow workflow at first and result in some initial inefficiencies. A common statement made by the project leader prior to go-live was “This will not make us faster, at least not at first.”

Multiple techniques were used to communicate with stakeholders and end users, including ad hoc meetings and regular hands-on “evaluation” sessions (using the Simulation Clinic) during which faculty members, staff, and students were given time to interact with test versions of the software, ask questions, and offer suggestions regarding configuration and workflow. The implementation team also developed a project website that served as a repository of information about the project and the main source of training material, such as FAQs, training videos, and how-to guides. Finally, the project leader sent out periodic email newsletters, dubbed “EPR Instant Messages,” to faculty, students, and staff, which highlighted behavioral issues such as how electronic records might impact the patient-provider relationship. The objective of the pre-implementation phase was that as many users as possible would have had hands-on experience with the new system prior to formal training at go-live.

The newly constructed Simulation Clinic played a critical role in training large groups of users due to its uniqueness as an actual clinic with chairside network computers. In this facility, users were provided frequent opportunities to familiarize themselves with the EPR and receive training on the system. The training, conducted by the project leader, was provided to the faculty, students, and staff and tailored to learner type. For example, student training sessions were conducted in large groups with upbeat background music and a training curriculum that required students to work together, while faculty training sessions were more individualized and in a quieter atmosphere. For all groups, the core training was performed on a training version of the EPR and designed to simulate the tasks and security each user group would have in the production system. The training sessions were perceived as effective, and it was noted that students rapidly learned how to use the system. In fact, it appeared that students were so proficient with the system early on that they graciously assisted those faculty members who needed a little help during the early days soon after go-live.

To complete training for undergraduate dental and dental hygiene students, direct patient care was simulated in clinic immediately before go-live with students pairing up as provider/patient and, led by faculty group leaders, performing scripted tasks in the production EPR. These tasks included scheduling appointments, creating and changing treatment plans, generating informed consents, and obtaining faculty approvals.

**User Perspectives Before and After Implementation**

To assess the level of user acceptance and awareness, two surveys were conducted among faculty, students, and staff (pre- and post-implementation). Demographic results are shown in Table 2, and comparative results for the questions are shown in Table 3. Although there were differences in the sample size between the pre- and post-implementation surveys, there were no significant differences between the types of respondents (percentages of faculty, staff, etc.) who replied to the two surveys (chi-square=4.5, df=5, p=0.48); similarly, there were no significant differences in the gender of respondents (chi-square=0.210, df=1, p=0.65). However, direct comparisons between the pre- and post-implanta-
tion surveys need to be interpreted with caution as the respondents were not matched and the post-implementation survey had a higher response rate.

The pre-implementation survey results suggested that many prospective EPR users were uncertain or even ambivalent about electronic records and were generally neutral about the impending installation. The most striking change from pre- to post-implementation attitudes was a reduction in the neutral category. Before implementation, users could only speculate on how the EPR would impact their work. As might be expected, hands-on experience with the EPR reduced the uncertainty or ambivalence that users might have had about its use. Notably, two results that hardly changed were the questions concerning cost and security. Few users were aware of or directly concerned with the cost of the system, and users had little or no direct knowledge about the security measures in place for a paper-based versus an electronic system. The other results that did not change significantly (though tending toward significance at p=.06) was whether an EPR improved patient care; apparently, users have not made up their minds about the long-term impact of the EPR.

After implementation, users seemed to have confirmed their opinions regarding the impact of the EPR on their work in the clinic. About the same percentage thought that an EPR improved their efficiency, but a significant percentage changed their opinion from neutral to negative regarding efficiency. Similarly, fewer were neutral and more agreed that the EPR required more time to complete than a comparable paper record. Despite these somewhat negative results, an overwhelming percentage of users

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<th>Table 2. Demographics of survey respondents, by number and percentage of total respondents</th>
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<td><strong>Respondent Type</strong></td>
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<tr>
<td>Faculty</td>
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<td>Support staff</td>
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<td>Predoctoral students</td>
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<tr>
<td>Postdoctoral students</td>
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<tr>
<td>Dental hygiene students</td>
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<td>Other</td>
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<td><strong>Gender</strong></td>
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<td>Male</td>
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<td>Female</td>
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*Note: No significant differences were found between the pre- and post-implementation surveys for respondent type or gender. Percentages may not total 100% because of rounding.*

<table>
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<tr>
<th>Table 3. Users’ responses to statements relating to the EPR before (pre) and after (post) implementation, by number and percentage of total respondents</th>
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<tbody>
<tr>
<td>Statement</td>
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<tr>
<td>1. Paper dental records are more secure than electronic dental records.</td>
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<tr>
<td>2. Electronic dental records improve efficiency for an instructor and/or dentist.</td>
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<td>3. Electronic dental records cost more than they are worth.</td>
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<tr>
<td>4. Electronic dental records require more time to complete than comparable paper record documentation.</td>
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<td>5. Prospective dental students expect a dental school to use electronic dental records.</td>
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<td>6. Electronic dental records improve patient care.</td>
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<tr>
<td>Statement</td>
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<td>7. I would recommend the use of electronic dental records to a dentist starting a new practice.</td>
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(91 percent) would recommend an EPR to a dentist starting a new practice, and over two-thirds thought prospective dental students should expect a school to use an EPR.

In addition to verifying if respondents had used the EPR, three questions were added in the post-implementation survey concerning users’ likes and dislikes of the new system and suggestions for improvement. In a departure from the previous survey, they were also offered an opportunity to enter free text, under “other—please specify.”

When asked “What do you like about the EPR?,” users seem to have been satisfied with the options offered by the survey team, as only eight (6 percent) of the 130 respondents entered comments explaining their “likes” (see Table 4). The eight respondents who positively commented mentioned presentations of the treatment plan, better system security, ease of following past treatment, better tracking of data, improvement in patient interaction (two), less paper, and excellent assignment of procedures to students.

When asked “What do you dislike about the EPR?,” users did not seem to find much in the offered answers that described their attitudes, as only one option (“Image quality is not as good as film,” selected by 58 percent) was selected by more than 50 percent of respondents. On the other hand, many respondents (fifty; 43 percent) took the time to type their dislikes into the free text area, and the open question “What suggestions do you have to improve the EPR?” received sixty-eight responses, some of which were quite lengthy. The fifty text responses (see Table 5) that indicated dislikes for the system and the sixty-eight suggestions for improvement were grouped into the following six categories:

- Usability: usability and interface issues, i.e., the system was confusing and/or difficult to use.
- Hardware: hardware settings (most often this was the time until the system automatically logged the user off), system reliability, and speed.
- Imaging: radiographic image quality and reliability of the image subsystem.
- Support: technical support and user training.
- Remote access: need for remote access outside the building, primarily checking schedules and appointments from home.
- Misc.: miscellaneous comments that could not be easily categorized.

Hardware (54 percent) and usability (28 percent) issues were the most frequently mentioned dislikes about the EPR. Users provided suggestions for improving usability (47 percent), hardware (31 percent), and digital imaging (28 percent). Similarities in users’ dislikes and suggestions indicated that improvements were needed in the responsiveness of some of the hardware and difficulty in using the digital imaging system.

**Discussion**

In this study, we interviewed key members of the EPR implementation team, reviewed project documents, and surveyed end users in order to determine how the EPR was implemented, factors that facilitated its success, and those that were challenges. The implementation process was completed in approximately twelve months. The in-depth interviews were invaluable in reconstructing the history of the implementation and in identifying eight critical issues that team members thought were important in impacting the implementation. We discuss lessons learned in the context of these critical issues.

1. **Makeup of implementation team.** One of the barriers to large-scale implementation of health IT is described as the lack of a “well-trained
workforce.”16,17 There is increasing recognition, particularly in the field of biomedical informatics, for the need for professionals who are trained in both the clinical and technology aspects in order to successfully implement clinical systems.16,17 The makeup of our implementation team in combination appeared to be well balanced, consisting of individuals from dentistry, health information management, and information technology. Failing to include clinicians in the process or having IT professionals with little understanding of academic dentistry would likely have resulted in a less favorable outcome. Our study also reaffirmed the valuable role of a trusted clinician (dentist) champion during implementation, a finding that has been extensively documented in medicine.18-20

2. Understanding clinical workflow. Electronic patient records cannot be used to mask bad clinical practices. Since EPRs often result in changes to business processes, we found that pre-implementation of an EPR is an ideal time to map and streamline workflow. Workflow changes such as these help to ensure that the full advantage of the system is captured and that redundant manual effort does not occur once the new system is in place. One limitation of our study was that we did not directly observe the workflow of users of the EPR. Although we understood that human factors play a key role in the acceptance of change for large-scale system implementations, these sociotechnical influences17 would have required significantly more implementation resources to observe individual processes and analyze the resulting data.

3. Support from centralized university IT. Although having a full-scale IT department within the dental school may have afforded greater control, partnering with centralized IT allowed the implementation team to focus its attention exclusively on the clinical aspects of implementing such as a system and not also be absorbed with hardware and software configuration issues. The dental school engaged the university IT administration and staff at the early stages of conceptualization and design of its EPR, and key university IT staff served on the implementation team. As a result, there was a close working relationship between school and university IT personnel during the implementation process.

Outsourcing core IT functions to a separate entity or vendor may also be an alternative for dental schools. The decision to outsource may depend on the architecture of the EPR system. Some EPR vendors may offer to host the system on their own servers and allow access through a web browser via the Internet without the need to install any software on a local computer. In this architecture, the vendor becomes responsible for maintaining and ensuring access to the system. However, dental schools adopting such an approach should think carefully about how protected health information is accessed by third parties and the consequences of being fully reliant on a vendor for a mission-critical system.

4. Pilot-testing. Our pilot test involved a small clinic, in which we were able to discover that while the clinic management/patient record application was stable and functional, the digital imaging system was not mature enough to be rolled out to end users. This pilot ensured that we could roll out a product with full functionality, which helped us maintain positive user satisfaction and acceptability. Other dental schools could build on this approach by either pilot-testing at multiple sites or using a larger site for the pilot. Either way, this might help to expose additional issues that might not emerge in less complex, smaller pilot sites.

5. Implementation approaches. The two primary strategies for implementing clinical systems can be summarized as “big-bang” (deploying all sites and modules at once) or “phased approach” (staging of the deployment according to a master schedule). Although the implementation team preferred a simultaneous “big bang” rollout, evidence suggests that incrementally adding functionality after demonstrating “small wins” has benefits.15,16 The incremental approach allows users to build trust with the system and eases the transition from a paper-based system to one that is electronic. Therefore, the technical problems and consequent delays in our digital imaging system may have unexpectedly contributed to a smoother rollout of the EPR. To increase the likelihood of success, dental schools should consider the benefits of a phased approach to implementing health IT systems rather than a “big-bang” rollout.

6. Data conversion. Although we elected not to convert our prior records into the new system, there would have been great benefits if this could have occurred. Many of the advantages of adopting an EPR are based on the availability of historical clinical data to minimize repeated tests and procedures or to be used for research and data mining purposes. There are various ways to import data from the paper chart into a
new electronic system. For example, clinical data from the paper chart could be manually rekeyed. The accuracy of this approach is related to the expertise of the human rekeying the data and the legibility of the paper chart. Alternatively, structured portions of the record could be scanned and automatically imported using technology such as optical character recognition (OCR). However, OCR technology is likely most accurate for numeric data such as vital signs rather than free text such as a clinical note. Although it is unlikely to provide many of the benefits of using an EPR, the simplest approach is to scan pages of the paper chart as images and attach them to the electronic record. If dental schools have the necessary resources and expertise to follow this approach, there would be great advantages to converting data from paper charts and legacy systems into a new electronic record system.

7. **Consensus on electronic forms for data collection.** Patient data can be entered as a free text note in an unstructured format or can be more structured by using predefined concepts. Unstructured data narratives may be more descriptive but are often difficult to aggregate and may vary in style and substance depending on the provider. Entering data in a structured format often limits expressiveness, but does provide the benefits of data consistency and uniformity, which is helpful for subsequent data analysis and retrieval for research, administrative, and clinical decision support. In our implementation, structured data entry was preferred, and the clinical providers also recognized the advantages of such an approach. However, the main challenge for the implementation team was to foster agreement among various specialists on the content of the forms. Ultimately, a consensus approach was used in which forms were created to be comprehensive. Although designing forms by consensus helped the adoption, it also resulted in lengthy forms. To realize many of the benefits of electronic records, dental schools should attempt to use structured data entry whenever possible.

8. **Communications and user training.** The implementation of an EPR in a dental school is a major initiative that will significantly change the work of the faculty, staff, and students. Therefore, users need to be educated about the benefits and limitations of such a system and should be provided ample opportunities to become comfortable with it and experiment with its features before actually using it in patient care. Our experiences suggest the value of developing a communications plan and providing multiple opportunities for users to learn to use the system.

**Conclusions**

End user surveys of faculty, staff, and students before and after implementation indicated that users had mixed feelings about the EPR in terms of efficiency and time required compared with paper charts. After using the system, many users felt that the EPR improved legibility and access to a patient chart and that they would recommend such a system to dentists starting a new practice. However, only 29 percent of users thought the EPR improved productivity, suggesting there are opportunities to further enhance the usability of the system. In future work, we plan to conduct yearly post-assessment surveys to document changes as the time from go-live increases and adjustments are made.

In this study, we primarily used interviews and surveys, which provided a wealth of information to help document the implementation process and to explore themes. However, our analysis could have been improved if we had used additional qualitative assessment methods in order to improve validity. For example, focus groups and “shadowing,” ideally by trained and/or independent facilitators or observers, are excellent sources of additional valuable data. We also had a low response rate for our surveys. Responses may have increased with more frequent reminders or lengthening the period in which the survey was open.

In summary, we identified eight critical issues as important contributors of implementing an EPR. Although there are likely other ways to implement information systems and our findings are local in nature, the general principles and considerations presented may be useful for other dental schools as they too embark on their journey for implementing complex clinical information systems.

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