



White Paper
Field Study
Intel Digital Health Group

Mobile Clinical Assistant Platform Prototype: Mobile Point-of-Care Technology in Emergency Care

Changi General Hospital, Singapore

Executive Summary

Ethnographic researchers from Intel's Digital Health Group have conducted a series of observational studies to evaluate clinicians' use of a mobile clinical assistant in acute care settings. The mobile clinical assistant (MCA) is a purpose-built device specifically for clinicians developed by designers and engineers in Intel's Digital Health Group.



Findings from the study suggest that mobile point-of-care (MPOC) technologies, such as the MCA, can improve the quality of patient care and can enhance clinician productivity in fast-paced trauma care settings, by enabling clinicians to quickly encode and retrieve information into and from the patient's electronic medical record (EMR), right at the patient bedside.

The study also highlights several factors that hospitals should consider and address when seeking to deploy MPOC solutions:

- How MPOC software design impacts desired clinical work processes and workflows.
- How physical attributes of the clinical environment affect clinicians' use of MPOC devices.
- The importance of training clinicians on how to input data into MPOC devices.

This white paper reports on one of these studies, which was aimed at evaluating the use of the MCA by doctors and nurses working in a fast-paced trauma/emergency care environment. The study represents a collaboration between Intel's Digital Health Group, Changi General Hospital (CGH) and Eutech Cybernetics.

Introduction: Improving Mobile Point-of-Care Solutions for Healthcare

Hospitals are increasingly deploying electronic medical records (EMRs) and other healthcare information technology (HIT) solutions to streamline the collection and dissemination of clinical information. Given the complexity and challenges of coordinating information in the healthcare environment, deployment of healthcare IT solutions requires platforms and devices that are customized to the variations in clinical work practices and workflows of the many healthcare professionals working in the acute care environment. Mobile point-of-care (MPOC) platforms are particularly important because they enable clinicians to quickly access information at the point of decision, which can improve both the speed as well as the quality of clinical decision-making—and hence the quality of patient care.

The need for robust MPOC solutions is global. Each hospital environment presents a unique combination of patient types, physical layout, workflow, and other factors. In order to explore the utility of an MPOC platform in a range of acute clinical work practices, ethnographic researchers have studied use of the MCA by acute care clinicians working in a variety of geographies and clinical settings. The first study reported on the use of the MCA by nurses working in transitional (step-down) and medical oncology inpatient units at a community hospital in Mountain View, California¹. This current paper reports on the use of the MCA by Accident and Emergency (A&E) physicians and nurses in a hospital trauma/emergency care setting.

Study Setting: Changi General Hospital A&E Department

Changi General Hospital (CGH) is a 797-bed public hospital that serves a population of 750,000 Singapore residents living in eastern Singapore. The hospital opened in December 1996 and was accredited by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) International accreditation in June 2005. CGH is one of the institutions under the Singapore Health Services (SingHealth), the largest public healthcare group in Singapore.

CGH's Accident and Emergency Department provides 24-hour medical and surgical services for trauma and non-trauma emergencies. Facilities include a three-room triage area for walk-in patients, a 12-bed resuscitation room, a 12-bed observation room, an operating theater, and dedicated x-ray services.

The main clinical application used by clinicians in CGH's A&E is Eutech Cybernetics' Copernicus* Accident and Emergency Module, deployed at CGH as the Accident and Emergency Physician Support System (AEPSS). AEPSS provides modules for triage, consultation, observation, and pharmacy, and is used by both physicians and nurses in the A&E.

¹ See Mobile Clinical Assistant Platform Prototype: Mobile Point-of-Care Technology in an Acute-Care In-Patient Setting, El Camino Hospital, California.

Table 1. Mobile Clinical Assistant Prototype Feature Summary

Feature	Objective
Docking station	<ul style="list-style-type: none"> Provide a place to store and/or charge the MCA. Enable hot swapping of batteries while continuing to use the system.
Pen/stylus data entry	<ul style="list-style-type: none"> Enable clinicians to enter text and navigate the software without being tied to a keyboard.
Sure-grip handle	<ul style="list-style-type: none"> Make the device easy to carry. Promote a secure grip during use.
Sealed casing	<ul style="list-style-type: none"> Enable the device to be easily wiped clean with disinfectant to help prevent the spread of infection.
Hardened chassis and hard drive	<ul style="list-style-type: none"> Minimize the impact of dropping the platform.
Slim, lightweight design	<ul style="list-style-type: none"> Enhance portability and ease of use at the bedside.
10-inch display	<ul style="list-style-type: none"> Enhance ease of viewing clinical information with minimal scrolling.
Wi-Fi* and Bluetooth* wireless technology connectivity	<ul style="list-style-type: none"> Enable easy, robust connection to wireless area networks. Enable integration of technologies to automatically upload patient vital signs and other data into the EMR.
Integrated camera	<ul style="list-style-type: none"> Enable visual clinical documentation (for example, wound documentation) at the point of care.
Integrated RFID reader	<ul style="list-style-type: none"> Enable clinicians to log on to each “layer” of the system without using a keyboard, mouse, or stylus. Reduce time on user authorization and authentication. Support positive patient identification and electronic medication administration.
Integrated barcode reader	<ul style="list-style-type: none"> Support positive patient identification and electronic medication administration.

Overview of the Mobile Clinical Assistant (MCA) Prototype

In the study at CGH, A&E physicians and nurses used the mobile clinical assistant (MCA) prototype with standard MCA features and customized software to enable new clinical work processes and workflows in the A&E resuscitation and observation areas. In addition to the standard capabilities of a tablet PC (for example: stylus input, virtual keyboard, and built-in Wi-Fi* and Bluetooth* wireless technology), the standard MCA prototype includes features designed to add value in clinical settings, such as: an integrated camera for visual clinical documentation (for example: wound documentation), and an integrated barcode/RFID reader for positive

patient identification and electronic medication administration. Integrated Wi-Fi provides clinicians with “anywhere, anytime” access to hospital EMR systems and other clinical information systems. The MCA can use integrated Bluetooth wireless technology to interface with other medical devices (vital signs monitors, etc.) to obtain patient data from existing medical devices and directly transmit captured patient data into the EMR in real time. The MCA’s physical design has also been adapted for use in acute care environments, with features such as a sure-grip handle to facilitate portability, and a sealed case for easy disinfecting. Table 1 summarizes capabilities and features of the MCA platform.

Study Overview

In preparation for our clinical study, an Intel ethnographer studied existing clinical workflows in the A&E. These studies suggested that an MCA solution might be appropriate for physicians in the resuscitation room and for nurses in the observation room. This became the focus of the technical field test team, which included engineers and solution architects from Intel's Digital Health Group, IT staff from CGH, and software engineers from Eutech. To provide enhanced workflow solutions in both arenas, the technical team customized an MCA software solution that provided access to the AEPSS software, as well as direct transfer of vital signs data into the AEPSS EMR.

In October 2006, Intel field personnel trained clinicians on the use of the MCA. Training covered the use of an electronic stylus for handwriting, the use of a virtual keyboard for AEPSS EMR navigation and text input, the use of RFID ID badges for automated log on to the MCA, and use of the MCA for wireless vital signs capture.

An Intel ethnographer observed four A&E physicians and four nurses as they used the MCA to care for patients in the A&E resuscitation and observation areas. They observed the clinicians performing the following activities:

- Accessing the AEPSS EMR to record patient history and assessment data, enter orders, and wirelessly capture vital signs.
- Physicians using the MCA for initial assessment, history-taking, and order entry at the patient bedside.
- Nurses using the MCA to chart completed orders and pain levels, enter nursing notes, and wirelessly capture and record vital signs.

Portability in Confined Spaces

Portability of the MCA has proven to be one of its key benefits for clinicians needing access to EMR and other clinical information systems when rounding patients that are located in separate rooms. Chang's A&E resuscitation and observation rooms were both large, single rooms with multiple patient bays. Clinicians didn't have to walk very far to get on a PC to enter orders or to chart physical histories and assessments after their patient encounter. Given the relatively easy access to existing desktop PCs in A&E's physical environment, we wondered if clinicians would derive any benefit from the MCA. Observations during the study revealed the portability of the MCA to be a key benefit for clinicians even when their clinical work takes place in a single-room environment.



Figure 1. Doctor using MCA to enter a report from paramedic.

Maintaining a Visual

Rapid access to patient information is an important consideration in all acute care settings; it is particularly critical in A&E environments, where a patient's condition often precludes the patient from being able to provide a verbal history, and where a patient's health status can change rapidly in a short period of time. With the MCA in hand, A&E clinicians were able to access patient histories and enter new orders and assessment data without having to leave the patient bedside to go to a desktop PC. Clinicians' use of the MCA at the bedside saved time and steps, while simultaneously enabling clinicians to maintain a "visual" on the patient to monitor and respond to changes in patient status.

Concurrent Workflow Tasks

The MCA's portability enabled physicians to more effectively manage the hectic workflow in the A&E resuscitation room. The typical physician workflow in the resuscitation room followed a sequential pattern of first stabilizing a patient, and then going to a desktop PC to chart on the patient. When several patients needed to be stabilized at once, physicians would multitask between patients. Charting simply had to wait until there was a convenient time to sit down at a PC. With the MCA, physicians were able to stabilize patients and then use the MCA to enter orders and complete clinical documentation without leaving the patient bedside. This allowed for concurrent tasking of medical care and clinical documentation. One physician remarked on the convenience of being able to use the MCA to wirelessly print documents such as discharge summaries, medical certificates, and referral letters from the patient bedside. She felt that wireless printing helped her accomplish more tasks in parallel.

Portability

The MCA's portability helped physicians use their time more efficiently. For example, while assessing a patient who had just arrived in the resuscitation room, one physician commented that the MCA's portability helped "save steps." Using the MCA, the physician was able to read the patient's past A&E record at the bedside without having to go back to his desk. On another occasion, a physician who was waiting for a nurse to complete an order on a patient in the observation room used the MCA to chart on a patient who was still in the resuscitation room. The physician commented on the convenience of being able to chart on a patient in one room while attending to a patient in another.



Figure 2. Doctor assesses a newly arrived patient.

Workflow Analysis and Software Integration

During our study, the MCA was only evaluated as a general-purpose medical point-of-care (MPOC) platform, tasked to retrieve and enter clinical information into the AEPSS EMR and to wirelessly capture vital signs data. While the MCA capabilities examined in the study were limited in scope, the study nevertheless revealed several implementation issues that hospitals should understand and address when preparing to introduce MPOC technologies in their clinical environments.

One issue to understand is the “costs” associated with early technology adoption. Because clinical units within a hospital typically have multiple interdependencies with other hospital units and departments, being the first unit or clinical area to adopt a healthcare IT solution can create more (rather than less) work for participating clinical units in the near term. During the study or pilot phase of a new Healthcare Information Technology (HIT) implementation, a clinical unit may have to maintain legacy paper practices to ensure continuity of information and patient care when crossing the interface to other clinical units and departments. In the A&E resuscitation and observation rooms, nurses continued to enter patient vitals and other patient data on paper nursing assessment forms in parallel with the MCA-enabled paperless process. This duplication of information was necessary in order to avoid disruption of patient care when patients were discharged, admitted, or temporarily transferred to another area in the A&E for diagnostic imaging or tests.

Findings from the CGH study (and other clinical work practice studies) suggest that the “cost” of early HIT adoption goes down and the benefits go up when an HIT solution moves from being a discrete, point solution within a single clinical unit or department to one that integrates clinical workflows and information across multiple interdependent units and departments. The A&E study demonstrated the importance of attending to information interdependencies that exist between clinicians working in a single clinical area. Successfully implementing a system-level HIT solution would require even greater attention to understanding the complex handoffs and interdependencies that exist between physicians and nurses working in different clinical departments and areas.

Hardware, Software, and Workflow Interdependencies

The study identified the importance of understanding existing clinical work processes and workflows in order to anticipate how design of the software running on MPOC platforms can enable and/or constrain the desired workflow. The tight interdependency between clinical workflow and MPOC software design requires carefully specifying the software modifications that will support seamless, system-level workflow integration.

In the A&E study, the MCA was customized to wirelessly interface with the A&E’s vital sign monitoring device using Bluetooth wireless technology. The researcher observed that nurses used the MCA more often when working in the observation room than they did when working in the resuscitation room. Moreover, nurses reported more positive experiences with the MCA based on use in the observation room compared to their experiences using the MCA in the resuscitation room.

The differences in user experience were due, in part, to how often vital signs were captured in the resuscitation room versus in the observation room. The design of the AEPSS software also impacted how nurses used the MCA to wirelessly capture vital signs and chart patient data in the observation and resuscitation rooms.

Typically, when a patient came to the A&E by ambulance, a resuscitation nurse would meet the patient at the ambulance door, take the patient vitals, and record the information on a paper nursing assessment form. After transporting the patient into the resuscitation room, the nurse would take and record subsequent vitals readings onto the assessment form, which stayed on the patient bed tray. When the doctor was ready (after stabilizing the patient) the doctor would simply pick up the nursing assessment form, which contained patient vitals and other nursing data, and would later copy patient vitals from the nursing assessment form (as well as patient history, physical assessment and other clinical data) into the AEPSS EMR. With the MCA-enabled workflow, resuscitation nurses couldn't take patient vitals using the MCA until after the patient's physician had put the patient record in a special software queue and then informed the nurse that the patient was in the queue. The software flow also didn't allow resuscitation nurses to enter nursing notes and other patient assessments into AEPSS. The software's sequential tasking between doctors and nurses, coupled with the inability to use the MCA to enter other nursing documentation in the AEPSS EMR, impeded resuscitation nurses' workflow and thus limited utility (and use) of the MCA by nurses in the resuscitation room.

In contrast, in the observation room, the provided software did not place sequential interdependencies between physicians and nurses. Once a patient was transferred to the observation room, nurses could use the MCA, at will, to capture patient vitals. In addition to using the MCA to wirelessly capture patient vitals into the AEPSS EMR in real time, design of the AEPSS observation software module also allowed nurses to chart completed orders, and to enter assessments and other nursing notes when monitoring patients in the observation room. In the observation room, vital signs comprise a larger portion of the nurse's workload, since each patient's vitals must be taken once an hour, which meant taking hourly vitals for up to 12 patients (equivalent to the room's capacity).

These observations demonstrated how the relative "fit" between workflow demands, clinical information interdependencies, and the design of enabled hardware/software capabilities results in very different user experiences.



Figure 3. Observation nurse capturing patient vitals at the bedside.

The Human Factor in Automated Data Collection

Our observation of nurses using the MCA for wireless vital signs capture reinforced the importance of incorporating error-proofing mechanisms into HIT systems, particularly those that wirelessly (invisibly) transfer data between medical devices and electronic medical records. This will help to mitigate the risk that new technologies might introduce new sources of error. In our study, nurses were able to review patient vital signs on the MCA at the time of capture, which gave them the necessary feedback to detect and question out-of-bound results and to verify captured information before committing it to the patient's electronic record.

Physical Environment

Our observations showed how the physical environment can impact clinicians' use of MPOC platforms at the bedside. In particular, findings from the studies suggest that clinicians need a designated place to put the MCA (or any MPOC platform) when they are at the patient bedside so they can free up their hands to insert IV lines, hang drips, administer medications, and complete treatments and procedures. In the A&E resuscitation room, patient bedside trays were often filled with supplies and papers, leaving no room for the MCA. This meant the clinicians sometimes put the MCA on the bed between the patient's legs. In some situations, researchers observed clinicians carrying the MCA back to the desk and docking it there to avoid having to create a space for it at the patient bedside.



Figure 4. A&E doctor sets the MCA down on a crowded patient bed tray in order to insert an IV line.

MCA Usability

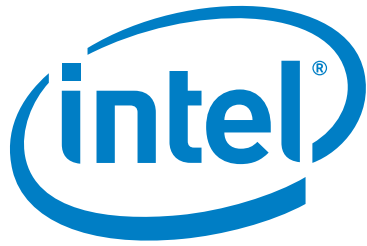
The field study generated further insights into usability of the current MCA design.

- **Handwriting recognition.** The ethnographer observed that successful bedside data entry and retrieval with the MCA strongly depended on clinicians' comfort with using a stylus as an alternative to using a mouse and desktop keyboard for text input. As a tablet PC, the MCA provided clinicians with an input panel that provided the flexibility to enter clinical data and notes using different tablet interface options.
- **RFID log on.** Use of the MCA's RFID log on feature effectively streamlined and accelerated application log on for both physicians and nurses. Expedited log on to the EMR, anytime and anywhere, will lower the barriers to more extensive use of MPOC platforms (such as the MCA) at the patient bedside.

Summary and Next Steps

This white paper described how Changi General Hospital, Intel's Digital Health Group, and Eutech Cybernetics came together to examine the use of the mobile clinical assistant (MCA) prototype in a fast-paced, trauma/emergency care setting. Findings from the live study showed that MPOC platforms such as the MCA can speed up retrieval and capture of clinical information and save steps for clinicians working in fast-paced clinical environments. The study also highlighted the need to attend to the relative fit between workflow demands, clinical information interdependencies, and hardware/software design when deploying new healthcare IT solutions. Lastly, findings from the study demonstrate how attributes of the physical environment, as well as clinicians' comfort with different human-computer interfaces and interaction modes, can impact use of MPOC at the patient bedside. By looking holistically at the interplay between clinical workflow, software/hardware design, and clinical environment, the MCA study at Changi provides useful insights and guidelines to hospitals and may improve the likelihood that investments in MPOC platforms will lead to real and observable improvements in clinical workflows and patient care.

As the leading supplier of building block technologies to the global computer industry, Intel frequently acts as an industry enabler. With field studies such as this one with Changi General Hospital and Eutech Cybernetics, we continue our commitment to collaborate with leading healthcare organizations and vendors to create technologies that can help improve healthcare's quality, efficiency, and accessibility.



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