THE USEFULNESS OF HANDHELD COMPUTERS IN A SURGICAL GROUP PRACTICE

by

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I would like to thank Priscilla Lewis and John Zelko for initiating this project and the administration and surgical staff of HealthFirst Medical Group for their support.

Abstract

Background

The mobile, or handheld, computer has attracted attention as a tool that can benefit communication among members of a health care team. However, to date the ideal role for handheld computers is uncertain. The purpose of this project was to design and implement a system based on handheld computers for use by surgeons in a large multispecialty clinic and then to evaluate the system's use.

Project Design

As a first step, a needs assessment was performed. The surgical department at HealthFirst Medical Group in Portland, Oregon, identified problems in 1) standardizing and coordinating schedules for the surgeons, 2) efficient and complete capture of hospital charges, and 3) intradepartmental communication. The second step was to design and implement a system to meet these needs. Handheld computers running the Windows CE operating system were chosen and distributed to the surgeons. In addition, Windows NT desktop computers were selected for the medical assistants and billing personnel, which used off the shelf software including Microsoft Outlook and Access. We synchronized calendar information between the handheld computers and the PCs, and we linked the PCs using Microsoft Exchange. In addition, a database and interface was designed using a Windows CE development program, Syware Visual CE, to collect billing information at the point of service and electronically pass it to the PC and the clinic network.

Evaluation Methods

Evaluation of the project used stable pre-implementation data spanning 11 months and compared this to post-implementation data collected over 4 months. Our hypotheses were that handheld computers would make it easier to coordinate physician schedules, make billing more timely and

cost-effective, and would improve communication among physicians. We analyzed the number of days it took to post billing after a surgical procedure or consultation, the number and amount of hospital charges for consultative services, and a pre- and post-implementation questionnaire which evaluated user satisfaction.

Results

Our study supports the role of the handheld computer with regard to the coordination of schedules. We were able to show potential enhanced revenue from increased capture of charges, but we did not specifically design the study to be able to show a cost-benefit analysis. The study seems to be neutral with regard to the timeliness of billing. The study also shows that the use of these devices enhances physician satisfaction.

Introduction

Specific Aims

Research Question

What is the usefulness of a handheld computer in a large multispecialty group practice when used by a group of general surgeons to coordinate their schedules and increase their efficiency?

Goals of the Study

The goals of the study are as follows:

1. To design and implement a database program to store and display all patient procedures, consultations and associated procedure and billing codes.

2. To design and deploy an integrated system utilizing handheld computers in conjunction with a network-based groupware product.

3. To test a set of hypotheses to determine the usefulness of handheld computers for a group of general surgeons.

    - *Hypothesis 1: The use of handheld computers will make it easier to coordinate the schedules of physicians who perform multiple procedures/consultations in multiple locations.*

    - *Hypothesis 2: The use of handheld computers will allow transmission of billing data to the organization in a more timely and cost-effective fashion.*

    - *Hypothesis 3: The use of handheld computers will improve physician communication.*

Background and Significance

As medical organizations grow in size and complexity, there is a need for information management tools to benefit communication among the members of the health care team, with regard to improving both the quality of medical care and business efficiency. One tool that has attracted a great deal of attention is the mobile, or handheld, computer. There are recent advances in networking and mobile devices that show great promise, but the optimal role of the handheld computer is still uncertain.

"Quality of care" is a phrase well known to all medical providers and administrators. In addition to providing services to patients, providers and organizations are being asked to document quality in a way that can be quantified and measured. These measures may provide the basis for current reimbursement or future contracting with insurance companies. In addition, there is an interest in patient care guidelines as a tool for improving outcomes. Some of the ways that handheld computers may improve quality of care include the following:

- **Documenting patient encounters at the point of service**. Whether in the exam room or at the bedside, the clinical note can be generated at the time the patient is examined and orders written [1, 2]. Data entered at the time of service is fresh in memory and likely to be more accurate than data recorded at a later time. Information may be transferred to a central medical record database, or may simply stay on the mobile device for reference by the provider at a later time. However, this presumed benefit may be limited by inaccurate or incomplete data entry by the provider when entering information on a handheld unit compared to the more traditional methods of data entry, such as the written note or dictation.

- **Providing patient care guidelines**. Organizational guidelines may be stored on a mobile computer, available for use when the patient is seen. As Shea notes, there is a "growing

body of literature showing that computer-generated informational messages directed to physicians at the "point of service" —at the time when and in the place where clinical decisions are made—can improve the quality and efficiency of health care [3]."

- **Providing improved communications among providers**. Appropriate communication among all members of the healthcare team can be difficult. A mobile computer has the potential to facilitate communication through e-mail and voice messaging. Acuff, at Stanford, has been investigating how emerging computer technologies can be used to facilitate some the more routine tasks involved in clinical settings. His group developed a system that delivered mobile e-mail to members of the health care team using small handheld computers and wireless local area networking [4]. A similar study is under way at the VA in Tampa by Malek [5].

- **Providing connectivity to the patient's longitudinal record or a central database**. If the mobile computer can be connected to the patient's medical record database, past information can be viewed and current information can be updated and immediately available to others. In one successful project, visiting nurses in the Washington D.C. area made home visits assisted by a portable laptop computer connected to their wide area network by modem [6].

"Business efficiency" is another phrase increasingly heard by physicians. With managed care and reduced physician income, it is evident that improving the bottom line has become a priority of many provider organizations. The handheld computer may improve business efficiency in the following ways:

- **Improving scheduling**. Many physicians have complex schedules. They may go to more than one hospital or practice out of more than one office. They may perform procedures

or provide consultations in the hospital. They may be called to assist another physician with a procedure. They also have meetings and, hopefully, a personal life. They are often available by pager and cellular phone, but once they leave the office, the staff has an incomplete picture of where they are at any one time. In addition, the physicians may not be aware of all changes that have been made to their schedules since the last time they were in the office. Mobile computers connected to a central network calendar at regular intervals have the potential to coordinate these schedules and improve physician efficiency.

- **Improving the capture, accuracy and speed of billing**. After a physician performs a service, the charge for the service must be sent to the billing office for processing. Revenue is lost or delayed when a bill is not recorded, when it is returned for reprocessing due to inaccurate information, or when there is a late entry. Mobile computers have been shown to increase the accuracy and speed of billing [7], and it is reasonable to design a system that will implement complete and accurate capture of charges.

Do patients accept computer use by physicians? The answer appears to be "yes." An early study by Tattersall showed that it is possible to collect and process clinical data in the patient's presence using a small handheld computer [8]. A subsequent study by Solomon showed no decrease in patient satisfaction when a computerized medical record was introduced into the examination room [9].

Physicians also seem to accept the use of mobile devices. In a questionnaire of 137 family physicians, 85% said they would consider carrying a handheld computer weighing one pound, and 51% said they would consider carrying a tablet-sized computer weighing two to three pounds [10]. Fishman studied portable electronic book systems, and found that physicians accepted the

devices and found them "enjoyable and useful in clinical practice" [11]. It is possible that mobile computers will take some of the drudgery out of clinical recordkeeping, being simultaneously more efficient and gratifying to use.

The design and implementation of the software for the handheld device is crucial. For a particular application, it may be necessary to write a custom application. As Davis notes, "We believe that if a system fits the needs of the organization, so the organization does not have to fit the needs of the system, most users will be satisfied" [12]. On the other hand, Miller advises the user to utilize off-the-shelf software whenever possible, and, if necessary, to create simple programs by using commercially available development tools[13].

In addition to content, the programmer must pay attention to the user interface. Poon found that even simple design changes to the interface could make dramatic differences in user performance [14]. Specifically, he noted that the "prototype that allowed the fastest data entry had the following three user-interface characteristics; it used a paging rather than a scrollable form, it used a fixed palate of modifiers rather than a dynamic "pop-up" palette, and it made available all findings from the controlled vocabulary at once rather than displaying only a subset of findings generated by analyzing the patient's problem list."

The ideal method of data entry by physicians is uncertain, resulting in what Cushing called "the data entry conundrum" [1]. He concluded, "In the short run, I'm betting on pen-based computing. A lightweight laptop that we can take anywhere seems feasible, if we can upload data in to the main computer by physical docking and data transfer or radio or infrared transmission."

Recently, there have been significant advances in groupware, as evidenced by the current versions of Microsoft Exchange and Lotus Notes. In addition, many other products are available to coordinate schedules, distribute e-mail, and provide office productivity tools. Handheld

computers, utilizing operating systems from Microsoft Windows CE, Psion, and 3Com's Palm Pilot, are selling in the millions of units. To date, physicians have rarely used these devices. Although we believe in the future of an integrated medical record, it is our belief that these relatively simple tools can meet many of the needs of physicians and their organizations. However, there is currently a shortage of information in the literature to give us guidance.

Objectives

HealthFirst Medical Group is a multispecialty group in the Portland area with approximately 100 physicians, including 7 general surgeons. The HealthFirst administrative department had been receiving a number of concerns from the surgeons regarding communication and scheduling issues. This set the stage for this study of the design and implementation of a system using handheld computers.

The primary author was asked to assist the HealthFirst IT department with regard to the following tasks:

- To further define the problem areas.
- To investigate the feasibility of using a handheld computer to assist the surgical department.
- To design and implement a workable system to solve the problems identified.
- To evaluate the findings.

Needs Assessment

To define the scope of the project, we performed a needs assessment of all involved personnel. We began to understand the problems and were able to create a prioritized list that we were able to implement.

Methods

To define the problem areas, a needs assessment was performed. The first step was to set up a working group consisting of the author, the CIO of HealthFirst, and one additional support person from the IT department. The working group then identified those persons at HealthFirst who would be primarily affected by this project—7 surgeons, 7 Medical Assistants (MAs), 4 clinic managers, 4 administrators, 2 persons from the business office and 3 additional persons from the IT department.

Discussions were held with all surgeons, both individually and in a group setting, and representatives from the other departments over a two month period of time to define the specific issues to be addressed. The following non-prioritized "wish list" and "hoped-for results" was used to determine the eventual scope of the project.

In the Office

- Each surgeon's schedule should be viewable and updateable by all of the surgeons and their nurses.
- There should be quick access to notes and reminders about patients that were seen in the hospital.
- Everyone should have ability to send faxes and send and receive e-mail.

Out of the Office

- The physician should be able to view a current schedule, updateable at any time by modem. He or she should be able to view and modify other physician's schedules.

- By having access to the schedule at all times, it should be possible to schedule procedures and perform rounds more efficiently. The physicians should be able to assist each other more often on procedures and cover for each other more often on hospital rounds.

- Improved quality of patient care should be reflected by reduced complications and reduced length of stay. An example of this would be a patient undergoing surgery at midnight, due to a scheduling difficulty, as opposed to 8 am, if the scheduling had been more efficient. Likewise, there might be reduced length of stay simply by being able to coordinate schedules more efficiently.

- The physician should have the ability to read and compose e-mail off-line, and send and receive e-mail at any time via modem. E-mail can be used for communications after weekend or evening call.

- The physician should have the ability to synchronize the schedule with his or her home computer.

Billing / Business Office Functions

- There should be the ability to track all procedures and consults and automatically link both to billing. The project should ensure that 100% of all hospital procedures and consults are billed, and there should be increased accuracy of charges. As surgeons are billing at the point of care, the coding should support documentation of more complex codes. There should also be more rapid turnaround of charges, since the charges are

passed to the billing office electronically on a daily basis. The system should generate a monthly list of billed procedures per physician and track missing charges.

- There should be a patient reminder, or recall, system.
- There should be the ability to store and analyze cases. The system should support outcome analysis.

Departmental Issues

- The surgical call schedule should be electronically available and updateable.
- There should be an ability to schedule meetings electronically.
- There should be a mechanism for improved communication with outside surgeons and referring physicians.
- There should be the availability to perform word processing, spreadsheets, presentations, and Internet access, especially useful if the physician is at a meeting or out of town.
- There was concern that there would need to be appropriate training and security measures.

Results

From the above list, we identified three main areas for our project:

- Standardizing and coordinating the schedules for the physicians when they performed surgery or provided consultation in the hospital.
- Ensuring that the capture of charges was complete and efficient.
- Improving intradepartmental communication.

From what our working group knew about networks and mobile devices, we felt it was likely that a handheld computer could be used to help solve the problems identified. However, we knew that we would have to learn as we developed the system, as we had no prior experience with these devices and there was no readily available model to show the way. We decided to focus on the three main areas—scheduling, billing and email—delivering as much functionality as we could reasonably develop.

Discussion

At HealthFirst, the clinic sites are connected to a central Unix server over T1 lines. The specific software products we use include Reynolds and Reynolds for our Practice Management System (PMS), Microsoft Office for office productivity, and Microsoft Exchange and Microsoft Outlook for e-mail and administrative scheduling.

We looked at handheld devices that could synchronize with Outlook. We chose the Hewlett Packard 620LX Handheld PC (H/PC) running Windows CE 2.1 because of its compact size, easy-to-read screen, integrated keyboard, ease of connectivity, software compatibility, and battery life. The unit connects over the network by ethernet or modem to a designated PC, or it can connect directly to the PC by a serial cable. Files are synchronized to reflect the most recent changes on either device.

This seemed to provide a solution for scheduling and email, but we were still uncertain how to provide an application for billing. We wanted to provide an application that would allow the physician to enter patient-specific data while seeing patients in the hospital and then would pass the data electronically to the billing department when the surgeon returned to the office. We did not find a solution using the software included with the H/PC, which were Windows CE versions of Microsoft Outlook, Excel, and Word. (Microsoft Access on the H/PC was not available when

this project was initiated.) We also did not find commercial software that met our needs, thus requiring the development of a database specific to this project.

Database Development

Using Visual CE, a commercial development tool, we created a shared database for the handheld computer that could link to the HealthFirst computer network.

Methods

We developed a shared database to store and display all patient procedures, consults and associated codes. The surgeon can enter billing information while making rounds at the hospital The data can be passed to a central database upon synchronization, and it can then be viewed by business office personnel, who verify the information and re-key the data into our PMS.

To understand the capabilities of a database program on the H/PC, it is necessary to understand the limitations of the operating system, Windows CE.

Windows CE

A Windows CE database is a general purpose, versatile, collection of data. Each database is comprised of records, and each record consists of one or more data elements. Each data element has a property that consists of a property identifier, a data type identifier, and the data value. Windows CE supports integer, string, time, and byte array data types.

Windows CE devices usually come with preinstalled databases, such as the calendar, tasks and contacts databases found in Pocket Outlook. Windows CE does not support a relational database structure. Records cannot link to, or reference, other records, and records cannot be shared by databases.

Visual CE

We evaluated the available database development programs for the H/PC and chose Syware Visual CE. The program creates an interface for a database on the H/PC that can be linked to any ODBC compliant database on the PC, in our case Microsoft Access.

Although Visual CE is reasonably intuitive and powerful, a number of undocumented features and problems slowed the development. However, after several months of trial and error, we had a system that was working well.

Results

The limitations of Windows CE meant that we had to design a flat file, and we chose to have one record for each patient, with multiple fields for hospital charges. The immediate limitation of this design is that the fields can quickly become filled, leaving no place for subsequent data entry. We solved this problem in two ways. The first was to create a memo field for overflow data entry. The second was to write a utility program to clean up the data. This Visual Basic application stored the pertinent data elements in one large memo field on the H/PC and restored the other fields back to their original state.

When the handheld and the PC are synchronized, the flat file on the H/PC maps to a table in an Access database on a central server. We then developed queries and forms in Access that allowed the billing office personnel to process the charges. The specifications for the database were developed after discussion with the billing office. The specific data elements for each record are listed in Appendix A, as well as a listing of the changes made to the database by the utility program. Many of the technical aspects of the Visual CE application are listed in Appendix B.

One specific difficulty with Visual CE limited our ability to provide the product as we had initially envisioned it. We had wanted multiple drop-down lists for diagnoses and procedures to minimize the need for keyboard data entry. However, when we loaded these fields with data

elements, the program slowed significantly, taking up to five seconds to redraw the screen, which we found to be unacceptable. Discussions with technical support for Syware revealed that compromises were required to fit the runtime program onto one floppy disk which severely affected its flexibility and speed. We found that we could achieve barely acceptable speeds if we limited the number of fields per record to 40 and used only a few drop-down lists with a small number of choices per list. This meant that our surgeons were required to type each procedure and diagnosis, although we were able to create efficient help screens to assist them with CPT code selection.

The database was developed on one handheld, field tested for several weeks, and then rapidly deployed to all surgeons. After the go-live date, the IT group met weekly to troubleshoot technical problems. Six weeks later the H/PC interface was revised to reflect changes requested by the users. This proved to be difficult to implement, as each handheld needed synchronization specifically to the PC used for the development of the program.

With any new device or software that is used for handling sensitive information, there is a concern for security. A handheld computer is especially vulnerable to being broken, lost or stolen, so there are special concerns regarding data integrity and user access. Our findings are summarized in Table 1.

Control	Current Status	Comments
Unique User Identification	A password is required to access and synchronize the handheld.	This needs to be monitored for compliance.
Access Controls	By administrative rules, only the surgeon and MA can use the handheld. Data can be also changed by the business office.	It is important to determine who has access to the information on the drive storing the Access files.
Audit trails	None available on handheld.	This needs to be addressed at a later date.
Physical security.	The handheld unit can be easily stolen or broken.	Consider soft case to protect unit. Consider warnings to providers. Stolen unit should be secure if passwords are enforced.
Disaster recovery	Standard backup on the network. Handheld easily synchronized to Outlook. Would need to reinstall Visual CE.	We tested recovery with Visual CE and found no loss of data.
Protection of remote access points	Not yet addressed, as this feature has not been implemented.	Consider firewall coming into the clinic network.
Protection of external electronic communication.	Data seems to be secure travelling on serial connection or over network from the Handheld to PC.	
Software discipline	The only additional software program on the HPC is Visual CE.	
Personnel practices	Staff is trained on the site.	Consider a confidentiality statement for all involved staff.

Table 1. Security

Discussion

We were pleased that our database application was able to meet all of our initial specifications. We were also pleased that we were able to design the interface in such a way as to achieve a good level of user acceptance. The synchronization of the handheld database with Access has been error-free, and we have not experienced any difficulties with data integrity. Also, since Access is stored on a network server, it is backed up automatically by the IT department.

It was relatively easy to develop the user interface with Visual CE, but it can be slow to run and difficult to deploy. The program allows the developer to create an unlimited number of runtime discs, one for each handheld, which reduced the overall cost of the program. However, we find it difficult to recommend this product for an enterprise-wide solution.

Another major frustration was the lack of a relational database structure in Windows CE. This resulted in an application that had multiple redundant elements, thereby slowing its speed and requiring a utility program to clean up the data and create another database that could be used for analysis. If we had been aware of this limitation initially, we would have investigated other platforms. Specifically, we would have taken a closer look at the Palm Computing Platform, which can support a relational database and seems to offer exceptional speed and convenience.

Deployment

We needed to introduce PCs, H/PCs, and associated software to our staff. The users were adaptable and enthusiastic, leading to a successful implementation.

Methods

We installed a PC with a network connection for each MA, who coordinates patient care for the physician, including the scheduling of most procedures and consultations. A separate PC for the surgeon was viewed as desirable, but not essential. The MA scheduled hospital procedures or consultations into Outlook on the PC, but the surgeon could also enter new patients on the H/PC.

We found that within a month, most MAs were comfortable with the e-mail and calendar functions in Microsoft Outlook and were able to view each surgeon's schedule. We then began entering all hospital procedures in the calendar, switching entirely from the paper-based system.

During this time we gave the H/PCs to the physicians so they could familiarize themselves with the units and learn to synchronize them with the MA's PCs. We developed a tutorial for the database program that is listed in Appendix C. Synchronization with Outlook has been flawless, with the exception of a software error that we receive on most units about once a month that prohibits the units from recognizing each other. This can be temporarily fixed by reinstalling Windows CE, but to date this remains an unsolved problem.

We noted that we were making several interventions. We linked schedules over our network, distributed handheld computers to the physicians, and developed a database program, a novel application to support hospital visits and billing. Although we are focusing on the handheld computer, any one of these elements may be responsible for our findings.

Results

The hardware has both positives and negatives. On informal review, our surgeons liked the bright screen and integrated keyboard of the HP 620 LX. However, the units were larger than they would have ideally liked. During the project, four out of nine units experienced failures. One unit failed when it got wet, one failed after it dropped onto carpet, and two failed for unknown reasons. Three were returned to the manufacturer and one was restarted by removing and then reinstalling the batteries. Because of hardware and software difficulties, the IT department has viewed this as a high maintenance project. We note that we did not specifically measure the maintenance costs associated with hardware and software problems, although in retrospect that would have generated data that could be useful in assessing a cost-benefit analysis.

Our business office also experienced a number of difficulties. Our major billing problems are as follows:

- Incomplete capture of charges. In the first two months we found 30 procedures (3%) that were not entered directly into the H/PC by the physicians. These were discovered by routine checking of our backup paper system.
- Inadequate patient identifiers entered by the surgeon to correctly identify the patient.
- Inadequate documentation of diagnosis and procedures.

Our feeling is that we are capturing more charges with the H/PC, but the staff still has to expend considerable effort to assure this. We believe that the solution to the problems may be in improved software design, and we have built a continuous feedback and modification loop into the project.

Discussion

We were pleased with the process that we developed for implementation. Everyone was involved early and users remained enthusiastic throughout our measurement period. From our initial go-live date to the present, the surgeons have entered all of their charges into the H/PC and have been uniformly supportive. We note that only one physician had experience with a handheld computer prior to this time.

We believe that one reason for the high user acceptance rate was that we planned the software to fit, or model, the actual work flow of the users. Our Visual CE screens were designed around a logical flow of data entry while making hospital rounds, and synchronization and passing the information to the billing office was almost effortless. The billing office also helped design the forms they would use to view and manipulate the data, so the presentation of the information was familiar and user-friendly.

Training the staff also went reasonably well. The MAs were all trained individually on the use of Microsoft Windows and Outlook by a member of the IT department. The surgeons were given a 30 minute discussion on the use of the handheld by the principal author and a tutorial to review. Based on informal observations during the project, it did not appear that the tutorial was used as intended, but nonetheless the surgeons were using the system correctly within a week or two.

Trial Evaluation

We chose several measures that we hoped would prove or disprove out hypothesis. The results were somewhat surprising.

Methods

Our hypotheses were as follows:

- *Hypothesis 1: The use of handheld computers will make it easier to coordinate the schedules of physicians who perform multiple procedures/consultations in multiple locations.*
- *Hypothesis 2: The use of handheld computers will allow transmission of billing data to the organization in a more timely and cost-effective fashion.*
- *Hypothesis 3: The use of handheld computers will improve physician communication.*

In order to test the first and third hypotheses, we developed a questionnaire to assess user satisfaction. To test the second hypothesis, we designed into the database a way to measure the timeliness of billing as well as the number and amount of charges.

The study subjects consist of 100% of the surgeons, surgical medical assistants, and surgical billing personnel at HealthFirst Medical Group. The project utilized a study design where stable pre-implementation data spanning 11 months was compared to post-implementation data collected over 4 months.

Days to Post

We measured the Days to Post charges (DTP), which is the length of time it takes from completing the procedure or consult to the time it takes to post the charge in the billing system. We ran a query on our PMS to include all hospital charges for our surgeons. Specifically we

looked at the physician identifier, the patient account number, the Date of Service (DOS), the date posted in the PMS, the DTP, and the CPT code. The data was imported into JMP for statistical analysis, testing for improved speed of billing.

Other variables include "Before" and "After" the intervention, the month of the study, DTP > 30 days, DTP > 45 days, and DTP > 60 days. We used the Chi Square Test to analyze grouped data.

Charges

Although we looked at all hospital charges, we specifically measured the number of charges with CPT codes >= 90000, which are charges for consultations and other cognitive services.

Questionnaire

A questionnaire was developed to assess satisfaction with the current system. We created the questions to test our hypotheses. These were arrived at by consensus from the IT group and were thus not previously validated.

Questions from the group of 16 were chosen as appropriate for each group of users: surgeons, MAs, and billing personnel. The same questions were asked before and after the intervention. In our study, there were 16 questions. Of these, 15 were asked of the surgeons, 8 were asked of the MAs, and 6 were asked of the billing office personnel. The questions were rated on a seven point scale, with 1 being most positive and 7 being most negative. The validity of the questionnaire was not evaluated given the small available sample size.

We used the Wilcoxon Signed-Rank Test to test for median differences (before and after) equal to zero. We tested for statistical significance with a two-sided significance level of 5%. As this is primarily a descriptive study, we did not adjust for multiple tests.

Results

Days to Post

The handheld computers were introduced on December 4, 1998. Between 1/1/98 and 2/3/99 there were 4907 entries, 3853 before and 1054 after the intervention. The report was run on 4/2/99, 58 days after the last Date of Service.

When we looked at grouped data, we found that the Mean DTP before the intervention was 20.37 days, and after the intervention it was 20.59 days. Likewise, the Median DTP before the intervention was 16 days, and after the intervention it was 17 days.

We found that before the introduction of the H/PC, 486 of 3853 charges (13%) were posted > 30 days from the DOS. After the H/PC, the number was 137 of 1054 (13%). This was not statistically significant. Results were similar for > 45 and > 60 days.

Measure	Before	After	p-value
> 30 days	486 (13%)	137 (13%)	0.74
> 45 days	219 (6%)	61 (6%)	0.89
> 60 days	123 (3%)	22 (2%)	0.05

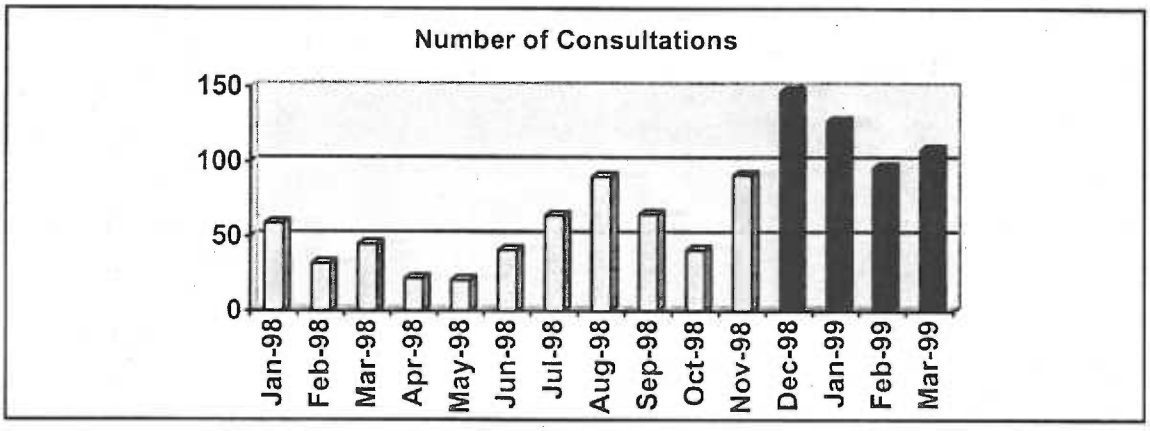
Table 2

Charges

As noted, the report was run on 4/2/99. Between 1/1/98 and 3/31/99 there were 4907 entries, 3853 before and 1054 after the intervention.

Before the introduction of the H/PC, there were 571 CPT codes >= 90000 (15% of the total or an average of 52 per month). After the intervention, there were 475 (25% of the total or 119 per month). This relative increase was highly significant, with a chi-square Likelihood Ratio p-value of <0.001. (See Graph 1)

The absolute increase in number of charges for consultative services, as noted above, went from 52 to 135 per month, an increase of 160%. Before the H/PC, the group billed $9379 per month in consultative services. After the intervention, they billed $18,390 per month for the same services, an increase of 96%. Analyzing the hospital procedures (CPT < 90000), the surgeons performed 298 procedures per month before the H/PC and 391 after, an increase of 21%.



Graph 1. Number of Consultations. The dark bars represent values after the introduction of the handheld.

Questionnaire

The questions were initially asked in November 1998, prior to the introduction of the handheld, but several months after the medical assistants received new computers with Microsoft Outlook installed. The questionnaire was re-administered in mid-February 1999, 2 ½ months after the introduction of the H/PC and one month after we felt that everyone was comfortably using the device on a daily basis.

We performed the Wilcoxon Signed-Rank test on each question for all team members and then looked at the average score for each group. The results are found in Table 2, and the questions are detailed in Appendix D. Note that we used a seven point scale with lower numbers indicating better ratings.

Question	Before	After	p-value	N
Q1: Schedule efficiently	2.57	2.00	0.197	14 /SM
Q2: Coordinate schedules	**4.36**	**2.57**	**0.009**	**14 /SM**
Q3: Timely billing	**4.56**	**2.25**	**0.001**	**16/SM**
Q4: Accurate billing	**4.44**	**2.19**	**0.002**	**16/SMB**
Q5: Document billing	**3.87**	**2.87**	**0.016**	**16/SMB**
Q6: Access/list procedures	**4.56**	**2.33**	**0.031**	**9/SB**
Q7: Track charges	6.00	2.50	0.500	2/B
Q8: Outcome analysis	**5.44**	**3.67**	**0.016**	**9/SB**
Q9: Communicate with team	**4.50**	**3.00**	**0.006**	**14/SM**
Q10: Communicate with others	4.49	3.29	0.063	7/S
Q11: View own schedule	**3.50**	**1.71**	**0.013**	**14/SM**
Q12: View other's schedule	**5.07**	**2.57**	**0.005**	**14/SM**
Q13: Notes and reminders	5.00	2.29	0.063	7/S
Q14: Hospital efficiency	4.00	2.00	0.141	7/S
Q15: Professional satisfaction	2.29	1.86	0.375	7/S
Q16: Administrative satisfaction	**5.86**	**2.57**	**0.031**	**7/S**
All Surgeons	**4.61**	**2.52**	**0.016**	**7/S**
All Medical Assistants	**3.66**	**2.50**	**0.047**	**7/M**
All Business Office	3.66	2.50	0.500	2/B

Table 3 *S=Surgeons M=MA's B=Business Office*

Discussion

Days to Post

There was not a significant change in the Mean or Median DTP after the H/PC was introduced. With regard to charges that are posted >30 days, >45 days, and >60 days, there does not appear to be an economically important difference between the groups. Although we are employing statistical analysis, the results must be considered descriptive, as we do not have a long enough period of study to capture markedly prolonged DTP data.

One limitation of the study that deserves special comment is that he report was run 58 days after the last date of service. Therefore there are a small number of procedures that could not be > 60 days to post by definition. However, since the data indicates that there is no significant improvement in days to post > 60 days, despite this factor that biases the results toward better results, we can conclude that evaluation at a later date would not change the conclusion.

Charges

We were able to show that the percentage of billing that reflects cognitive services increased significantly with the use of the H/PC. Part of this increase may be due to the growth of the surgical practice. However, the number of hospital procedures increased by only 21% per month after our intervention, whereas the number of consultative charges increased by 160% and the amount of these charges increased by 96%.

We believe that our physicians were forgetting to turn in their billings for their hospital consultations and that the ease of entering codes into the unit while they were making rounds in the hospital resulted in an increased capture of appropriate charges. An alternative explanation might be that the surgeons were actually performing more consultative services, but we viewed this explanation as less likely, as an informal survey indicated that their practice patterns were

essentially unchanged during the study period. It is also possible that there was no significant change in billing, and that subsequent follow-up will demonstrate that this was simply a month to month fluctuation, or that there was a trend toward increased charges for reasons unknown that is unrelated to the use of the handheld computer.

Questionnaire

All questions showed a trend toward improvement, and the study had sufficient power to show statistical significance for 10 of the 16 questions. In addition, there are some interesting trends that can be noted from those questions that did achieve significance.

Questions 2 (coordinate schedules), 11 (view own schedule), and 12 (view other's schedule) showed that users were more able to view, access, and coordinate their own and other's schedules. This is not surprising, as they were moving from a system that was largely paper-based.

Question 9 (communicate with team) also showed that users felt they were better able to communicate with members of the surgical team, which supports one of our key hypotheses. Question 10 (communicate with others) also showed a positive trend when asked about the ability to communicate with other physicians, going from values of 4.49 to 3.29, but this did not achieve statistical significance.

Questions 3 (timely billing), 4 (accurate billing), and 5 document billing) showed that users felt that the system allowed them to turn in billing that was more accurate, timely, and complete with regard to documenting the complexity of the visit.

Questions 6 (access/list procedures) and 8 (outcome analysis) showed that users felt that the system allowed them to access a list of procedures and consultations previously performed and to perform outcome analysis.

Question 16 (administrative satisfaction) is interesting, as it shows that physicians had an increased level of administrative satisfaction—satisfaction with the "business" of medicine—with use of the H/PC. This value went from 5.86 (quite dissatisfied) to 2.57 (somewhat satisfied). The level of professional satisfaction—satisfaction with the "art" of medicine—also went up from 2.29 to 1.86, but it was not statistically significant, partly as a result of a high level of professional satisfaction before the study was initiated.

Looking at grouped data, the average surgical response went from 4.61 to 2.52. ($p = 0.016$), while the average MA response went from 3.66 to 2.50 ($p = 0.047$). Whereas it is difficult to interpret this in words, it seems reasonable to state that the responses went from dissatisfied to satisfied, with the surgeons perceiving a somewhat larger gain from use of the H/PC than the MAs.

Cost-Effectiveness

One of our initial goals was to show that the use of handheld computers would be cost-effective. However, the study was not designed in such a way that this point could be proven. One approach that we could have taken would be to perform a cost-benefit analysis. This would require assessment of various aspects of the process before and after the implementation of the H/PCs. The costs could then be compared to the additional billing charges that use of the new system seemed to have captured.

We looked at two endpoints which can give us some information about charges, the days to post and the number and amount of consultations billed.

While our DTP information is not totally complete since we did not look at very late postings, it indicates that no benefit would be gained, and therefore no increased revenue expected, based solely on improving DTP. Also, we did not find the use of this endpoint by other studies, which

means that it has not been validated. It may be that we are looking at a variable with a ceiling effect that makes cost-analysis difficult. In other words, the department may have been doing a good job of getting the billing in on time before the introduction of the handheld, so that improvement would not necessarily have a significant economic impact.

It seems clear that the introduction of the handheld correlated well with increased capture of consultative charges. It remains to be seen if this trend continues once the initial enthusiasm of the users wears off. It is also not clear how much additional revenue is generated by this increased billing. In a capitated managed care environment these charges may not have any economic impact. However, in a fee-for-service environment, it is likely that there would be increased revenue. We also note that this is only one measurement, and other factors should be considered before performing a cost-benefit analysis. This would be an appropriate subject for a follow-up study.

Summary and Conclusion

Handheld computers are extremely popular with the public and are making their way into medical applications. Our goals were to design and implement a system using handheld computers in a surgical group practice, which we were able to accomplish, and to test a set of hypothesis to determine the usefulness of the system.

Hypothesis Testing

Our hypotheses were that handheld computers would make it easier to coordinate physician schedules, make billing more timely and cost-effective, and would improve physician communication.

Our study supports the role of the handheld computer with regard to the coordination of schedules. We were able to show potential enhanced revenue from increased capture of charges, but we did not specifically design the study to be able to show a cost-benefit analysis. The study seems to be neutral with regard to the timeliness of billing. The study also shows that the use of these devices enhances physician satisfaction.

Although further studies are needed to confirm the generalizability of our findings, we expect that the use of handheld computers for physician billing and scheduling will become a common practice in the near future.

Implications for Practice

The physician may ask, "Will this work in my practice?" We think that the answer is "Yes." Many handheld products can easily synchronize calendars with PCs, allowing physicians and office staff to coordinate schedules. With additional technical expertise, this can be expanded over a computer network. By carefully choosing hardware and software, an organization of any size can quickly develop an integrated scheduling solution including handheld computers.

For billing, the physician has a choice of developing a system using readily available products, such as database or spreadsheet software, having a system custom-designed for the practice, or purchasing commercial software. It is our opinion that an organization should look for a solution that has the following characteristics:

- Ease of deployment and maintenance.
- Ability to integrate with the existing network.
- Ability to model current work processes.
- A quick and responsive handheld interface.

Implications for Research

Our findings show many opportunities for future research. A rigorous cost-benefit analysis could help guide organizations trying to decide how much resources to allocate to the implementation of a handheld system. Our endpoints could be more closely examined, and other endpoints could be developed. A validated set of questions would be helpful to assess user satisfaction. Refining the user interface could help produce more useful applications and comparisons of the various platforms could help guide product development.

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Appendix A: Database Elements

The following table lists the data elements in our database (Field and Data Type).

The Action is a listing of the type of action performed by the utility program that is evoked when the biller has completed posting charges. Certain elements do not change (NC = no change). Other elements are changed back to "< None>" or null. On the handheld, there are data elements that are removed from one field, but added to a memo field for later reference. Lastly, a new record is created in another database that preserves the original data in a format that allows report generation.

Field	Data Type	Action	Update Handheld	Update Database
	N=number T=text D=date M=memo			Button click starts new record in tblDatabase of link.mbd
OID	N	NC		
LastName	T	NC		x
FirstName	T	NC		x
MRN	T	NC		x
DOB	D	NC		x
SSN	T	NC		x
Provider	T	NC		x
Location	T	< None >		x
Room	T	null		
PCP	T	NC		x
Flag	T	NC		x
AdmitDate	D	null	Procedure Notes	x
DischDate	D	null	Procedure Notes	x
Diagnosis	M	< None >	Procedure Notes	x
Status	N	NC		
Charges	N	NC		
ClinicalNotes	M	NC		x
ProcedureNotes	M	NC + new		x
MoreCharges	M	null	Procedure Notes	x

Proc1Date	D	null	Procedure Notes	x
Proc2Date	D	null	Procedure Notes	x
Proc3Date	D	null	Procedure Notes	x
Proc4Date	D	null	Procedure Notes	x
Proc5Date	D	null	Procedure Notes	x
Proc1	T	null	Procedure Notes	x
Proc2	T	null	Procedure Notes	x
Proc3	T	null	Procedure Notes	x
Proc4	T	null	Procedure Notes	x
Proc5	T	null	Procedure Notes	x
Proc1Com	T	null	Procedure Notes	x
Proc2Com	T	null	Procedure Notes	x
Proc3Com	T	null	Procedure Notes	x
Proc4Com	T	null	Procedure Notes	x
Proc5Com	T	null	Procedure Notes	x
DateBillingComp	D	null		
FollowupComment	M	null		
TIMESTAMP	D	null		
NewPatientNumber	T	NC		
NewBillType	N	NC		
NewMRN	T	NC	MRN	MRN
NewBillerComments	M	NC		
NewDateBilled	D	NC		

Appendix B: Designing the Database

Visual CE

We found a number of undocumented features, and detailed instructions for these features are listed below. The following details are specific to our application:

- Our version of Access was Access 97.
- Windows CE, and therefore Visual CE, allows up to four indices for each database. Our indices were Status, Charges, LastName, and DOS.
- Our Visual CE file was named Surgery.vce.

Install Visual CE

- If needed, install Microsoft ODBC 2.5 drivers, which installs the "ODBC Desktop Driver Pack 3.0"
- Check to see that there is a User DSN in the ODBC control panel called "MS Access 97 Database". Create one if needed.
- Create a blank Access database in the appropriate folder with the appropriate name. (Example: Provider\Provider.mdb.
- Map the drive on the PC to match the folder (Example: I:\\SERVER1\HANDHELD.)
- Install Visual CE from the Runtime disk. Check the Wceodbc.ini file for correct path and database.
- Create a shortcut from Visynch to the desktop.

- Create a new record on the Handheld. Save and press the Visynch shortcut to create a new table. Click yes to create the TIMESTAMP column.
- Check the Handheld list views and click Status, Charges, LastName, and DOS to establish the indexes
- Go to the Handheld\Desktop\My Handheld PC\Control Panel\Regional Settings\Long Date Format and select MMMM,dd,yyyy.
- Add supportive documentation, if needed, such as tutorial or help files.

Create the Runtime Disk

This is the procedure for creating the disk used to install the Visual CE program on the H/PC.

- Copy Runtime files to the root directory of the floppy drive
- Follow directions in Visual CE to create the disk
- Customize Surgery.vce and replace Expenses.vce
- Specify the path to the Access database, save and transfer \Windows\Wceodbc.ini to floppy
- Change the Visual CE.lod file

Changing Tables in Access

One tricky part of setting up the database involved having Visual CE synchronize to a query in Access, rather than to a table. The following instructions document the steps needed to add fields to the table and then to set up a query for synchronization. Note that the field names are specific to our application.

- Go to folder ProviderDB in folder Handheld. Open ProviderDB.mdb.

- Rename HFMGDB to tblHFMGDB
- Add the following fields to tblHFMGDB
    1. NewPatientNumber (text)
    2. NewBillType (number)
    3. NewMRN (text)
    4. NewBillerComments (memo)
    5. NewDateBilled (date)
- Check for zero length strings and set to "yes" (not done on my database)
- New query from tblHFMGDB for all fields from OID to TIMESTAMP. Name query HFMGDB.
- Go to link.mdb | tables and delete linked table tblProvider
- Go to file | get external data | link tables and choose the new tblHFMGDB. Rename tblProvider.
- Create new link,mdb table (one time). Select tblHFMGDB, copy and paste, and delete all records. Rename tblDatabase.
- Open qryProviderNotBilled and change "DateBillingComp" to "NewDateBilled"
- Make changes in frmProviderNotBilled (one time)
- Open forms. Copy and paste frmProviderNotBilled from previous form, changing provider name as needed. Replace the existing form. Open in design view | properties and change to qryProviderNotBilled.

Modifying the H/PC Database

When we changed the interface for Visual CE, it needed to be downloaded to the H/PC. The following instructions document the steps to do this if using a laptop or otherwise connecting the H/PC directly to the PC that was used to create the Visual CE file.

- Connect personal Handheld. Open Visual CE. File | Synchronize and deselect synchronize on contact.
- Open Mobile Devices folder and deselect options for synchronization (Tools | ActiveSynch Options)
- Connect new Handheld.
- Open vce file. Change the Provider name if needed.
- Change indexes and download
- Reset preferences if desired.

Appendix C: Tutorial for the H/PC

This is a tutorial that we created specifically for our application.

Creating Your Password

Your Handheld PC will contain confidential patient information. HealthFirst Medical Group requires each user to protect this information at all times by the use of a log-on password. To create your password, follow the steps below.

- Turn on your HPC by pressing the *ON/OFF* key. Tap the Start button on the bottom left corner, then tap *Settings->Control Panel->Password.*
- Enter your password. This can be as short as one letter or as long as you wish. Press TAB or tap on the next box and re-enter your password. Note that if you forget your password, all information on the HPC must be erased and recreated from backup files.
- Tap *Enable Password Protection* and *OK.*
- Press *ON/OFF* to turn off the HPC, and then press it again to turn it on. Type your password and then press *ENTER.*
- You can change your password as often as you like. Tip: Keep the password short and use characters near the *ENTER* key.

Using the Surgery Database

Follow this short tutorial to quickly learn the basics of entering and retrieving clinical and billing information using the Surgery database.

- Double-tap the *Surgery* icon on the desktop. (If the Surgery icon is not in your current view, tap the *Desktop* icon in the lower right corner of your HPC.)

- The database has three menus, *Record, Edit and Option*. Tap each to see the sub-menu items.
- The next four icons across the top are *Insert Record, Print, Recalculate and List.* (Our application does not use Print or Recalculate.) Press the List icon to see the *List View* and tap it again to return to the *Record View.*
- The next four icons are navigation buttons: *First Record, Previous Record, Next Record* and *Last Record.*
- The last icon is *Search.*
- To insert a new record, tap the *Insert Record* icon or tap *Record->Insert* or type *CTRL-N* (hold down both keys at the same time).
- Note that *Last, First, Provider, Location, Admit Date, Status* and *Charges* are in bold letters. These are required elements, and must be present to process your charges correctly.
- Tap in the *Last* field and type "Brown."
- Tap in the *First* field, or press the *TAB* key, and type "Mary." (Note that pressing the TAB key does not necessarily move you to the next field. This is because the TAB ordering determines the location of the field in the *List View*, which is necessarily different from the *Record View*.)
- Tap in the *MRN* number and type "1234567."
- Tap in the *DOB* field. Enter "April 16, 1948." Click the month (from the drop-down list). Enter the year (double-tap the current year and then type the desired year), or click the right- and left-arrows to increase/decrease the year. Click the date in the calendar area. (To change back to today's date, click Today.) To confirm your entries, click OK.

- Tip about dates: If you don't want to specify a date, you can enter a null value. Make the Date field the focus -- if it isn't already, press the Tab key on your keyboard until the Date field is highlighted or tap the Date field and press Cancel. Then press Delete (the back arrow key) on the keyboard.
- Tap in the *SSN* field. Backspace to the front of the field if necessary and enter "111223333."
- Tap in the *Location* field. Enter "St. Vincent." Tap the *Room* field and then tap the down arrow on the right side of the Location field. You will see < None > and St. Vincent. You have now created a drop-down entry that you can use in future records. Tip: Spell items in drop-down boxes correctly, as they will stay with you for a long time.
- Enter *Room* "542" and *PCP* "Blackman".
- The *Flag* field is optional and for your own use. Enter "Urgent."
- The *Admit Date* is the date the record was started. Change it to yesterday's date.
- Leave the *D/C Date* blank.
- Enter "TIA" in the *Diagnosis* field. Note that this box has arrows that will show up if you have more than two lines of text.
- Note that the *Status* and *Charges* buttons are pre-set to *Admit* and *Pending*.
- Tap the *Notes* tab. The *Clinical Notes* section is for your own use, and is not viewed by anyone else. The *Procedure Notes* section will list the charges billed. You cannot enter anything in this field.

- Tap the *Charges* tab. For Procedures 1-3, enter yesterdays date and select the following from the *Medical Services* drop-down list: "ADMIT (comprehen, high), SERVICES 10PM – 8AM, and SERVICES SUNDAY/HOLIDAY." Note: You cannot add items to this list.

- For procedure 4, enter today's date and type "Carotid endart L" in the *Procedures/Comments*. (Enter a descriptive term, and the billing office will obtain the op note for accurate billing information. You can also enter any information that you feel would be helpful to them, such as modifiers or complications).

- Tap the *More* tab. You can list additional charges here, if needed. Tap the *Patient* tab to return to the original screen.

- Enter two more patients, but fill out only the required fields for speed of entry and completion of this tutorial. However, mark one Status "D/C" and Charges "Complete" and the other Status "D/C" and Charges "Pending".

- Tap the *List* icon. Tap the word "*LastName*" and then tap "<<". (Because the program lists all records below the *highlighted* record, it is necessary to go to the first entry in the sorted list to see all entries. This is inconvenient, but often necessary.) The entries are now sorted by last name.

- Tap the word "*Status*" and then "<<". This gives a list of patients by inpatient status, and can be used to see who is in the hospital.

- Tap the word "*Charges*" and then "<<". This gives a list of all charges that are still pending. Find the entry that has a status of "D/C" and charges of "Pending" and double-tap it. Now you are back to the *Record View*. Tap the *Charges* tab, enter any date and procedure, tap the

Patient tab, enter a discharge date of today, change the *Charges* to complete, and you are done.

- To find a record, go to the *List View* and make sure the records are sorted by Last Name. Select *Record–>Search* or click the *Search* button. Enter a portion of the name and tap *"OK"*. Note: You can only search for records based on the currently selected sort/search order. If you want to search by MRN, first tap "*MRN*" then press the Search button.
- To delete a record, tap *Record->Delete* and then tap *Yes*.
- To leave the Surgery application, choose *Record–>Close* or click the Exit button *"X"*.
- **IMPORTANT: When you are done seeing the patient in the hospital and have entered all of your charges, enter the D/C date, change the Status to "D/C" and the Charges to "Complete." The billing office will be notified of this and will process your charges.**
- **IMPORTANT: If you readmit a patient that is already in the database, or enter new charges to a previously completed record, you MUST ENTER THE NEW ADMIT DATE and RESET the Status and Charges appropriately. (If this is not done, the billing office will have no way of knowing that new charges have been entered.)**
- If you feel there is a potential for confusion, error, or lost charges, have your MA communicate directly with the billing office.
- There will be a feedback mechanism so you can see exactly what has been billed. The details of this will be finalized soon.
- Keep a paper record of all patients and charges while the database is being implemented and tested.

Using the E & M Code Help Document

There is a document available to help determine the appropriate E & M code.

- Double-tap the *My Documents* icon on the desktop. (If the *My Documents* icon is not in your current view, tap the *Desktop* icon in the lower right corner of your HPC.)
- Double-tap *Synchronized Files* and then *E & M Codes*.
- Tap *View* and make sure the *Status Bar* is checked. If not, tap it.
- There are three sheets. Tap *Sheet1* at the bottom of the screen, and tap *Sheet2* and *Sheet3* to see all of them.

Appendix D: Questionnaire

All 16 questions showed a trend toward improvement in the scores after the introduction of the H/PC. We note that statistical significance is of questionable value given our small sample size. Nonetheless, by using this value as a dividing point, we found some interesting trends, which are described in the body of the paper. The following questions achieved statistical significance:

- **Q2: Coordinate schedules:** Rate your system's ability to coordinate the schedules of more than one surgeon.
- **Q3: Timely billing:** Rate your system's ability to turn in billing in a timely and cost-effective fashion (i.e. no loss of revenue).
- **Q4: Accurate billing:** Rate your system's ability to turn in billing in an accurate fashion (procedures and consults identified correctly).
- **Q5: Document billing:** Rate your system's ability to document complexity of visit to support CPT coding.
- **Q6: Access/list procedures:** Rate your system's ability to access/list procedures and consultations previously performed.
- **Q8: Outcome analysis:** Rate your system's ability to perform outcome analysis.
- **Q9: Communicate with team:** Rate your system's ability to communicate with other members of the surgical team.
- **Q11: View own schedule:** Rate your system's ability to view/access your own or your surgeon's schedule.

- **Q12: View other's schedule:** Rate your system's ability to view/access other physician's schedules.
- **Q16: Administrative satisfaction:** Please rate your level of administrative satisfaction (the business of medicine).
- **The grouped responses for all surgeons.**
- **The grouped responses for all MAs.**

The following questions were not shown to achieve statistical significance:

- **Q1: Schedule efficiently:** Rate your system's ability to schedule procedures efficiently.
- **Q7: Track charges:** Rate your system's ability to track missing charges.
- **Q10: Communicate with others:** Rate your system's ability to communicate with other physicians.
- **Q13: Notes and reminders:** Rate your system's access to notes and reminders about patients seen in the hospital.
- **Q14: Hospital efficiency:** Rate your system's ability to perform hospital rounds efficiently.
- **Q15: Professional satisfaction:** Please rate your level of professional satisfaction (the art of medicine).
- **The grouped responses for the business office.**