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Improving Quality of Care and Nursing Workflow: A Clinician Usability Pilot of the Motion™ C5 Mobile Clinical Assistant

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Executive Summary

As hospitals, clinics and other healthcare organizations deploy electronic medical records (EMRs) and related technology solutions, it becomes increasingly critical to provide clinicians with convenient access to those technologies at the point of care. The University of California San Francisco (UCSF) Medical Center has deployed a contemporary EMR and provided access through desktop PCs and computers on wheels (COWs). In daily use, however, it became clear that the limited portability of these workstations impeded clinicians' workflow and limited information access, making it difficult to fully exploit the EMRs' potential to improve care. Additionally, the user logins required to comply with current security standards were consuming a significant amount of nursing effort and leading to user frustration.

UCSF collaborated with GE Healthcare, Intel Corporation and Motion Computing® to determine whether an innovative solution, developed around a new mobile device – the Motion™ C5™ mobile clinical assistant (MCA) – might enhance patient care and clinician workflow. The Motion C5 is the first commercial product based on Intel's mobile clinical assistant reference design, developed following their extensive ethnographic research into the needs of clinicians in acute care environments. UCSF piloted a new clinical workflow that incorporated the Motion C5 into patient vital sign collection using GE's DINAMAP® patient monitoring devices and the GE Centricity Enterprise EMR. Performance data were collected via time motion studies pre- and post-implementation, and clinicians were formally surveyed to assess attitudes towards the device and the overall solution.

Data collected during the pilot demonstrate significant improvements in nurse productivity and clinical documentation accuracy. Importantly, there was a substantial reduction in documentation delays and the number of clinician logins and the time that they consumed. Nurses consistently preferred the Motion C5 mobile clinical assistant over COWs, reporting that it enhanced patient interaction, better fit their work environment, offered greater portability, and was easier to move in constrained areas. They reported that the Motion C5 made it easier to enter and access data and improved the ergonomics of data entry.

Among the pilot's specific findings:

- 60% reduction in time consumed by vital signs documentation, saving each clinician 30 minutes per 8 hour shift.
- Clinical data latency (the time between capturing vital sign data and entering it into the EMR) was reduced by more than two hours.
- Data demonstrate an 83% reduction in the number of data items that needed to be transcribed thereby reducing the potential for transcription error.
- Reduction in the average number of time-consuming clinician logins from 42 to 12 per shift.
- A 20% increase in point of care charting beyond the automated vitals sign acquisition

This pilot demonstrated that by enabling convenient, efficient information access and data entry at the point of care, the Motion C5 – integrated with robust technical infrastructure, advanced healthcare applications and supported by organizational leadership – can improve clinician workflow, efficiency, and satisfaction and increase the accuracy and timeliness of critical clinical data.

Introduction: Challenges of EMR Adoption

The University of California San Francisco (UCSF) Medical Center is a leader in medical research and healthcare delivery. With two campuses located in San Francisco, UCSF has 642 beds and an average daily census of 489 patients. In FY 2007, UCSF had 28,367 discharges and almost 700,000 visits to its 90 ambulatory practices. UCSF is widely recognized as an innovator in adopting healthcare IT solutions that can improve care and enhance clinical workflows. In 2002, UCSF began implementing IDX's CareCast (now GE Healthcare's Centricity Enterprise) as its new electronic medical record (EMR). The rollout in the acute care areas, completed April 2005, provides for extensive results retrieval, clinician documentation, and ADT integration. Clinical workstations provide single sign-on functionality and support user and patient context awareness. Computerized physician order entry (CPOE) and clinical decision support are to be implemented following the deployment of a new pharmacy system.

At UCSF's Parnassus campus, all acute care provider and nursing documentation (other than medication administration and care plans) is entered directly into the EMR. To support the deployment, UCSF added more than 300 new workstations, including computers on wheels (COWs) and desktop PCs.

Workflow Issues

While the EMR provides substantial benefits, such as improved data access, more legible documents, and the ability to provide clinical decision support to reduce medical errors, it also adds significant technical and procedural overhead. Locating an available computer workstation, entering a user ID and password, and then inputting clinical data or observations are time consuming tasks. As clinician workflows are inherently mobile, many hospitals have implemented COWs in an attempt to improve documentation workflow and decrease the documentation burden. However, COWs' portability is limited by their size, weight, and restricted maneuverability. As a result, at UCSF, implementing the EMR on COWs did little to improve a nursing documentation burden that nurses have described as overwhelming.

Moreover, COWs were not as reliable as expected. Repairs often removed them from the unit for days at a time, decreasing the number of devices available to clinicians. When nurses needed to enter or look up information in the EMR, COWs and nursing station PCs were often in use by attending physicians, residents, or other nurses. Nurses would either hunt elsewhere on the floor for a workstation or move on to another patient or task, delaying data entry, and impacting nurse productivity.

Lacking a readily available, truly portable device, nurses relied on a paper "brain," or handwritten notes they kept during their shift (see Figure 1 for an example). The paper "brain" is not part of the patient's medical record, has no standardized format, and is not passed from nurse to nurse. It also creates duplicate work and opportunities for transcription error.

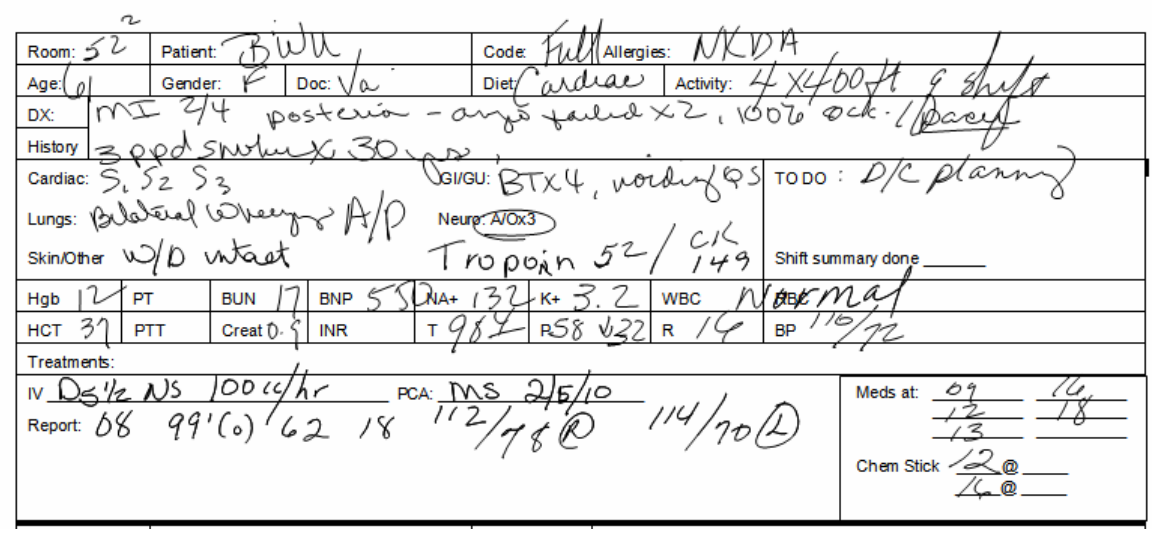

Figure 1. Example of a nurse's "brain" used as a temporary documentation method prior to final entry into EMR.

For example, consider a nurse who checks on a patient 58 minutes after pain medication is given. The patient states pain is at a 2/10. While in the room, the nurse notices that the patient has voided 125cc of foul-smelling cloudy yellow urine and empties the urinal. The nurse now has five data elements and two assessments to document, and must decide whether to locate and log on to a COW or fixed desktop PC, or wait and batch chart a larger amount of data later in the shift.

On rounds, most UCSF nurses wrote numerical information on the paper "brain," memorized assessment data, and continued patient rounding. Nurses typically gathered data for 1-2 hours before transcribing the information into the EMR.

Other Issues: Usability, Cost, and Mobility

The implementation of the EMR on COWs created other issues as well. The COWs were shared-access devices, and to maintain security, users had to log on each time they needed to access or enter information and then log off when done. Log-in latency, defined as the time between a user's first touch of a keyboard and the moment when the EMR was available for documenting care, was approximately 20 seconds. Much of the login time was tied to reloading Java components, which was unavoidable given the technical and security constraints of the environment. For busy nurses, the burden of the repeated log-ins eroded efficiency and morale. Observation showed that nurses logged in an average 42 times per shift, spending an average of 14 minutes per shift waiting for the EMR to load.

The acquisition and maintenance cost of COWs are significant issues for UCSF. Equipped with a laptop, display, keyboard, mouse, and battery, each COW costs approximately $6,000. According to Michael Blum, MD, Chief Medical Information Officer at UCSF, "The COWs take quite a beating, and the wear

rate is obviously in excess of fixed workstations. The batteries require constant charging to maximize their serviceable life which adds to the users' frustration." Batteries are also a cost issue since the lead acid chemistry is not as charge-able as the battery technology more commonly used in mobile computing devices. The expected life of the COW battery is typically 18 months, and carries a replacement cost in excess of $2000 each. While lower cost replacement batteries are now becoming available, USCF estimates the operating expense for each COW to be in excess of $1,200 per year.

Space constraints are another issue, particularly in older facilities such as those at UCSF. COWs have a bulky footprint and provide only limited mobility, making them very difficult to move and maneuver through tight spaces. They are commonly parked in hallways on a fairly permanent basis, being moved only once or twice per shift. In older facilities with narrow hallways, this creates a potential violation of fire safety requirements that call for at least 8 feet of clear space in the halls. Numerous sites have reported demands by safety officials, state regulators, and JCAHO to remove the COWs from the hallways.

Preparing for Change

UCSF wanted to create a more mobile workflow that would enable clinicians to easily access and enter patient information, at the point of care. In preparation, UCSF undertook a pilot to identify whether the Motion C5 mobile clinical assistant (MCA), a portable device designed specifically for clinicians working in acute care environments, could improve clinical workflow, efficiency, and user satisfaction.

The pilot utilized a clinician usability study methodology developed by Motion Computing. The methodology uses a structured approach and a clinician-centric model to choreograph the introduction of technologies within workflow and practice patterns. Leaders representing UCSF nursing, operations and IT formulated a set of hypotheses, performance improvement goals, and metrics. Major objectives were to:

- Improve EMR data accuracy and timeliness
- Enhance nursing productivity and workflow
- Improve nursing satisfaction
- Reduce device count in hallways

A primary workflow goal was to reallocate nursing effort away from administrative overhead (logins and documentation tasks) and towards patient care activities. The ROI was not expected to accrue from reduced headcount, but rather by giving nurses more time at the bedside with patients. Therefore, the anticipated ROI would be in the form of enhanced care and patient and clinician satisfaction rather than dollar savings.

The pilot was conducted on UCSF's Adult Transplant Unit (solid organ), which has 30 beds. Prior to the pilot, a team of clinicians from UCSF and Motion Computing observed workflow on the patient care unit documenting:

- Nurse and CNA walking patterns: where clinicians walk, sit and stand by discipline
- Common workflows
- Patient and information flow patterns
- Data access and input requirements by clinical discipline, location, modality, and data type
- Space constraints, facilities, Fire Marshall and Joint Commission requirements such as NFPA 101 2006
- Infection control and prevention protocols for fomite (inanimate object) disinfection (including requirements for isolation patients), as well as the standard antimicrobial and germicidal agents used
- Staffing models and ratios by discipline and shift

Clinician Usability Pilot: Changing Technologies and Workflows

The team from UCSF and Motion developed a series of metrics that would rigorously examine baseline, target, and actual performance measures across multiple variables. Baseline measures were recorded focusing on time/motion data such as frequency and time required per login, time required to complete discreet tasks such as vitals acquisition and data entry into the EMR. Baseline clinician satisfaction was assessed on a Likert scale using a standardized survey tool. This data, combined with nursing input and UCSF objectives, helped formulate performance improvement goals as well as the scope of the pilot.

Study Device: The Motion Computing C5

For the pilot, UCSF modified its device provisioning model from a shared-use model to a user-assigned device model. Each nurse participating in the pilot was assigned a Motion C5 mobile clinical assistant for the duration of his or her shift. The MCA is a new reference design created by Intel based on its extensive ethnographic research. Motion Computing combined its own clinician research and mobile healthcare device design expertise with Intel's reference design in developing the Motion C5. Created to meet the demands of the acute care environment, the Motion C5 provides a sure-grip handle, a sealed case for easy disinfecting, a lightweight design for portability, a 10.4-inch screen for easy viewing of clinical information with minimal scrolling, rugged construction that minimizes the impact of dropping the device, and pen and stylus input so that clinicians can enter text and navigate the software without being tied to a keyboard. The Motion C5 also includes integrated barcode and RFID readers for positive patient

identification and/or electronic medication administration, an integrated camera, and built-in Wi-Fi and Bluetooth for interfacing with other clinical devices. UCSF clinicians, infection control experts, IT administrators and an interdisciplinary group of clinical leaders were among many in the industry who provided input into the unique design and features of the Motion C5.

Implementing the Motion C5 changed the nurses' relationship with technology in several important ways:

- Nurses had a lightweight, portable device that was theirs to use for the entire shift. They no longer had to contend with other clinicians for access to a device. The time and consternation previously associated with searching for COWs or desktops could be reallocated to patient care, and nurses could enter and access information when and where their workflow called for it.
- Since the Motion C5 was a personal rather than a shared-access device, nurses remained logged into their C5 throughout much of their shift. With this new workflow, nurses reduced their mean number of log-ins from 42 to 12 per shift.
- The devices were truly mobile and easily portable. Nurses often carried them between rooms and used them in a variety of settings where they could not maneuver the COWs, such as the break room, medication room, and nursing station. This additional agility and portability improved nursing productivity, satisfaction, and bedside charting.

Improving Workflows for Vital Signs Acquisition

Vital sign acquisition was a significant source of workflow inefficiency at UCSF, and was a primary focus of the pilot. Although most vital signs data were captured digitally, data elements were generally transcribed to the nurse's paper "brain" and batch entered into the EMR at a later time. "Despite the investments made by USCF, the process of vital sign collection remained largely stagnant," said Ann Williamson, RN, PhD, interim Chief Nursing Officer for UCSF. "Nurses would take vital signs using the GE DINAMAP, collecting blood pressure (B/P), pulse (P) and oxygen saturation (O2Sat). Temperature was taken separately, and respiratory rate observations were done manually. All data elements were then written down on paper and carried by the nurse until they were entered into the EMR system." Figure 2 depicts this workflow.

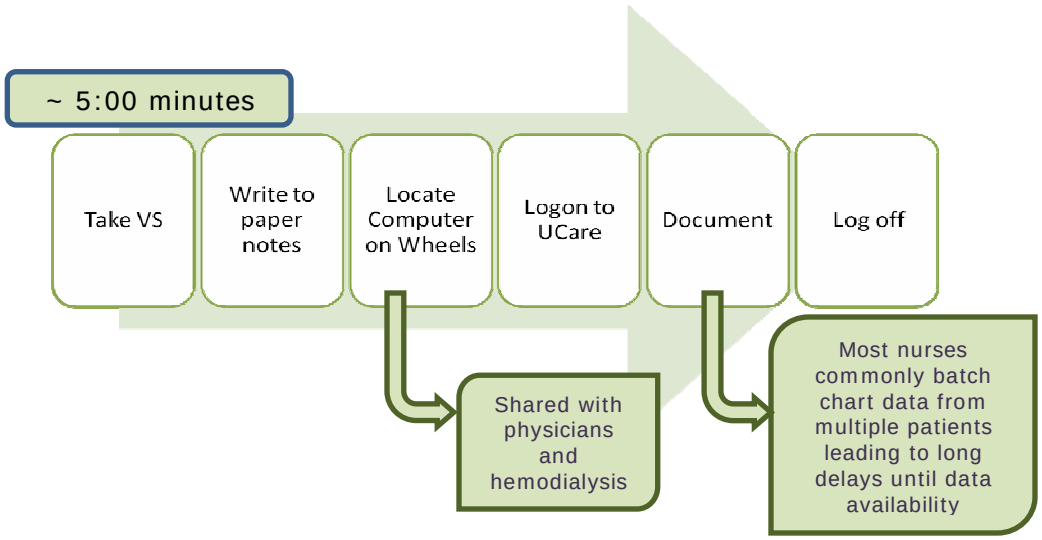

Figure 2. Traditional vital signs acquisition workflow.

UCSF collaborated with Motion Computing and GE Healthcare to develop a new process for vital sign acquisition that incorporated the Motion C5 into nurses' vital signs documentation workflow. To support a mobile workflow, Motion Computing worked with GE Healthcare to develop a new cable system that allowed vital sign data collected using the GE DINAMAP to flow directly into the EMR client running on the Motion C5. With this new configuration, nurses placed the Motion C5 into a docking station affixed to the rolling GCX pole holding the GE DINAMAP device. The connection between the Motion C5 and the DINAMAP device occurs without any further action from the nurse. Once the vital signs were acquired and transmitted to the C5, the nurse would accept the results with a single tap of a button on the screen, importing them into the EMR while still at the point of care. Figure 3 shows this optimized workflow.

Michael Blum, MD and Ann Williamson, RN, PhD with the Motion C5/DINAMAP device

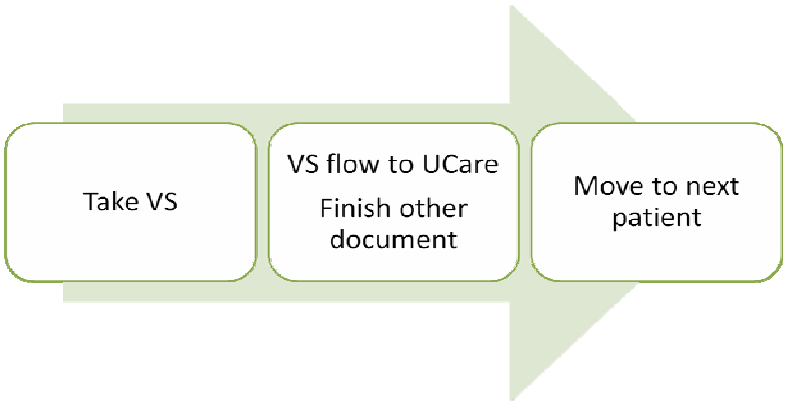

Figure 3. Revised vital signs acquisition workflow.

GE Healthcare developed a new Java applet to optimize this new workflow that integrates with the Centricity Enterprise EMR client. On a single screen, the applet displays the vital signs acquired from the DINAMAP and supports entry of additional data elements (e.g. temperature, respiratory rate, pain score, etc.) that were not collected by the DINAMAP devices (see Figure 4). GE optimized this new user interface for navigation and data input using the Motion C5's pen and stylus capabilities.

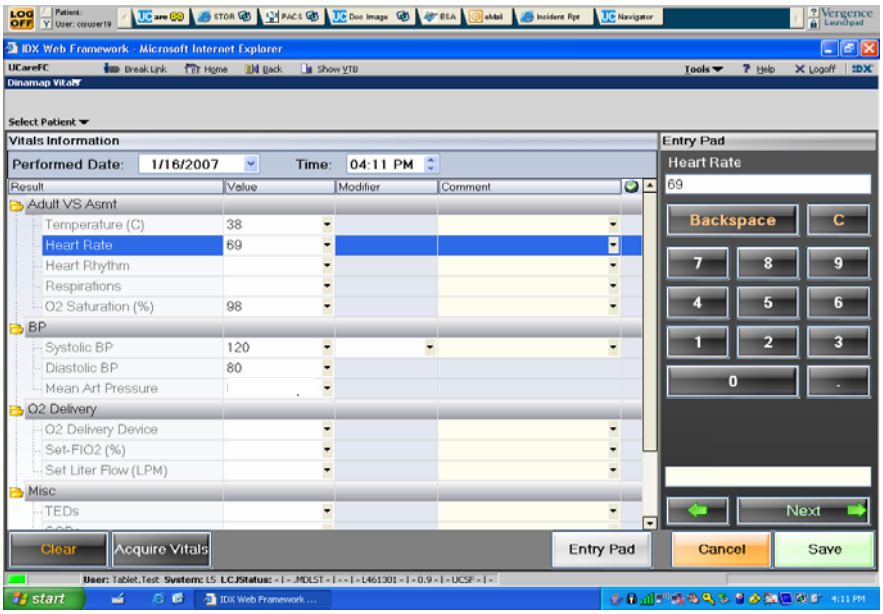

Figure 4. GE applet for vitals acquisition and electronic documentation

Methodology and Results

Baseline measurements of data latency (defined as the length of time between vital sign data collection and the time at which the vital signs were placed into the EMR and available to other clinicians) revealed a mean delay of 123 minutes across multiple nursing units. The average latency on the Adult Transplant Unit was 119 minutes. After staff training and implementation of the new Motion C5 with the DINAMAP interface, observers collected data recording the start and end times of vital collection, the length of time until data was input into the EMR, and factors related to the accuracy of data. At the conclusion of the pilot, nurses completed an online survey regarding their satisfaction with the Motion C5 mobile point-of-care workflow compared to their workflows using the COWs and desktop PCs at the nursing workstations.

Decreased Data Latency

Latency decreased from an average of 119 minutes at baseline to less than 1 minute with the new C5 workflow, an improvement of 99% (Figure 5). With data available in the EMR almost 2 hours sooner, clinicians could base their decisions on more accurate, up-to-date information, and have the potential to spot developing problems earlier.

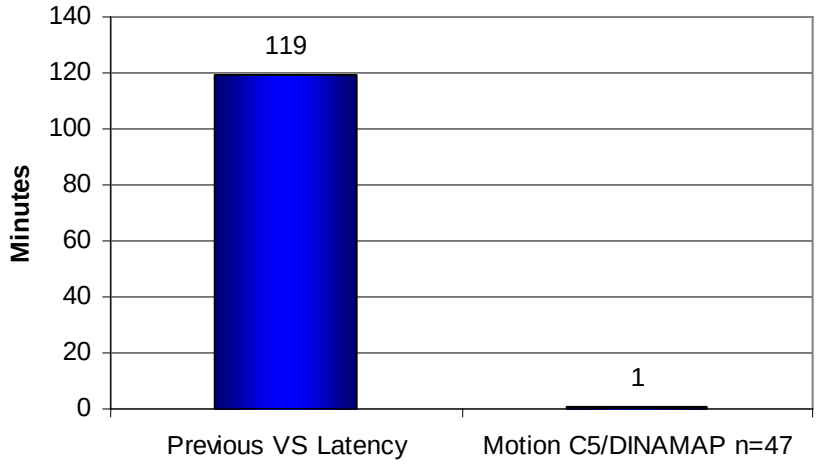

Figure 5. Time from vital sign collection to the recording of the results into UCare.

Lower Risk of Transcription Error

Data transcription can lead to increased error. In a recent study[1], researchers examined 1,463 sets of vital signs and found that between 14.9% and 25.6% of them contained one or more transcription errors.

The mobile C5 workflow implemented in this pilot reduced the number of data items transcribed, thereby reducing this potential source of error. In the previous workflow, nurses transcribed six discrete data elements – systolic blood pressure, diastolic blood pressure, pulse, oxygen saturation, temperature, and respiratory rate. Each data element was transcribed first to paper and then to the EMR, for a total of 12 transcriptions. This workflow is illustrated in Figure 6.

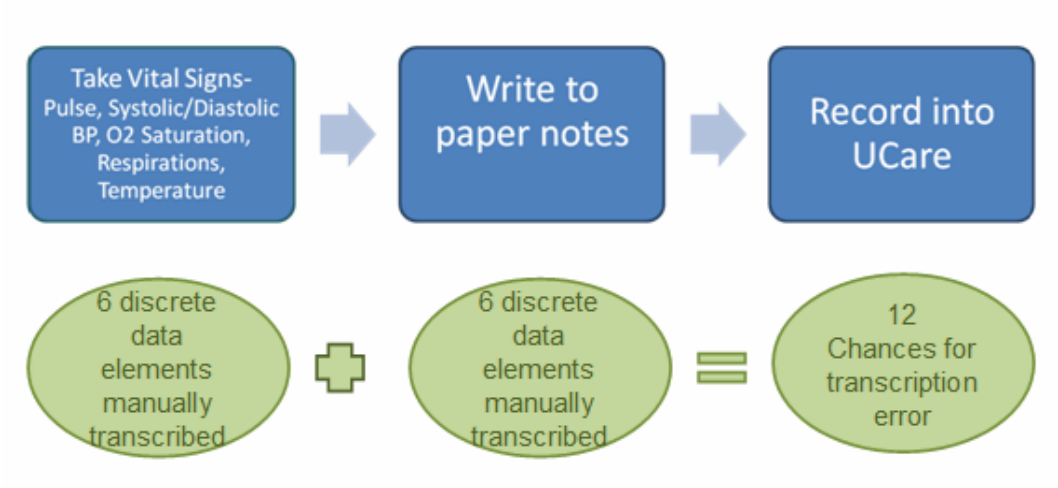

Figure 6. Twelve data elements required transcription with the traditional workflow.

With the mobile C5 workflow, only two data elements, temperature and respiratory rate, which were not part of DINAMAP's automatic data collection, had to be manually transcribed. This process change decreased the number of transcribed data elements from 12 occurrences to 2, an 83% reduction in work and opportunity for error (Figure 7).

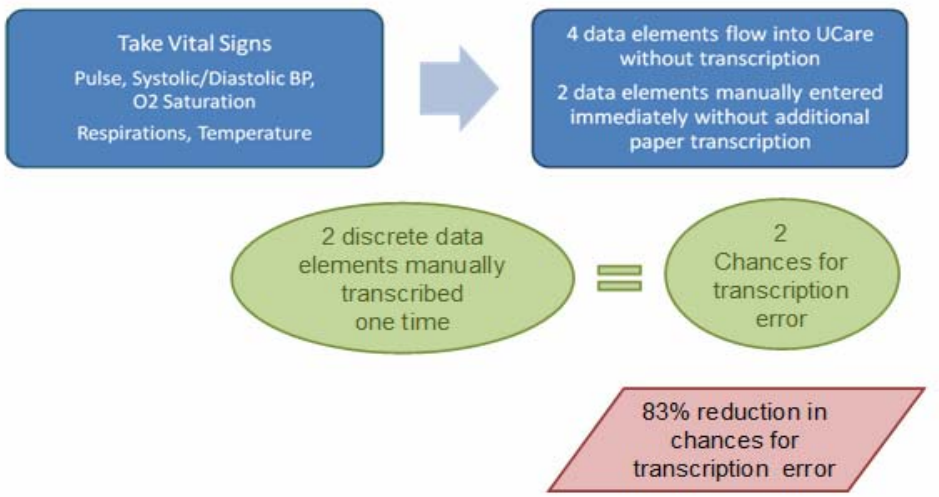

Figure 7. Number of transcribed data elements decreased from 12 to 2 with process change with an 83% reduction in the chance for transcription error

Improved Nursing Satisfaction

Previously, the strain of carrying a full patient load was exacerbated by the frustrations of searching for an available system, logging in anew for each session, and taking valuable clinical time away from direct patient care to work with the computer. Some nurses also experienced neck and back pain from pushing heavy COWs. Collectively, these issues adversely affected nursing satisfaction.

Nursing satisfaction increased in all areas when comparing the experience working with the Motion C5 to COWs and desktop PCs. Figure 8 shows the results of an online assessment of nurse satisfaction**.** Nurses preferred the Motion C5 mobile clinical assistant to the COW on overall mobility, work pace, ability to move in constrained areas (common in older facilities), ease and ergonomics of data entry with the pen, access to needed information from anywhere on the nursing unit, and enhanced patient interaction.

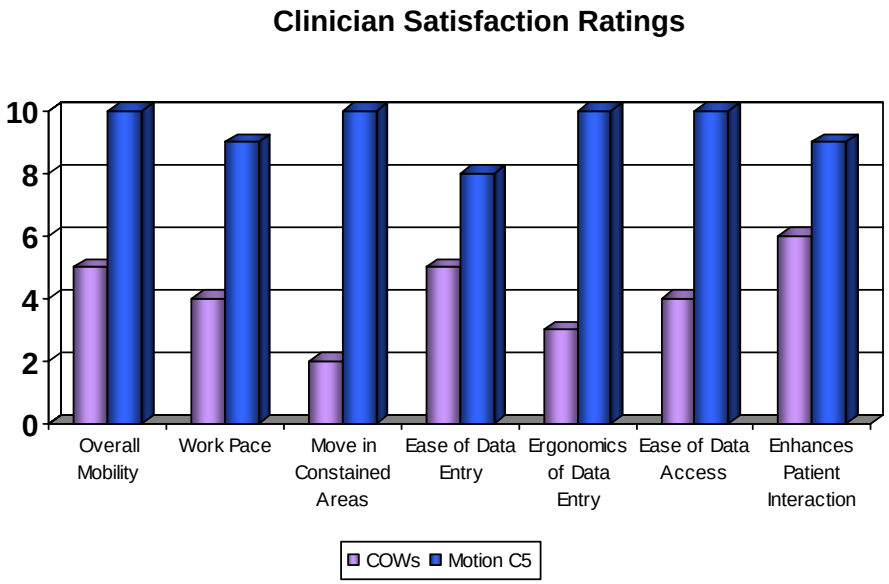

Figure 8. Higher nurse satisfaction with Motion C5 MCA.

Among nurses' comments on the Motion C5 MCA:

- "Pleased and surprised at how well recognized my handwriting and medical terminology"
- "Felt good because my documentation was done when I walked out of the room since it usually is hanging over my head to be done later
- "Allowed me to be mobile and chart anywhere"
- "Made my work easier"
- "Made rounding with physicians more efficient – I could follow the rounding team and still update my documentation"
- "I never had to look for a COW"
- "Easy to learn to use"

One patient on the pilot patient care unit related increased satisfaction with the new process, offering comments such as, “Results get to my physician faster” and “less chance of error from writing information on paper and entering later.”

Cost Savings

Although cost was not a primary focus of the clinician workflow pilot, the relative cost of acquiring, maintaining and supporting the end-user device computing infrastructure is obviously an important consideration. A simple cost of ownership comparison was made analyzing upfront acquisition costs, annual operating expense, forecasted annual failure rate, and practical useful life of a Motion C5 compared to the COWs currently utilized. Figure 9 compares the relative acquisition and operating expenses required to support COWs compared to the Motion C5 mobile clinical assistant. Extrapolated over a 3-year useful life and assuming a 250 unit deployment, the Motion C5 was found to be $562,500 less expensive for UCSF to purchase and maintain compared to the COWs.

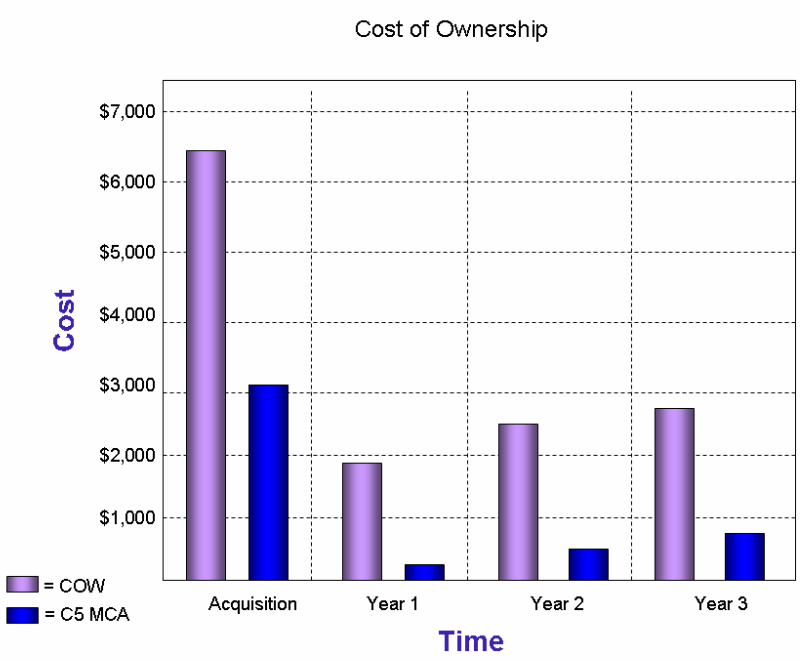

Figure 9. Comparison of the relative costs to acquire/support COWs vs. the Motion C5

Collaborating for a Successful Pilot

The UCSF Medical Center collaborated with Intel, Motion Computing, and GE Healthcare to conduct its clinician workflow pilot. Prior to the pilot, UCSF did extensive pre-work to observe and analyze existing workflow issues, identify pilot objectives, and develop relevant metrics. Intel, Motion and GE Healthcare worked together to determine how GE Centricity Enterprise could best integrate and exploit the unique,

advanced feature set of the Motion C5 mobile clinical assistant to support UCSF's goals. GE software developers completed a series of technical tests and developed prototype forms, user interfaces and integration or extraction routines. Motion worked with UCSF and GE to conduct interactive design sessions with clinical, operations and IT leadership to define the system performance thresholds and Quality of Service (QoS) metrics. Project resources were then put in place to achieve and sustain performance consistent with the clinician usability targets and QoS targets.

UCSF's infrastructure teams worked closely with wireless engineers from Motion to tune the wireless network to meet the demands of ultra-mobile devices such as wireless VoIP phones, tablet PCs, and Wi-Fi enabled PDAs. UCSF and Motion provided on-the-job in-service training and reinforcement tools to help nurses become competent and confident in using the Motion C5 with the GE DINAMAP and GE Centricity Enterprise EMR within their workflows.

Summary

UCSF undertook a pilot to assess potential improvements in clinician productivity and satisfaction by enabling documentation at the point of care and eliminating redundant tasks. The data from the pilot demonstrate a substantial improvement in nurse productivity and satisfaction, and in the timeliness and accuracy of clinical documentation. The elimination of multiple data transcription steps also reduces the opportunity for error.

By thoughtfully applying technology to improve workflow, healthcare leaders at UCSF have demonstrated new ways to improve patient care while optimizing clinician productivity. Product innovations such as the Motion C5 mobile clinical assistant, in concert with industry collaboration, can help healthcare institutions achieve positive and lasting change. Following the successful pilot, UCSF is deploying the Motion C5 and related accessories to additional patient care areas to extend the benefits of the mobile point-of-care solution. UCSF is also following the Motion Clinician Usability study methodology in evaluating future technology-enabled change initiatives as it continues to leverage the ability of healthcare information technologies to improve patient care and clinician productivity.

"Information management is a vital part of safe and effective health care," said Mark Laret, CEO of UCSF Medical Center. "UCSF Medical Center's collaboration with Intel, General Electric, and Motion Computing has brought together experts from business and medicine to develop the most innovative products in medical informatics today. We are confident our efforts will help clinician's better serve patients and will advance the art of medicine worldwide."

References

1. Gearning, P, Olney, CM, Davis, K, Lozano, D, Smith, LB, Friedman, B. Enhancing patient safety through electronic medical record documentation of vital signs. J Healthc Inf Manag 2006; 20:40-45.