

Digital Hospitals Move Off the Drawing Board

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About the Authors

First Consulting Group provides consulting, technology, and outsourcing services for health care, pharmaceutical, and other life sciences organizations in North America and Europe. More information about FCG is available at: www.fcg.com.

About the Foundation

The **California HealthCare Foundation**, based in Oakland, is an independent philanthropy committed to improving California's health care delivery and financing systems. Formed in 1996, our goal is to ensure that all Californians have access to affordable, quality health care.

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I. Introduction

THESE ARE CHALLENGING TIMES FOR THE hospital industry. Across the country, institutions that provide medical and surgical care are facing new pressures on multiple fronts. In one particularly vivid example, a 1999 Institute of Medicine study reported that 98,000 people die in U.S. hospitals each year from preventable medical errors, fueling a justifiable demand from employers, payers, and patients for improved quality.

Hospital capacity is constrained. In 2001, two thirds of hospitals were forced to divert ambulances at some point during the year, and one in ten reported diverting emergency cases 20 percent of the time.¹ Further, to meet increasing demand from the elderly population, at least 238,000 new hospital beds will be needed by 2027.² With this growing demand, U.S. hospitals also have a critical shortage of staff; 90 percent have a shortage of nurses³ and 15 percent of imaging technician positions in hospitals are vacant.⁴ Declining reimbursements are also a reality at both the federal and state level.⁵

The Institute of Medicine has emphasized that advances in technology will be vital to “crossing the quality chasm.”⁶ A growing number of hospitals are incorporating information technology in the construction and design of new facilities to increase efficiency and ensure that care is provided in accordance with best practices. Perhaps inevitably, these have come to be known as digital hospitals.

Purpose

This report provides an overview of digital hospitals in the United States. The scope of research includes both new digital hospitals and hospitals that are transforming specific processes or departments using an innovative technological approach. Emphasis has been placed on documenting the results of existing efforts and capturing the lessons that have been learned in planning and implementation.

First Consulting Group was retained by the California HealthCare Foundation to explore, through interviews and site visits, the various efforts to build the digital hospital. Because of the limited number of digital hospitals in operation, the scope of the study was expanded to include hospitals that had transformed departments, such as the operating room (OR), the emergency department (ED), and the intensive care unit (ICU).

Hospitals currently under construction were included in the research to help validate any conclusions and gain some perspective into what the future might hold.

When looking for potential sites, the authors focused on those that are using technology to transform care as outlined by the ten goals in the second Institute of Medicine report, “Crossing the Quality Chasm,” paraphrased below.

- Patients should receive care whenever they need it and in many forms, not just face-to-face visits.
- The system of care should have the capability to respond to individual patient choices and preferences.
- Patients should be given the information they need to exercise control over decisions that affect them, and the health system should be able to accommodate differences in patient preferences.
- Patients should have unfettered access to their own medical information and to clinical knowledge; clinicians and patients should also be able to communicate effectively and share information.
- Patients should receive care based on the best available scientific knowledge. Care should not vary illogically from clinician to clinician or from place to place.

- The health care system should reduce risk and ensure safety by paying greater attention to systems that help prevent and mitigate errors.
- The health care system should make information available to patients and to their families that allows them to make informed decisions when selecting a health plan, hospital, or clinical practice, or choosing among alternative treatments.
- The health system should anticipate patient needs, rather than simply reacting to events.
- The health system should not waste resources or patient time.
- Clinicians and institutions should actively collaborate and communicate to ensure and appropriate exchange of information and coordination of care.⁷

The 13 sites that best addressed those goals were asked to participate. Two of these sites, Oklahoma Heart Hospital and Indiana Heart Hospital, did not participate in the study.

Between one and four key staff members familiar with the design and operation of the facility were interviewed by telephone. Interviewees included chief information officers, project managers, department leaders, and end users. Discussion focused on:

- Goals of the hospital
- Approaches to integrating technology into the organization
- Lessons learned
- Results achieved

Site visits were then arranged with three of the hospitals to gain a deeper understanding of the details around digital hospital planning and operation. Visits included an extensive tour and interviews with the project leaders, hospital executives, physicians, and nurses who have been directly affected by the effort.

The following table lists the hospitals that are included in this report.

Table 1. Lists of Participating Hospitals

New Hospitals			
Hospital Name	Location	Project	Status
El Camino	Mountain View, CA	Replacement facility	Scheduled to open in 2008
Physicians Hospital	El Paso, TX	New facility	Scheduled to open fall 2003
Sacret Heart Medical Center at Riverbend	Springfield, OR	Replacement facility	Scheduled to open in 2007
Existing Hospitals			
Inland Northwest Health Services	Spokane, WA	Collaboration of 5 citywide and 25 regional hospitals to integrate technology across participating organizations	All hospitals are open
St. Vincent's Hospital	Birmingham, AL	Integrating a variety of technologies across the organization	Open
Digital Departments			
Hamot Medical Center	Erie, PA	Digital imaging department Digital OR	Open
Mount Carmel St. Ann's Hospital	Westerville, OH	Digital ED	Open
NorthCrest Medical Center	Springfield, TN	Digital ED	Open
Sentara Norfolk General Hospital	Norfolk, VA	Digital OR Digital ICU	Open
University of Pittsburgh Medical Center	Pittsburgh, PA	Digital OR	Open
Washington Hospital Center	Washington, DC	Digital ED	Open

II. The State of Digital Hospitals

Definition of Digital Hospital

Although the concept of the digital hospital has begun appearing in the press,^{8,9,10} no accepted definition exists within the industry. Therefore, for the purposes of this report, the term digital hospital is defined as: *An acute care facility incorporating the widespread use of information technology to dramatically improve the processes and outcomes of care.*

Current Landscape

There are 5,801 registered hospitals in the United States,¹¹ and many replacement and new hospitals are under construction to meet future demand.

The most-publicized digital hospitals are new specialty hospitals—especially the 88-bed Indiana Heart Hospital in Indianapolis, Indiana; the 80-bed Oklahoma Heart Hospital in Oklahoma City, Oklahoma; and the planned HealthSouth facility in Birmingham, Alabama. Smaller acute care digital hospitals are nearing completion, with Physicians Hospital, a 40-bed facility in El Paso, Texas set to open its doors in fall 2003. The large replacement hospitals at PeaceHealth in Springfield, Oregon and El Camino in Mountain View, California are not scheduled to open for three or four more years.

With 153 new acute care or specialty hospitals under construction now, and 223 in the planning stages,¹² it seems likely many more announcements of new digital hospitals will be forthcoming in the near future.

There are also a growing number of institutions that are transforming critical hospital areas. Research is being funded on how to do it well—for example, in May 2003, a total of 10 hospital systems were selected by the Robert Wood Johnson Foundation to participate in a \$4.6 million redesign of emergency departments.¹³ Fewer institutions that are gradually integrating technology across the organization were identified, but this may be because these approaches are less publicized rather than less prevalent.

New Hospital Construction Activity 2002									
Type of Facility	Completed			Broke Ground			Designed		
	Number of projects	Number of beds	Construction cost (in billions)	Number of projects	Number of beds	Construction cost (in billions)	Number of projects	Number of beds	Construction cost (in billions)
Entire acute care hospitals	82	6,259	\$2.6	105	13,254	\$6.1	152	16,785	\$11.0
Acute care expansions	432	5,237	\$3.9	382	10,666	\$7.1	649	20,006	\$11.1
Acute care renovations	1,467	5,318	\$2.4	720	4,790	\$2.5	1,111	6,026	\$3.6
Entire specialty hospitals	62	2,861	\$1.2	48	3,822	\$2.0	71	3,591	\$3.0
Specialty expansions	84	458	\$0.7	61	1,205	\$1.0	79	1,579	\$1.7
Specialty renovations	158	489	\$0.2	68	372	\$0.2	101	842	\$0.5

(Source: Modern Healthcare's 24th Annual Construction and Design Survey, *Modern Healthcare*, March 3, 2003)

Goals of Making the Digital Transformation

Digital hospitals focus on transforming the workflow associated with a paper-based environment to create a more efficient and effective organization. To accomplish this goal, hospital and department leaders at the study sites consistently stressed three key themes. Technology is being used to improve:

1. Access to information;
2. Process efficiency; and
3. Process reliability.

These themes are often interrelated. For example, improving access to information in a patient's record not only improves clinical care, it can also eliminate the time required to look for charts, resulting in streamlined, hospital rounds. Increasing the reliability of medication administration through the use of bar codes and scanners can reduce medication errors while simultaneously improving documentation.

Interviewees report significant benefits from digital transformation efforts, including better patient outcomes, reduced hospital costs, improved productivity, and higher provider satisfaction. The following section of the report describes specific examples for each of these themes.

Access to Information

Timely access to information is a crucial component of the care delivery process. Studies have shown that providing physicians with access to a patient's medical record at the point of care results in better educated decisions and improved outcomes. In a digital hospital, a single device such as a personal digital assistant (PDA) can allow a physician simultaneously to view data from multiple sources, such as a patient's electronic record, a bedside heart monitor, a recent radiology exam, or a database of care protocols.

"How do you define a 'digital hospital?' You can't define it by technology, things change too quickly. That's why we focus on finding better ways to provide access to information anytime, anywhere."

Tim Stetheimer, CIO, St. Vincent's Hospital

Hospital leaders also emphasize that eliminating the time spent looking for charts or x-rays can have a profound effect on workflow. One interviewee estimated that searching for information consumed more than 60 percent of staff members' time in the paper-based environment. This can be eliminated when all data is available electronically. To ensure that clinicians have access to necessary information from any location in the

hospital, interviewees are deploying a variety of tools, including PDAs, tablets, wireless laptops, flat screen televisions, and bedside monitors. Some examples of improved access to clinical information include the following:

- To eliminate the time-consuming processes associated with a paper-based environment, the emergency department at NorthCrest Medical center in Springfield, Tennessee has become completely paperless. Documentation and order entry is completed through tools such as Pocket PCs, and information can be retrieved from flat touch screens located throughout the department. Plans are also underway to automatically upload data from emergency medical services' future electronic patient tracking application to NorthCrest's clinical information system when a patient arrives via ambulance.

Eliminating paper—and the need to search for documents—has allowed physicians to focus more on administering care. The time patients spend in the emergency department has been cut by an average of 30 minutes. Despite an increase in volume of 13 to 15 percent, NorthCrest has been able to maintain its current staff level. Clinician satisfaction has increased, and emergency department Director Laurie Maxwell notes that the department has not had an open position in more than a year.

- To ensure that clinicians have immediate access to necessary information from any location in the hospital, Drs. Craig Feied and Mark Smith from MedStar Health helped design Insight, a fast, comprehensive clinical information system. Developed by General Datomics, Insight receives and stores real time information from all hospital legacy systems. Clinicians have immediate access to patient data, including lab tests and images dating back to 1997. In less than five seconds, staff can view video of previously recorded proce-

dures, a full motion cardiac catheterization, or a full motion echocardiogram. First deployed in 1996 in the emergency department at Washington Hospital Center, Insight now receives and stores 3 to 4 terabytes of real time data per year for each of the five MedStar Health hospitals using the system.

According to Dr. Feied, Director of Informatics, Insight is currently the fastest and most extensive clinical information system in the world. Since rolling out the solution in 1996, the emergency department at Washington Hospital Center has been able to double its admissions from 35,000 to 70,000, without the need for additional emergency department space.

- Inland Northwest Health Services is a collaboration of five Washington State hospitals in two integrated delivery networks and twenty-five regional facilities. In the push to improve the flow of information across all participating facilities, the nonprofit organization created a unified electronic medical record (EMR) for more than two million patients in the region. Community physicians can access full fidelity clinical imaging, in addition to patient data, from their homes, offices, and at the point of care on desktop or laptop computers. Many also choose to use software provided for their PDAs that allows them to link wirelessly to the EMR and gain access to data for all their hospitalized patients from any hospital. Frederick L. Galusha, CIO, reports that the tool has led to a decrease of 30 to 45 minutes in daily rounds for each physician.

Inland Northwest Health Services will soon allow patients to download software to their personal PDAs that gives them access to information from their medical record when they are within the hospital's wireless network. Patients can review their information privately, over a secure connection, on their own time.

Facilities are also using technology to improve access to clinical expertise. Through videoconferencing and remote monitoring equipment, physicians can quickly seek the opinion of a specialist, track a patient's progress, or even administer care from a remote location. Some examples include:

- In an effort to make more efficient use of staff and address capacity problems, Sentara Norfolk General Hospital in Norfolk, Virginia monitors patients in multiple intensive care units from a remote location. The “virtual” ICU team—consisting of an ICU physician, a critical care nurse, and associated clerical staff—can track a patient's condition through four screens that display: video of the patient room; the patient's vital signs; the patient's electronic medical record; and alerts to significant changes in heart rate and other critical parameters. When intervention becomes necessary, the virtual staff can communicate with on site personnel through the ICU's video and audio capabilities.

Remote monitoring of patients in the ICU has led to quicker intervention, resulting in improved patient outcomes and reduced costs. A study of Sentara's first year with the system in 2001 showed faster intervention led to a 25 percent decrease in hospital mortality rates for ICU patients. After subtracting the total costs of the project, the hospital was able to realize a 26 percent savings for ICU patient stay and a 17 percent decrease in ICU length of stay. These savings equated to \$2,150 per patient and a total of \$3 million per year for their two digital ICUs. Use of the system also meets the Leapfrog ICU standard for around-the-clock coverage by an intensivist.

“We've learned that remotely monitoring patients in the ICU does work. The results are there and the skeptics have been quieted. Day to day, early intervention saves dollars, saves ICU days, and saves lives.”

Ann-Marie Cochran RN, Product Manager
for Information Technology,
Sentara Norfolk General Hospital

- Hamot Medical Center in Erie, Pennsylvania, is making use of real-time network connections and video-conferencing equipment to establish contact with physicians outside the physical walls of the hospital. To ensure around-the-clock radiologist coverage, Hamot has partnered with a site in Australia. The 14-hour time difference allows technicians in Erie to send digital images at off hours to an “on-call” Australian radiologist for rapid diagnosis. The relationship is conveniently reversed half a day later.

Finally, some digital hospitals are also focused on improving access to information for patients.

- The Patient Portal at PeaceHealth's new hospital in Springfield, Oregon will allow patients to view a simplified version of their clinical and financial information, make appointments, and order prescription refills. Physicians will be able to view current patient records and order services for hospitalized patients from their offices. Through a Webcam in the neonatal intensive care unit, new parents will be able to watch their children from home.

The new hospital will also experiment with different types of patient monitoring technology that providers and family members can use to review a patient's condition from a remote location. For example, through a “virtual waiting room” system, families will be able to get regular, real-time updates through a mobile device, rather than keeping a vigil at the bedside.

- Physicians Hospital in El Paso, Texas is planning to install patient entertainment systems in its new hospital. Through bedside devices, patients will be able to view movies, access the Internet, watch educational films, and even order meals. Physicians will be able to sit with patients and families to review the patient's own digital images and clinical information from a touch screen at the bedside. All these features are designed to play a significant role in improving the patient experience.

Process Efficiency

Interviewees also relied on new technology to automate existing processes and streamline workflow. By improving process efficiency, hospitals can increase throughput and capacity. Physicians and nurses spend more time with patients, contributing to a rise in satisfaction. Also, by studying the data on process performance, sites were able to identify and address potential problems early on.

“Without enough data to evaluate something, what is the point? If you can't effectively measure a process, you can't improve it.”

Dr. Frank Orth, Mount Carmel St. Ann's Hospital

- The system from A4 Health Systems selected for the new emergency department at Mount Carmel St. Ann's Hospital in Ohio automates all aspects of patient data collection and care delivery from initial check-in—which takes less than two minutes—to final disposition. Using color coding and a comprehensive set of icons (currently about 110), the system is able to drive workflow and alert clinicians to critical values and outstanding tasks. Clinicians can view the condition, location, and admission time of all patients in the department through an electronic “grease-board” available on mobile devices and computers throughout the department.
- The system allows staff to track the average time that patients are spending in the ED from admission to discharge, and determine if specific clinical complaints are causing bottlenecks in flow. Overall, in the first year of operation, the department saved more than \$1.5 million from improved process efficiencies.
- St. Vincent's Hospital in Birmingham, Alabama is engaged in a pilot project to test Vocera communication badges. Using a small, one-button device worn around the neck, staff can immediately contact a specific clinician, a group of clinicians, or a type of specialist. By pressing the button and saying, “Call Jane Jones” or “Find neurologist,” a connection is established to the nearest contact who is in the hospital and not in a procedure room. Staff outside the walls of the hospital can access the system by calling an 800 number and using the same verbal commands used to operate the device.
- Since deploying the communication badges in May 2003 across the neurology unit, Vocera reports that nurses at St. Vincent's have been able to save up to 30 minutes each day that would have been spent finding a clinician.
- The digital operating rooms at the University of Pittsburgh Medical Center have integrated new technology with physical design changes to streamline surgeries. HERMES voice-controlled software allows the surgeon to make small, precise adjustments to the operating table camera or lights using only voice commands. In traditional surgeries, a nurse would have to be interrupted each time a change needed to be made. Most of the new equipment is mobile or fixed to the ceiling on booms, and can be quickly rolled out of the way, making clean-up between cases faster.

In the first year of operation, executives at UPMC believe the new operating rooms were able to save as much as \$400,000 by reducing time between cases and cutting clean up time in half. Overall, the new technology lead to a reduction in actual case times of 5 to 8 percent.

In a randomized trial, researchers at UPMC found that physician and nurse satisfaction rose significantly after introducing the speech recognition system used by the surgeons to control a number of operating room devices. Asked to rate their satisfaction with the system on a ten-point scale, nurses assisting with surgeries returned an average score of 9.2, compared to 5.3 for those in traditional sites who had used the technology in the past. The response from physicians was just as positive (9.0 vs.5.1).¹⁴

Process Reliability

Unnecessary variables in the delivery of care can lead to medical errors. Computers allow tasks to be performed exactly the same way for every patient. With sophisticated decision support, the systems can check for potential errors, remind about overdue tests, and support protocols for care.

- When it opens in fall 2003, Physicians Hospital in El Paso, TX, will promote patient safety by linking bar-coded medications with a patient's electronic medical record. Nurses will document medication administration through a handheld device. Before a drug is given to a patient, the bar code on the drug's packaging will be scanned and compared with a bar code on the patient's wrist. An alert will be generated if the medication has not been ordered or if a potentially dangerous drug interaction is found or an allergy exists.
- In a paper-based world, ensuring that all care related charges are accurately captured and associated with a specific patient can be time consuming and inaccurate. St. Vincent's Hospital, which tags IV drugs administered during surgery with bar codes, is using the DocuJet system from DocuSys to record medication administration. When a syringe is loaded into the device, the system displays the drug and concentration level. The bar code is verified against the patient's electronic record to check for allergies, drug interactions, and even recent doses. Any potential problem prompts an alert—both on the device's small screen and on the monitor in front of the physician. As the drug is administered, a camera inside records the total amount dispensed. All information is stored in the patient's record, ensuring that the hospital can track and account for all IV medications and bill accordingly.
- Advances in robotics in the minimally invasive endoscopic suites at Sentara Norfolk General Hospital are designed to increase safety of surgical procedures. Instead of relying on a scalpel or probe, the surgeon sits at a console away from the operating table, viewing the surgery from a monitor. Using hand controls, the surgeon can remotely pilot the robot's two surgical arms. Endoscope position, light intensity, and table height are manipulated by the physician's voice. Any movement of the robot or adjustment to the table is precise and exact, greatly reducing the risk of error. The OR at Sentara recently became one of the first in the country to perform a laparoscopic radical prostatectomy with robotics.

Approaches to Making the Digital Transformation

Organizations have taken two approaches to integrating technology into the operational model of the hospital. Some are building a new facility and incorporating technology into the hospital design. These can be completely new hospitals, like the 40-bed acute care Physicians Hospital in El Paso, Texas, or replacement sites, like the facilities under construction at El Camino and PeaceHealth. Other hospitals, already in operation, are working to make the transition to a digital environment by integrating technology in stages, either across the organization or within a specific department.

Integrating Technology in New Hospitals

Most organizations building a new facility start by establishing a vision. The vision includes goals for the future as well as descriptions of the future environment and how the application of technology will enable better care.

In determining the goals for El Camino Hospital, for example, CEO Lee Dominico and his colleagues were responding to a number of trends in health care, including the transition:

- From exclusively selling large blocks of services at low prices to third party payers to selling individual services to patients who are taking an active role in their health care.
- From a “no questions asked, physician-driven environment” to shared decision making between the patient and the family and the doctor and nurses, accelerated by advances in technology, such as the Internet.
- From human intervention at all times to increased technology substitution for human capital, lowering cost and improving performance.
- From “episodic, hospital-centered, one-size-fits-all care” to administering care on multiple delivery platforms beyond the physical walls

of the facility, including the internet, at home clinics, and partner hospitals.¹⁵

El Camino then set three goals for the new hospital:

- Build the “smart” hospital of Silicon Valley.
- Create the health care destination of Silicon Valley.
- Create a care system based on individual patient needs and values.

PeaceHealth built their vision around achieving the goals laid out in the IOM report “Crossing the Quality Chasm.” To convey their vision to the entire enterprise, they created a document that describes the future health care experience from a patient, nurse, and physician perspective.

Approaches to Planning New Hospitals

At the drawing-board stage, digital hospitals generally had a planning team that included operational staff and members of the IT department. In the case of new hospitals, this team was small, but dedicated all their time to planning the facility. Replacement hospitals often had only one or two staff people assigned to the project, but involved many others in planning committees for specific processes (access to care, supply chain management) or operational areas (laboratory, ED, etc). Almost all hospital design teams had members of the architectural design firm as well as outside technology consultants as key participants.

The planning was typically structured based on the lead-time required to implement decisions. The teams started with design of the physical plant, then identified technology that would be needed, and finally designed the operational model. This approach is not always effective, however. Admitting can be in a centralized department or at the bedside; documentation at a central nursing station or via mobile technology anywhere in the hospital. The operational model affects the architecture design.

“In planning for the new hospital, the most important thing is to determine how you are going to do business in the future. We’re trying to predict what the hospital will look like years from now.”

Dennis Sato, El Camino Hospital

Planning teams realized that while plans for architecture, technology, and operations should ideally be done in parallel, the logistics of the changes may not allow for such an approach. One hospital assessed what technologies had the greatest potential impact on the facility design and focused on those considerations first. Technology standards were adopted—consistent with the anticipated national standards three years into the future—so that all equipment purchased would fit with the new facility’s technology architecture.

“It’s not so much about what we want to do in 2008 when our new hospital opens. It’s about the changes we are making to our practices today. For example, one of our goals is to be completely filmless by 2008 and we are not planning to build a film room in the new hospital. Waiting until then to incorporate changes to the associated processes would be disastrous—we need to start doing business differently today.”

Mark Zielazinski, CIO, El Camino Hospital

Most hospitals do not have a single person who is responsible for both clinical and information technology, which makes integrated planning a challenge. Likewise, overall responsibility for facility construction and IT planning was split between two people at every study site. Often the responsibility for operational planning was decentralized, with separate teams focused on the

design of nursing care, supply management, the laboratory, etc. Planning for clinical technologies was always decentralized, with each department choosing its technology. All participating sites recognized the need to have more coordination among these groups. Several recommended creating a program management office to take responsibility for integrating the planning for IT and operations with the design of the facility.

Integrating Technology in Existing Hospitals

Building a new or replacement hospital from the ground up is not a viable option for most sites. In fact, while there are almost 6,000 hospitals in the United States, only 105 new entire acute care hospitals broke ground in 2002.¹⁶ Planning and construction requires hundreds of millions of dollars and a significant investment of time and resources—for example, El Camino estimates costs approaching \$300 million for their new facility. In light of practical and financial limitations, many existing sites are taking a staged approach to building the digital hospital.

Some of these sites are focused on incorporating a number of technologies across the enterprise. Others have identified a specific problem within a department and are looking for the right technology to solve it.

“We tried to gradually integrate new technology. By putting an electronic wrapper around all existing processes, our hope was to make all old processes go away. We want old systems to die a natural death.”

Dr. Craig Feied, Director of Informatics,
MedStar Health System

St. Vincent's Hospital in Birmingham, Alabama is integrating a variety of technologies across the organization. The site is the designated digital hospital for Ascension Health System and is intended to serve as a model facility, showing other hospitals in the system and the country what can be accomplished with information technology. Leaders at the hospital are always looking for new, innovative technology solutions. Decisions are driven by determining which new products can fill the gaps in supporting care processes. For example, in assessing software from Adobe, the hospital realized they could integrate certain components of the paper-based record (such as documents requiring signatures) into the electronic medical record. The hospital has since entered into a partnership with the company to use its workflow tools and eliminate all remaining paper.

Inland Northwest Health Services is a collaboration of two competing Spokane, Washington-area health systems that strives to become a recognized national leader in innovative health care solutions. In addition to creating an integrated information system for the participating hospitals, the nonprofit organization has sponsored initiatives like Inland Northwest TeleHEALTH Services, a network that allows rural physicians to communicate with specialists in city hospitals through real-time video and audio conferencing capabilities. This technology, in combination with the integrated clinical information system, has also been applied to create a digital, paperless TelePHARMACY network between larger Spokane hospitals and rural hospitals where pharmacists are in short supply. Key decisions on technology projects and initiatives are determined by which new solutions can best address the strategic plans for hospitals, departments, physicians, and consumers.

Sometimes efforts to integrate technology across the enterprise start by optimizing a single department. Many efforts are underway nationally to create the OR of the future, the ED of the

future, and the ICU of the future. Some are driven by a vision of the way care will be delivered. Others are the result of a specific operational crisis. Either way, these departments are high stress points in the current health care system and can serve as a proving ground for the entire hospital. For example,

- The digital ORs at University of Pittsburgh Medical Center (UPMC) are the vision of surgeons Jim Luketich and Phil Schauer. Although no operational crisis existed at UPMC, the surgeons believed that minimally-invasive surgery was going to grow dramatically and that it could be done most effectively in a specially equipped operating room. The two physicians began by selling their vision to the executive team, and leading a number of meetings between surgeons, department heads, and industry leaders. The first two operating rooms were built in 2001, three additional rooms were reconfigured shortly thereafter.

“Administrative support is essential, and to keep that support for a long period of time, you need to be using the technology, driving revenue, publishing papers, and teaching residents. You need clinicians with a passion – their energy will carry the whole project forward.”

Dr. James Luketich, University of Pittsburgh
Medical Center

In other cases, the departmental transformation results from solving a specific operational problem, as the following examples describe.

- The intensive care units at Sentara Norfolk General Hospital were suffering from capacity problems, high costs, and inconsistent care processes. As an organization accustomed to exploring new technology, Sentara selected the eICU product from Visicu to maximize the

use of intensivists and facilitate fast interventions when patients are in need of care. The technology has been so successful that Sentara has rolled it out to three of the six hospitals in the system and will expand to a fourth site this year.

- Before opening their new emergency department two years ago, Mount Carmel St. Ann's Hospital in Ohio was struggling with capacity problems. The decision was made to design the facility with the assumption that the technology would make it paperless.

“You need to examine every aspect of every process, thinking about screens in the context of hospital workflow. Sometimes you need to make adjustments to the system, sometimes you need to fix the process. It's the hardest thing I've ever done.”

Sonja Howard, Clinical Educator, Mount Carmel St. Ann's Hospital

While phasing technology in at a measured pace allows hospitals to focus on specific areas of operational excellence, challenges still exist. For sites introducing technology into a department with a high number of patient transfers, just one area in the facility may be affected. New information needs to be integrated with existing systems to create a complete medical record. The location or design of the existing space may also limit what can be done.

III. Common Themes and Lessons Learned

THE DIGITAL HOSPITAL IS NOT YET A REALITY. The early state of current efforts makes it impossible to define best practices for achieving the digital transformation and what results can be expected. In spite of the limited experience nationwide, interviews with those at the study sites did reveal some common themes on the barriers that must be overcome and the practices that contribute to success. Five themes were stressed consistently:

The Need for Strong Leadership

All study participants cited leadership and vision as keys to success. Several sites had a CEO who believed that technology was the key to the future. Curtis James at St. Vincent's Hospital has long been a technology advocate within both Ascension Health and one of its predecessor organizations, Daughters of Charity. John Haywood at PeaceHealth can clearly articulate his vision for the role of technology in next generation health care. His predecessor was of the same mind, advocating the purchase of the PHAMIS system (now IDX CareCast).

“The administration needs to fully understand the depth of commitment that is required, and be prepared to take the appropriate action to ensure success.”

Sonja Howard, Clinical Educator, Mount Carmel St. Ann's Hospital

However, the drive to go digital does not have to come from the top. At the University of Pittsburgh Medical Center, Drs. Luketich and Schauer came to the hospital to lead a program of minimally invasive surgery with the vision that the ORs would be optimized to conduct what was then a new approach to surgery. While they have full support from administration, their COO, John Innocenti, characterizes his role as “making sure nothing gets in their way.”

Washington Hospital Center realized that performance of the emergency department needed to be dramatically improved. Drs. Craig Feied and Mark Smith were hired to lead the transformation. One of their first interventions was to develop an information system that would ensure timely and accurate information from all sources was available in the ED.

Explore the Possibilities

Hospitals were asked about strategies for obtaining and evaluating new operational designs or new technologies. Several organizations hired leaders who could show them what needed to be done. Within departments, ideas sometimes came from canvassing the exhibits at trade shows and talking with colleagues at professional meetings. Hospitals that had reputations as technology advocates had less of a problem finding technology; their challenge was efficiently screening solutions that were brought to them by entrepreneurs and salespeople for technology firms.

All of these approaches proved to have disadvantages. They were hard to sustain across an entire hospital, and the people advocating particular solutions often lacked any data to support their choice, nor could they act as good sources of information about the relative benefits of alternative technologies.

Other study sites took a different approach. The University of Pittsburgh Medical Center selected Stryker as a vendor partner for their digital ORs to not only provide equipment, but to serve as the general contractor. If Stryker did not manufacture a needed product (such as the voice recognition software that controls the lights, table, and cameras), they found another supplier. Stryker was responsible for ensuring that the entire solution would work together to create the ideal minimally invasive OR.

“It is essential to pre-sell the concepts and benefits to the physicians and other clinical staff. The biggest learning curve is the fear of the unknown.”

Ann-Marie Cochran, R.N., Product Manager for
Information Technology, Sentara Norfolk
General Hospital

PeaceHealth is a member of HealthTech (The Health Technology Center). HealthTech produces reports on emerging technologies that address the current state of the technology and

its likely evolution. These reports predict the likely impact of technology on staffing, IT needs, reimbursement, and hospital utilization. PeaceHealth used these as one source of information on what clinical technologies they should use in their new facility. They also summarized the reports to educate the entire leadership team about how technology could help achieve their plan for a next-generation health care facility.

The Importance of Training

Training is probably the most overlooked component of introducing new processes and new technology into any setting. However, health care presents special challenges. Hospitals must train staff that work 24 hours a day and 7 days a week. Training typically needs to be available on the same schedule, unless the hospital is willing to pay staff to attend training in off-work hours. In most hospitals the physicians are not employees, and time spent in training detracts from their ability to see patients and generate revenue.

One goal in the study sites was to minimize the need for training by selecting systems that are simple to use and guide the user from one activity to the next. Built-in safety features to prevent users from making serious errors are also important. At St. Vincent’s Hospital the OR documentation system takes the user through a task list that automatically moves to the next task when one is completed.

“The technology needs to be user friendly, fast and reliable. If physicians can write it down faster than they can enter it in the system, you are going to have problems. Once the choice has been narrowed down, take the most average user you can find and measure their success with the system.”

Paul Minton, ED System Administrator,
NorthCrest Medical Center

One-on-one training and demonstrations are replacing classroom training in many settings. The objective is to tailor training to the needs of the user and to confirm mastery of the knowledge as training is delivered. The University of Pittsburgh Medical Center has the most advanced training capabilities of all participating hospitals (and one that might not be cost effective outside of a major teaching hospital). The new digital ORs are equipped to transmit images of the OR, the patient's data, and the internal image of what the surgeon is seeing and doing. While observers can follow the procedure from a viewing room next to the OR, they can also see the same images in an upstairs conference room or at a remote facility.

The University of Pittsburgh Medical Center also has a large simulation laboratory. The training center can be used to train and certify people on new technology and new procedures using simulated patients in hospital rooms, the ED, and the OR. They have an extensive curriculum developed by hospital staff that is used for voluntary and mandatory training. The students can track the results of specific actions and review the scripts of virtual encounters to learn from mistakes. The video of each simulation can be reviewed at a later time by students and professors through the center's Web portal.

“Our training laboratory can simulate any kind of potential disaster and prepare staff for once in a lifetime situations. Physician's reaction to what happens one percent of the time saves lives.”

Dr. John Williams, Chair, Dept of Anesthesiology,
University of Pittsburgh Medical Center

The Value of Vendor Partnerships

Participating hospitals stressed the importance of partnering with vendors. At a minimum, the partnership involved an agreement from the vendor to modify or develop a product to meet pre-defined needs, and required an exchange of knowledge from both sides to be effective. In some partnerships, such as the one between St. Vincent's and DocuSys to develop an OR system, both parties collaborated to create the product. Others, such as the relationship between Stryker and the University of Pittsburgh Medical Center, more closely resembled standard contractor/purchaser arrangements. In some instances the vendor also provided funding for research at the institution or for learning centers, but in many cases the only direct monetary benefit to the hospital was free equipment for the initial test.

The Value of User Partnerships

Hospitals that were selected for site visits created strong partnerships between the end users and the IT experts to design and implement their digital services. Where the focus was on redesigning departments, a user typically led the effort. In those sites investigating how technology could be applied across the hospital, the IT department staff were often in the lead. In all cases a person who understood both the clinical use and the technology played a key role. These people were sometimes formally trained in clinical informatics, but often were nurses who worked in the IT department or physicians who had pursued an interest in technology. In all the study sites the efforts were sanctioned by the institution, which made staff available to work on the project.

“A large part of our success stemmed from the fact that the system was designed and driven by people who are experts in both medicine and technology.”

Dr. Craig Feied, Director of Informatics at
MedStar Health

IV. Future of the Digital Hospital

Expectations

In talking with the people who are planning new facilities, it became clear that the benefits of incorporating digital technology into hospital operations extend far beyond the installation of new equipment. Many of the institutions being conceived today are truly health systems that integrate information across the continuum of care, including hospitals, physician practices, and long-term care, and can even extend into a patient's home. The participants in this study of digital hospitals recognized that access to information was the first key barrier to overcome within the hospital. Providing access to information among settings is even more challenging, and these connections barely exist today.

For example, how does the hospital know what medications the patient is taking on an ambulatory basis so they can avoid drug interactions with medications being given in the hospital? How does the emergency department know whether an abnormal EKG pattern is new or has been there for years? When a patient appears in a physician's office two days after discharge from the hospital, what will they know about the course of treatment? Providing a seamless, instant flow of information between all authorized caregivers is the digital hospital's ultimate goal.

The institutions involved in this research stated that they were devoting more than half of their efforts to changing processes as opposed to implementing new technology. Hospitals on the drawing board seem to be weighted more heavily toward the process end of the spectrum. For instance, at PeaceHealth, the new design was framed around the ten principles outlined in the Institute of Medicine Report "Crossing the Quality Chasm." Their goal is not paperless or digital but transforming their entire operation to meet the IOM goals.

The Bottom Line

The reality of the digital hospital is still two to five years away. While most institutions planning next-generation health care want to learn from past experimenters, access to that experience is very limited. Few sites are operational and have results to show; fewer still have done formal evaluations of their digital experience or even documented their lessons learned. This report is one step toward filling that knowledge gap.

A disproportionate share of the current and planned digital hospitals are specialty institutions, and many involve opening new facilities, rather than replacing existing ones. The specialty hospitals often have different business models, and new facilities have staff dedicated to planning the new facility. Since most U.S. hospitals are nonprofit, acute care general hospitals, many are waiting to see whether this model proves to be both broadly applicable and affordable. Therefore, projects such as the new El Camino Hospital and PeaceHealth's new Sacred Heart Medical Center at Riverbend will be very important for the advancement of next generation health care.

Based on the findings of this research, the authors recommend that all organizations adopt some sort of "technology watch" function by creating a formal process for educating the leadership about emerging technologies. They might also consider adopting a formal technology advocacy program to evaluate the potential benefits of new technologies. All of these steps would help prepare the organization to make integrated decisions about how facility designs, clinical technologies, IT, and operational models can help to implement their vision of next-generation health care.

Appendix

Inventory of Digital Hospital Projects

Hospital Name	Location	Initiative	Details	Interviewees
El Camino	Mountain View, CA	Building a new digital hospital	<ul style="list-style-type: none"> ● Replacement facility ● 350 beds ● Costs expected to range from \$240 to \$300 million ● Scheduled to open in 2008 	<p>Mark Zielazinski, CIO Dennis Sato, CIO from Eclipsys (outsourced)</p> <p>Marilyn Davis, R.N., Manager of Business Applications</p>
Hamot Medical Center	Erie, PA	Digital imaging department, digital OR	<ul style="list-style-type: none"> ● 336-bed tertiary care facility ● Open ● Imaging department of the future 	Joe Bulter, CIO
Inland Northwest Health Services	Spokane, WA	Collaboration of 5 city-wide and 25 regional hospitals to integrate technology across participating organizations	<ul style="list-style-type: none"> ● Formed in 1994 	Frederick L. Galusha, CIO
Mount Carmel St. Ann's Hospital	Westerville, OH	Digital ED	<ul style="list-style-type: none"> ● Emergency department averages about 65,000 visits each year ● 80 percent of hospitals admissions come through the emergency department ● Went live on system June 2001 ● Opened new emergency department December 2001 	<p>Sonja Howard, R.N., Clinical Educator</p> <p>Dr. Frank Orth, Physician Facilitator, Emergency Care Center</p>
NorthCrest Medical Center	Springfield, TN	Digital ED	<ul style="list-style-type: none"> ● 109 bed community hospital ● Emergency department averages 25,000 visits per year ● System rolled out in May 2000 	<p>Paul Minton, ED Systems Administrator</p> <p>Laurie Maxwell, Director of ED</p>
Physicians Hospital	El Paso, TX	Building a new digital hospital	<ul style="list-style-type: none"> ● 40 bed acute care facility with a 3 bed, level 4 ER ● Privately owned by a group of local investors ● Scheduled to open in fall 2003 	Tom Coulehan, CIO
Sacred Heart Medical Center at Riverbend	Springfield, OR	Building a new digital hospital	<ul style="list-style-type: none"> ● Replacement facility for Sacred Heart ● Scheduled to open 2007 	Dr. John Haughom, CIO

Appendix: Inventory of Digital Hospital Projects (cont)

Hospital Name	Location	Initiative	Details	Interviewees
Sentara Norfolk General Hospital	Norfolk, VA	Digital ICU, digital OR	<p>Digital ICU</p> <ul style="list-style-type: none"> ● Live as of June 2000 ● Currently in place in 3 of 6 hospitals in the system <p>Digital operating room</p> <ul style="list-style-type: none"> ● First surgery performed in September 2002 	<p>Ann-Marie Cochran, R.N., Product Manager for Information Technology</p> <p>Iris Welsch, Clinical Director of Surgery</p> <p>Kathleen O'Brien, Team Coordinator</p>
St. Vincent's Hospital	Birmingham, AL	Integrating a variety of technologies across the organization	<ul style="list-style-type: none"> ● 338 beds ● 18,000 patient discharges, 120,000 outpatient visits, 27,00 ED visits in last fiscal year 	<p>Timothy Stettheimer, Ph.D., Vice President/CIO</p> <p>Jackie Kennedy, Director of Information Infrastructure</p> <p>Tony Byram, Clinical Systems Specialist</p> <p>Kay Buchwald, Clinical Systems Specialist</p> <p>Barbara Knight, PACS Administrator</p> <p>Steve Anderson, Director of Information Solutions</p> <p>Patsy Booher, Laser Coordinator in Surgery</p> <p>Kim Wright, Health Information Manager</p>

Appendix: Inventory of Digital Hospital Projects (cont)

Hospital Name	Location	Initiative	Details	Interviewees
University of Pittsburgh Medical Center	Pittsburgh, PA	Digital OR	<ul style="list-style-type: none"> • 5 of 41 operating rooms are digital • Each room is 600 square feet • First room operational in November 2001 	<p>Dr. John Williams, Chair, UPP Dept of Anesthesiology</p> <p>Dr. Philip Schauer, Department of Surgery</p> <p>Dr. James Luketich, Department of Surgery</p> <p>Ron Andro, Vice President, Operations UPMC Shadyside</p> <p>John Innocenti, Senior Vice President & COO, UPMC Presbyterian/ Shadyside</p> <p>Paulette Bingham, Director of Surgical Services, UPMC Presbyterian/ Montefiore</p> <p>Scott Tanabe, Stryker Corp</p> <p>Dr. Erin Sullivan, Department of Anesthesiology</p> <p>Tom Dongilli, Operations Director WISER Institute</p>
Washington Hospital Center	Washington, DC	Digital ED	<ul style="list-style-type: none"> • WHC is a 900 bed hospital • 70,000 ED admissions each year • Clinical information system called Insight rolled out in 1996 	<p>Dr. Craig Feied, Director of Informatics, MedStar Health</p>

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