



Mobile Technologies at George Eliot Hospital Show Ability to Enhance Productivity

In a pilot conducted with Intel® Solution Services, the 440-bed National Health Service Trust hospital saw that providing mobile access to clinical information systems produced significant time and resource savings. See how mobile technologies can help hospitals improve care and efficiency.

Executive Summary

Mobile computing technologies, combined with systems such as electronic patient records (EPR) and electronic picture archiving and computing systems (PACS), show great potential for improving the productivity of healthcare workers and enhancing the efficiency of hospitals, clinics and other healthcare organizations. George Eliot Hospital (GEH), a 440-bed acute care hospital in England, worked with Intel® Solution Services, Intel Corporation's worldwide professional-services organization, to put mobile technologies to the test. GEH deployed 20 wireless tablet or notebook PCs to a cross section of care providers. These care providers used the devices with a mobile application portal to access pathology and radiology results, a dashboard application for tracking patient status, and other information sources.

The pilot demonstrated significant time savings for mobile clinicians and reduced the administrative burden on nurses. On an individual basis, time savings included:

- **Locating pathology results** during a clinic visit: consultant and nurse saved 5 minutes each per patient (25 percent).
- **Community monitoring** of chronic patients: nurses saved 45 minutes daily (approximately 10 percent).
- **Recording and filing** surgery notes: administrative staff and consultant saved 20 minutes per procedure.
- **Retrieving surgery notes** at follow-up visit: saved 10 minutes per patient visit (50 percent).
- **Charting of inpatients:** ward nurse saved 10 minutes per shift, medical staff on wards saved 20 minutes per shift (6 percent).
- **Scanning of pre-op patients:** nurses saved 45 minutes per shift (approximately 10 percent).

Return on investment (ROI) analysis showed that these and other time savings would enable the pilot to deliver ROI in 15 months. If the technologies were extended to consultants, senior medical staff and senior house officers (SHOs), ROI would occur in five months. Patient safety and quality of care were also impacted positively. Future introduction of mobile clinical systems such as PACS and electronic patient records will amplify the value of the mobile technologies.

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Driving to Improve Care and Efficiency

George Eliot Hospital is a 440-bed National Health Service Trust hospital with 1,830 staff and an annual budget of £80 million (USD\$140.5 million). GEH delivers traditional district general hospital services, including acute services, to a local population of around 250,000 people in the areas of Nuneaton and Bedworth, north Warwickshire, southwest Leicestershire and Northern Coventry. In a typical year, GEH treats more than 23,000 inpatients and day cases, 122,000 outpatients and 58,000 visits to the Accident and Emergency (A&E) department.

GEH has a strategic mission of providing “Better Care without Delay” to its patients. Hospital administrators have set a goal of becoming a “no-wait” hospital, and are taking steps to increase the hospital’s responsiveness, efficiency and capacity.

GEH has made significant progress toward its goals in the past fiscal year. While admissions have increased, waiting times for elective procedures have decreased from nine months to within six months. Of all A&E patients, 99.91 percent are now admitted within four hours, and the average is admitted within 90 minutes.² Still, further efficiency improvements are needed if GEH is to become a no-wait hospital, and mobile technologies show an ability to enhance the productivity.

The Need for Mobility

Like many hospitals around the world, George Eliot Hospital has computerized many of its administrative functions, but relies primarily on manual, paper-based processes for clinical care. Paper-based reports are often inaccurate, misfiled or delayed reaching the appropriate ward or clinic. Quality of care is poorer when the clinician doesn’t have timely access to all needed information. When results and reports are missing, patients may be subjected to repeated tests or rescheduled appointments, adding costs and inconvenience.

Some clinical information at GEH is computerized, but the interfaces are via centralized desktop PCs or terminals, so information and applications are not readily available at the bedside, exam room or other point of care. This adds costs and inefficiency in a variety of ways. Clinicians make notes by hand, which takes time and effort and often involves consolidating existing information. Administrative staff must decipher hand-written information and enter it into the system. In addition to requiring redundant effort, this has the potential to introduce inaccuracies and cause delays in keeping records up to date. Nurses spend inordinate amounts of time gathering clinical information and printing it out for physicians. This diverts their attention from patient care.

Space is at a premium and there are rarely enough conveniently located desktops. Clinical staff often can’t get physical access to desktops during peak times. They either walk to another location in the hospital to locate a free system or queue to use the ward desktop. Both options result in wasted time and reduced access to vital information. Information systems are supported by different departments and require different

user credentials to access. A care giver may have to learn and master several different user interfaces, which wastes the time of busy professionals.

Management productivity and effectiveness are also affected by the lack of mobile computing. Senior management and operations staff are forced to stay in their offices when dealing with email and personal administration. This does not support the hospital's philosophy of "management by walking around."

GEH recognizes that providing timely clinical access to evidence-based medicine will help the hospital achieve its quality and efficiency goals, and that mobile technologies play an important role in these broader initiatives. Areas of interest for mobile technologies at GEH include outpatient follow-up, admissions, chronic disease management and clinical support services.

Pilot Overview

As a first step toward taking advantage of the wireless network, George Eliot Hospital and the Technology Office of the National Health Service (NHS) Connecting for Health (CfH) initiative worked with Intel® Solution Services on a pilot to understand the implications and impact of introducing mobile technology into an acute clinical environment.

GEH had recently installed an 802.11b/g^s wireless network. The hospital had also deployed an Accident and Emergency patient-tracking dashboard known as the A&E Trakker, the first such digital dashboard system at GEH, but the dashboard was available only from desktop systems.

With input from key administrators, clinical users and ward managers, Intel Solution Services developed a mobile information portal that made a number of information sources

available to GEH clinical and administrative staff (see Table 1). To provide access to the portal and its services, 20 Fujitsu Siemens* laptop and tablet PCs were deployed to a range of users, including general and specialty nurses, medical and surgical consultants and SHOs.

Pilot users represented a range of wards and functions and included the A&E and emergency medical unit (EMU) wards. A&E handles unplanned emergency admissions from the local community, while EMU takes care of planned emergency admissions from the primary care environment and overspill from A&E. Several of the clinicians spent significant amounts of time dealing with patients in different physical locations within the hospital. This pilot focused solely on clinical staff, and devices were not provided to administrative personnel.

The pilot concentrated on the productivity impact of a new system that allowed secure, online access to pathology and radiology results. Clinical and IT staff received relevant training prior to and during the pilot deployment. Feedback was gathered through structured interviews and online questionnaires, as well as regular visits to the wards and drop-in meetings with mobile clinical staff.

Pilot Technologies

The pilot employed a number of technologies already in place at GEH. In addition to the wireless network, these included Microsoft Active Directory*, Exchange Server* and SharePoint Services*. The wireless network covered all wards, clinical areas and most administration areas of GEH, offering approximately 80 percent total site coverage. The portal used a combined security model with WEP authentication and encryption to ensure the confidentiality of data and results.

Table 1. Mobile Information Portal Capabilities.

Intel AMT Features	Description
Main site	Portal entry point providing single sign-on facilities for Microsoft Active Directory*, news facilities and role-relevant menus.
A&E Trakker	Existing in-house application used for prioritizing patient treatment and tracking four-hour status in Accident & Emergency ward. A web-based application nurses update manually to show patient admission, discharge and visitation in real-time.
Results viewing	Web-based viewing of radiology and pathology results, based on Indigo Review* by Indigo4. Review provides role-based user authentication and can be used by clinicians, consultants and relevant ward staff.
Clinical view	Dashboard view of a consultant's pathology and radiology results, as well as patient record view. Designed as web components for loosely coupled integration into GEH's legacy hospital information systems.
Information management	Existing in-house intranet-based hospital dashboard.
Document management	Customized view of Microsoft SharePoint* document management features.
Intranet	Existing trust intranet site.
Ward information center	Existing externally hosted website providing a web front-end to key fields in the hospital's patient administration system (PAS).
MySite	A personalized page created using integrated SharePoint MySite feature. The interface was simplified, allowing staff to use the page primarily for web-based email access via Outlook*.
Clinical internet sites	Role-based clinical links to existing clinical organizations such as ToxBase and British National Formulary (BNF)
SHA extranet sites	Regional Accident and Emergency Capacity Management System

Table 2. Hardware Technologies

Platform	Description
Wireless network (existing)	Airespace wireless network with Airespace* 1200 access points, Airespace* 4000 LAN switches and Airespace Control System* software. Supports 802.1X port-based authentication model (EAP PEAP-MSCHAPv2 authentication and TKIP/RC4 encryption). Pilot implemented WEP security only.
Laptop PCs	5 Fujitsu Siemens Lifebook* T4010 convertible laptops configured with the Intel® Pentium® M 733 processor at 1.1 GHz and WLAN, Bluetooth*, 10/10 Ethernet and modem communications, weighing 1.88 Kg and running Microsoft Windows XP Tablet Edition* 2005.
Tablet PCs	15 Fujitsu Siemens* ST5020 tablets configured with the Intel Pentium M 725 processor at 1.6 GHz, and WLAN, Bluetooth* 10/10 Ethernet and modem communications, weighing 1.55 Kg and running Microsoft Windows XP Tablet Edition 2005.
Servers	2 Dell PowerEdge* 2850 servers, each with dual Intel® Xeon™ processors at 3.4 GHz with 1MB internal cache and an 800 MHz system bus, running Microsoft Windows* 2003. One acted as a SQL database server and the other as an IIS Web server.

Table 2 summarizes the hardware technologies deployed.

Prior to the pilot, the ability to view pathology results electronically existed only to a limited number of clinicians through a text based system, and no electronic access was available to radiology reports. The pilot introduced a number of new functions by providing Indigo4's Indigo Review* to all clinical staff:

- **Electronic availability** of radiology summary reports, previously available only in paper format.
- **Display of pathology and radiology** requests and matching reports, previously available only on a text-based, green-screen system.
- **Aggregated display** of results by a specific patient, ward, requestor or test type.
- **Historical, non-questionable** record of a patient's test history with graphical trends where possible.
- **Audit trail** indicating timings of test delivery to the lab and when the results were made available.
- **Visible audit trail** of who viewed which report and when.
- **Normal/abnormal indications** as set by the local lab.

Intel® Solution Services integrated Indigo4 Review Server* into the portal, providing a transparent sign-on experience for the user. Indigo4 Review Server is a robust and flexible product and GEH is adopting it quickly.

Results: Time and Resource Savings

With just 20 mobile devices in deployment, it was not possible to directly assess the organizational benefits of providing healthcare workers with mobile access to information and applications, so the pilot focused on identifying the impact and benefits at the individual level. These benefits were considerable, with mobile clinicians realizing significant time savings in both the outpatient and medical wards. Mobile devices also reduced the adminis-

trative burden on the nurses in these wards. Further benefits were seen in the areas of patient safety and quality of care.

The following are examples of the types of time and resource savings observed.

Patient and Results Tracking in Medical Ward

In GEH's general wards, a team of consultants, registers and SHOs monitor patients. To maintain a constant treatment thread, each ward maintains a list of patients that includes the patient's name, date of birth and NHS number, bed number, date admitted, working diagnosis, next steps, current treatment and discharge plans.

Typically, information is noted manually by the physician during ward rounds or memorized for each patient. The information is then entered into a Microsoft Word* document when the clinician gains access to the ward desktop PC. This requires 10–30 minutes per shift for the medical team, as well as additional time for the nursing staff to update patient movements. In some cases, the records are not updated until the SHO's shift is over, resulting in inaccurate information that can impact the quality of care.

When equipped with tablet and notebook PCs, clinical staff could record patient notes directly into the system at the patient's bedside. This reduced their administrative tasks at the end of ward rounds, minimized duplicate effort, improved the quality of information and made the information available to other clinical staff immediately. Ward nurses saved an average 10 minutes per shift, and medical staff 20 minutes per shift.

Clinical staff in the medical wards also benefited from the ability to quickly locate pathology and radiology results. With mobile access to information at the bedside, the SHO did not waste time gathering information prior to ward rounds. The flow of the ward round was not interrupted while staff tried to track down information and results. The burden on the nursing staff was reduced, and there were fewer disruptions to patient care and to the sharing of information among care givers.

Pre-Op Patient Screening

The pre-operative assessment ward at GEH prepares approximately 30 patients daily for surgery. A key task for the senior nursing staff is to review the patient's pathology results and ensure any abnormalities are flagged before the patient arrives, to reduce the chance of having to cancel a procedure at the last minute. There are typically between one and four results to review for each patient, and patients are planned and screened up to seven days in advance. This task typically consumed 2-3 hours every day.

Before the pilot, screening these results was a manual process often requiring the nurses to track down information in different parts of the hospital. With the tablet PCs and the Indigo Review* application, nurses performed the work online and saved an estimated 45 minutes daily. This change reduced the time spent chasing paper results and minimized the need to reschedule surgeries because test results could not be located. It also freed nurses to pull up patient results whenever and wherever they had some quiet time, rather than waiting until the end of the day. Patient care improved because the Review application provided an audit trail identifying tests that had been checked. Patients avoided the distress and inconvenience of rescheduled surgeries.

Surgery Notes

Surgery notes are critical for maintaining accurate records of surgical procedures and are used to guide the care provided after the operation. Typically, the surgeon dictates notes during the operation, and they are later typed by administrative staff, then reviewed and approved by the surgeon. The average turnaround time is 7–10 days before notes are completed and available to other staff and clinics. If delays or filing errors occur, then notes are not in the file when the patient returns for a post-op visit. The quality of care can be affected, and patients may have to be rescheduled, adding costs and decreasing patient satisfaction.

During the mobile pilot, select surgeons used ink recognition to fill out template surgery notes and drawings, which can be saved to a file as well as printed. The notes are filed immediately, and the report is available at the post-op visit in both paper forms and online. Surgeons and administrative staff saved an average of 20 minutes apiece for each surgery, and the post-op clinic staff saved 10 minutes by not having to search for missing notes.

Outpatient Reception

GEH's outpatient ward consists of 45-50 consulting rooms and a number of reception areas and offices, and services 122,000 patients annually through various weekly clinics. To minimize wasted time for consultants, clinics and patients, patients are asked to report one-half hour early for their appointment. When they arrive, their files are retrieved and checked. If a file or results are missing, time is taken to locate the file and print the results. As a result, some patients are rescheduled, or their appointment is delayed.

The pilot introduced tablet PCs to a number of doctors who participate in outpatient visits as well as to clinic nurses. Productivity savings resulted because it was no longer necessary to wait for paper results. In addition, clinic visits requiring radiology results were dramatically improved since there was no need to search for reports in the hospital archive. Patients avoided having to arrive 30 minutes early for pre-processing, and nurses saved 5-45 minutes searching for pathology and radiology results.

Results: Patient Safety and Improved Care

Other instances of improved patient care and patient safety were recorded in addition to those noted in the preceding examples. For example, in the past, when caring for a patient with a heart attack in A&E, a staff member would have to step out of the room and phone for lab reports. With a tablet or notebook at the bedside, results could be monitored at a glance allowing an additional member of staff to be in the room and caring for the patient.

Long-term monitoring of chronic patients was also enhanced. The full medical team (patient, GP and consultant) could be notified immediately if a primary care patient's results were abnormal, leading to faster modification of treatment plans.

The mobile applications and devices provided a variety of non-tangible benefits that impacted patient care:

- **Faster clinic turnaround time.** Numerous individual tasks were completed more quickly because the needed information was available immediately and locally.
- **Faster, more informed decision making.** Physicians were able to look up medical information, reference documents and up-to-date web-based resources when needed instead of having to wait until later in the day or the next day when the physician was back in the office.

- **Improved continuity of care.** Mobile devices allowed information access and transfer to happen in real-time and at the patient's bed or during a staff consultation. Consultation and information flow was not interrupted to track down missing paper documents.
- **Enhanced patient confidence.** Clinicians and nurses used the mobile devices to educate patients, helping to increase comprehension and treatment compliance. Patients were shown their results and trends visually to discuss progress and treatments. Patients might also be shown externally available public websites relative to their condition.
- **Improved patient satisfaction.** Changes such as shorter wait times and fewer lost results tend to make patients feeling more satisfied with their encounters with the healthcare system.

Return on Investment

ROI analysis of project costs and the time savings observed in outpatient clinics, specialty clinics and by consultants, predicts that GEH can return the investment of the pilot within 15 months. With extension of the pilot to cover the senior medical staff, consultants and senior house officers, the pilot investment would be returned in five months. Additional benefits were also seen regarding the adoption of pathology/radiology results viewing throughout the hospital, along with mobile benefits around patient safety and improvement of patient care. However, these were not factored into the ROI analysis.

The benefits used to calculate the return on investment, while significant, will be potentially much larger with the introduction of future mobile clinical systems such as picture archiving and computing, results ordering, and electronic patient records. In addition, formal changes in processes and working habits will increase these benefits over time.

The ROI model followed does not include the benefit of the introduction of results viewing to the hospital in general; i.e., the benefit from providing this capability to all staff regardless of tablet devices. It does not include costs reduction to IT budget due to decrease in desktops, printing costs, and other related items.

Initial Pilot Scope

The following model is based on the costs of the original pilot—the infrastructure required and the deployment of 20 mobile devices.

Table 3. ROI for Initial Pilot

Initial Scope (costs in GBP)	
Costs	
Implementation Costs	123,072.00
Year 2-3 Costs	14,988.00
Additional expansion costs	—
Total Costs	138,060.00
Yearly Costs saving	
	109,415.65
Time in months for ROI	15.14

Scope Extended to Consultants

Based on the data collected during the pilot, the major savings were obtained from the medical teams, both in clinics, ward rounds and takes and acceptances. Since it was difficult to base the model on exact staffing numbers, we examined two deployment models.

- **Providing tablets to each ward** to serve clinicians—70 tablet devices deployed
- **Providing tablets to each consultant** and SHO—130 tablet devices deployed

In both cases, the ROI analysis indicated that the time saved would provide a return on investments within five months. The following tables summarize the costs:

Table 4. ROI for Extending Pilot to Consultants and SHOs

Expanded Scope—Consultants at Out-Patient Clinics	
Costs	
Initial Implementation Costs	123,072.00
Year 2-3 Costs	14,988.00
Additional expansion costs	80,550.00
Total Costs	218,610.00
Yearly Costs saving	
	452,954.17
Time in months for ROI	5.79
Expanded Scope—120 Doctors (SHO and Consultants)	
Costs	
Initial Implementation Costs	123,072.00
Year 2-3 Costs	14,988.00
Additional expansion costs	194,760.00
Total Costs	332,820.00
Yearly Costs saving	
	767,464.17
Time in months for ROI	5.20

Summary

The pilot at George Eliot Hospital demonstrated clear efficiency savings from the use of mobile technologies by care providers. It also indicated the potential for improvements to patient care and safety. These benefits, while already significant, will expand as GEH implements the planned electronic patient record system, “mobilizes” additional applications, deploys mobile devices to additional users and functions, and implements process changes designed to promote the use of mobile computing. Use of mobile solutions in outpatient wards can potentially decrease the waiting time for patients and release nursing staff pressure. In specialty clinics, mobility can enhance patient care, shorten administrative time and improve data capture. In medical and surgical wards, the use of mobile devices for patient monitoring, tracking and rounds can improve decision-making, improve the consistency of care provided to patients and reduce the administrative burden on SHOs.

Take Advantage of Mobile Technologies

Mobile computing, combined with process changes and innovative applications, can transform healthcare by enabling hospitals to increase productivity, enhance patient care and deliver healthcare services more efficiently. Intel technologies, including tablet computers based on Intel® Centrino® mobile technology, handheld devices based on Intel® Mobile Media™ technology and servers based on the Intel® Xeon® and Intel® Itanium™ 2 processor families, provide a powerful foundation for this transformation. Intel® Solution Services combines in-depth knowledge of the Intel® architecture, state-of-the-art facilities and strong industry alliances, to help hospitals and other organizations accelerate time-to-value through cost-effective, cutting-edge solutions to complex business challenges.

Learn more about how Intel mobile technologies and Intel Solution Services can help you transform your hospital or other healthcare organization. For further information, talk with your Intel representative or visit us on the web:

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Information about Intel mobile technologies:

www.intel.com/products/notebook/index.htm

www.intel.com/products/wireless/index.htm

Information about Intel Solution Services:

www.intel.com/go/intelsolutionservices



¹ An SHO is equivalent to a resident in the United States.
² See http://www.geh.nhs.uk/foundation/star_rating.htm.
³ See http://www.airespace.com/products/AS_1200.php.

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