

THE HOSPITAL OF THE FUTURE

Megatrends, Driving Forces, Barriers to Implementation, Overarching Perspectives, Major Trends into the Future, Implications for TATRC And Specific Recommendations for Action

**Report to the Telemedicine and Advanced Technology Research Center [TATRC]
United States Army Medical Research and Materiel Command
Fort Detrick, Maryland**

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Research Methodology for This Report

TATRC engaged a consultant, Stephen C Schimpff, MD, to develop this white paper for action.

The initial sections were drawn from research for his 2007 book “The Future of Medicine – Megatrends in Healthcare,” published by Thomas Nelson. Schimpff interviewed over 150 medical leaders from across the USA asking what each saw as the major changes in medical care that would occur in the coming five to fifteen years. He also asked what were the drivers that would accomplish those advances. He then distilled all of the collected suggestions and comments into six megatrends and a set of drivers from basic science research as well as advances in engineering and computer science. This material, augmented in 2007 and 2008 by further interviews, readings and meeting presentations, represents the first sections of this report.

Beginning in the fall of 2007 and into early 2008, Dr Schimpff also conducted extensive interviews of TATRC leadership along with many staff. This led to the development of the TATRC Hospital of the Future vision and directions and laid the groundwork for the proposals at the end of this report as to what TATRC should do next to advance its “Hospital of the Future” agenda.

Schimpff then interviewed an additional 67 individuals across the country, asking them to comment specifically on what and why they expected would be the elements of the Hospital of the Future, defined as over the next ten to twenty years. Many, but not the majority, were partners and collaborators of TATRC along with TATRC staff. As with the book interviews, each person had his or her own set of perspectives and some were frankly parochial, but when viewed in total, there was a remarkable consistency to how healthcare will evolve and how healthcare should evolve. These comments were distilled and synthesized into sections on Barriers, Overarching Perspectives, Major Trends and the Hospital of the Future Summary. [Of note, materials on the specifics of the rising cost of medical care and the current political considerations around health care reform are not included here.]

Then, working with TATRC leadership, Dr Schimpff summarized TATRC’s core competencies and created a set of suggestions as to critical issues for TATRC, the implications of the Hospital of the Future on TATRC’s work and some organizational recommendations for the TATRC leadership. Finally, he developed a set of specific technology recommendations for TATRC to pursue. In many cases, TATRC staff and TATRC collaborators were critical and indeed essential in assisting to define and shape the substance that lead to these recommendations. Although these specific technology recommendations were developed iteratively with TATRC leadership, they represent Dr. Schimpff’s conclusions and recommendations and should not be construed as having TATRC leadership “approval” or its “imprimatur.” Indeed, it is hoped that these recommendations and proposals will inspire substantial discussion, debate and deliberations within TATRC and among its partners and collaborators as to the most useful avenues and directions for advancing the “Hospital of the Future” agenda.

Executive Summary

In the coming five to fifteen years we can expect that medicine will change dramatically such that it will become custom-tailored [also known as “personalized medicine”]; there will be greater emphasis on prevention; medicine’s ability to repair, restore or replace organs, tissues and cells will markedly advance; medical information will finally become fully digitized with instant access, anytime and anyplace; healthcare quality and safety will improve dramatically; and, in a all likelihood, there will be realistic attempts to address the rapidly rising costs of medical care.

These changes are being driven by advances in biomedical research such as the advent of the genomics era with targeted drugs, drug prescribing with assured efficacy and safety, disease prediction and disease prognostication and improved diagnostics; the developing understanding of stem cells; the improved understanding of immunology that is leading to the creation of vaccines for both infections and chronic diseases such as atherosclerosis and Alzheimer’s and to methods for improved transplantation including xenotransplantation; and the advances arising from the pharmaceutical and biotechnology industries with new drugs.

Less appreciated are the advances in medicine that derive from engineering and computer science. These include vastly improved anatomic imaging and the beginnings of functional or molecular imaging; medical devices such as pacemakers, stents, bioengineered tissues and nanotechnology devices; improvements in the operating room such as new instruments but also the advent of simulation for training, practice and certification, the use of robots for surgery and surgical assistance, and new approaches such as natural orifice surgery. Engineering and computer science are also driving the push to having all medical data digitized which will lead to an effective electronic medical record with its ability to improve handoffs, assure safety and improve quality, and later to lead from information manipulation to knowledge development with data mining, alerts and prompts, and on demand real time education. Digital medical information will also allow distance medicine to become effective and commonplace; for each person to have and to control their own medical data and will provide the basis for designing simulation of cognitive function in medical education.

There will be a very large growth in demand for medical services, driven, at least, by a growth in the population, an aging of the population and a shift from acute to chronic diseases as those most prevalent. Consumerism is beginning to have an impact that will spread rapidly and increase exponentially with resultant patient expectations changing.

The costs of medical care are high and rising and ultimately this will lead to efforts to reign in the rate of rise.

Despite the drivers of change and the strength of effort behind those drivers, there are at least as many barriers to prevent change, slow change or modify it. Many are financial barriers. Health care financing is fragmented at best and pays for care in a manner that does not encourage primary care, preventive care, care management, disease management or team-based care. Nor does it pay for eMedicine such as email, distance medicine or other virtual means of patient care that can in fact reduce costs and improve quality of care. Other barriers are professional shortages and changed professional work expectations. There is currently a shortage of nurses and pharmacists and soon will be a shortage of physicians overall, especially in rural and urban poor areas. A lack of important standards inhibits advances – interoperability is needed for the interaction of devices such as monitors in the intensive care unit [ICU], equipment in the operating room [OR] and among various electronic medical record products.

America spends more per capita than any other country for health care, yet does not have the best health status, by a wide margin. Medicine focuses on “disease and pestilence,” not health. There is little emphasis on prevention and health maintenance – and no incentives to do so. American medical care is very expensive without achieving peer standards. Unhealthy life styles are rampant and are leading to ever more illness. And despite the national political debate, “healthcare reform” does not address health – rather it addresses medical care financing.

Hospitalized patients will be different from today. They will be more in number, older and sicker with complex, chronic diseases. Access to capital is severely constricted today because technology and facility costs have escalated dramatically and will continue to do so. The current credit market situation is a further barrier by limiting the hospital’s borrowing capacity. This means that a smaller hospital is severely limited in opportunities to grow and develop new programs, to build or renovate and to purchase technology. This will lead to a major wave of hospital consolidations to achieve access to capital markets. Levels of care in the hospital will intensify and there will be a consolidation of advanced care into tertiary centers. Hospital care will increasingly utilize technologies and hospitalists will do most inpatient care, yet, more and more care will be performed at less intense sites, including home.

Hospital beds will increase in number, intensity and format. More hospital beds will be constructed to serve the added needs of an aging, growing population with complex, chronic diseases. There will be multiple approaches to connect specialists & technology. The eICU [electronic ICU] will become commonplace with the specialist present physically some of the time and virtually all of the time to both improve care and reduce costs. More rehabilitation hospitals may be constructed, especially as part of hospital systems. More sub acute units of general hospitals may be developed, if reimbursement systems so encourage, to give more appropriate care while reducing costs of care. Palliative care and hospice care will become ever more prevalent

and home care after hospitalization will take on a greater role. Unfortunately, the reimbursement system hampers optimum use of these modalities with their potential to not only improve care but to reduce the costs of care.

It is unfortunately unclear whether there will be government support for an integrated and enhanced system of public health to match the ongoing advances in medical care. Likewise it is unclear at present whether or to what degree the patient or the family will become empowered for self care using developing technology.

Professional shortages will lead to the use of nurse practitioners, physician assistants, optometrists, psychologists, and social workers for high prevalence conditions; as adjunct caregivers in highly complex cases, e.g., cancer; and for chronic care disease management. New forms of professionals will emerge to fill the growing primary care physician gap such as the doctorate of nurse practitioner. Meanwhile, physician professional expectations will lead to large group practices or hospital employment with less call, more flexible hours, malpractice coverage and little or no management duties. There will be more employed physicians, especially hospitalists and intensivists and there will be more specialists on hospital employed staffs for critical service needs [e.g., neurosurgery, orthopedics]. These changes will mean a need for more physician leaders at all levels to assure better interaction and relationships with medical staff.

Two classes of medical care exist today and will tomorrow; universal coverage will not eliminate the two classes of care because there will be inadequate numbers of primary care providers, especially in rural and urban poor areas. Further, the pressures of low pay for cognitive care by internists and family practitioners will lead to other forms of physician compensation such as “concierge” medicine where the patient pays an upfront fee to the doctor for the privilege of immediate access, extended visit times and the physician in turn limits his or her practice to many fewer patients.

Off shore hospitals will increasingly compete for the tertiary care needs of patients. Insurers increasingly will send patients, paying for transport, housing, food for self and significant other with no deductibles or co pays whenever the off shore hospital can provide the care for less yet with high quality service and outcomes. Consider this as just one more type of professional outsourcing in a global marketplace to countries where costs are lower.

Given the rise of consumerism and the shift from acute care to complex, chronic disease management, medicine will shift from its current discipline-oriented approach of care to a disease-orientation with care by multi-disciplinary teams. This will drive the development of centers for cancer, cardiac, diabetes care and others and a reduced emphasis on current organizational models of departments of, for example, medicine and surgery or their divisions of cardiology and cardiac surgery or medical

oncology and surgical oncology. A related phenomenon will be the development of regional echelons of care especially for acute, emergent conditions such as trauma, acute myocardial infarction [AMI] and stroke. This will be a major change for the average general hospital with care being diverted instead to the nearest certified center that, for example, is capable of immediate coronary artery computerized tomography [CT] scanning, angioplasty and stent placement for AMI.

All medical information will be digitized – once the two key barriers [interoperability and effective physician documentation] are overcome. All data will be in a digital format; the patient will “own” their data and control its access which will be easily accessed, transmitted, and secure. The electronic medical record [EMR] will be designed around physician work flow so that it will enhance productivity. ePrescriptions and drug order entry with alerts and knowledge built into the algorithms will become the norm. These advances will have a fundamental impact on medical care, care quality and safety, costs, and will open opportunities for effective research with data mining.

A major shift is occurring in how medicine advances with more and more related to advances in engineering and computer science. Basic science is and still will be critically important but technology advances will take its place as an equal. With the rapidly rising cost of healthcare, technology, when properly deployed, although usually a major driver of increasing costs, will instead serve as a means to reduce the rising costs of health care by reducing workload, improving productivity, accounting for the shortage of professionals, and making hospital care more affordable. This is one of the critical challenges for developers, manufacturers and end users of technologies.

Technology demands highly trained staff which, in turn, implies the need for more, not less, professionals. However innovative uses of technology could reduce staff workload in specific circumstances.

Some key technologies that will have a major impact on the Hospital of the Future are: imaging, including anatomic and functional imaging plus interventional radiology; major advances in the operating room including telemedicine, telesurgery, telemanipulation, simulation and robotics; the creation of medical devices which are increasingly smaller, more effective, and long lasting; the eventual emergence of the electronic medical record; ubiquitous identification devices using RFID and other technologies, and routine use of distance medicine.

Simulation technology will fundamentally alter the approach to training, practice and certification of procedural based skills by decreasing training time, increasing competency, measuring decision-making skills and measuring technical expertise. Robotics will offer a major opportunity to improve medical procedures and to improve effectiveness and efficiency of many

hospital functions. Not only will there be robotic surgery and a robotic scrub nurse but also robotic distance consults with the patient – e.g., “Robodoc,” along with pharmacy robots, supply chain robots and central sterile supply robots. Identification devices will allow for the immediate appreciation of where a device, a pill, a patient or a surgeon is located at any given time and over time, dramatically improving supply chain, pharmacy controls, OR effectiveness, and patient safety.

Although technology will be critical to the Hospital of the Future, so too will advances in biomedical research. Genomics, stem cells, immunology, and pharmaceutical advances will be critical to disease prediction, disease prognosticating, targeted drug development, and rapid diagnosis along with new approaches to cell, tissue and organ repair, restoration and replacement. The new “blood bank” will be the hospital farm where animals are raised for xenotransplantation and stem cells are prepared for cellular replacement as in diabetes and for biotissue creation of dialysis devices or bladder replacements.

Trustees of hospitals will need to become much more accountable and hence more knowledgeable. They will have to shift their focus from solely finances to that of safety, quality and responsiveness. Cost effective care will be paramount. “First Do No Harm” will affect choices on construction, technology, hospital organization, and staffing and hospital leaders will need to demonstrate both quality and improved safety.

To summarize, the result of all of these advances will be 1] custom-tailored medicine, 2] a much greater focus on prevention, 3] vastly improved ability to repair, restore or replace organs and tissues, 4] readily accessible and manageable medical information leading to new knowledge and 5] much improved quality and safety.

What are the implications of these changes in medicine and the “Hospital of the Future” for TATRC?

Technologies will become ever more important in medicine and the “Hospital of the Future”, both military and civilian, and for both acute medical care and care of complex, chronic diseases. Not only will new technologies advance medicine but if

used properly they will improve quality and safety and function to lower the cost of care. Further, technologies can potentially offset the coming shortage of professionals.

Technology development is the heart of TATRC activities, both internally and especially via its partners and collaborators. TATRC's vision is to *"be the model of government enablement of technology transfer to use"* and its mission is to "execute a congressional special interest program of medical science and engineering technology research that maximizes benefits to military medicine." TATRC's vision for the Hospital of the Future is to *"be a dominant agent of change to transform health care to a safe, cost effective, predictive, preventative, evidence based, and participatory system."*

Given the overall TATRC vision and mission and the TATRC Hospital of the Future vision, TATRC is well positioned to lead the nation in the development, acceptance and eventual mainstream use of, at least, the following technologies:

- Simulation
- Distance Medicine
- Digital Medical Information/ Informatics
- Operating Room of the Future
- Technologies to Enhance Safety and Quality
- Robotics
- Identification Devices [radio frequency identification device or RFID, Bar Coding, Other]

Each of these technologies fit the TATRC Hospital of the Future vision; they can be instrumental in advancing safer medicine, more cost effective medicine, developing a more preventive approach to medicine, aiding the advance of evidence-based medicine and making medicine more participatory such as the evolution to a disease-based care system that focuses on the emerging problems of complex, chronic illness in an ever growing, older population.

Moreover, each represents a disruptive rather than just an evolutionary improvement in medical care and hence can have a unique, lasting and substantive impact on American and world-wide healthcare.

Further TATRC is exceedingly well positioned to ensure that the critical needs for interoperability of medical devices and the electronic medical record will be accomplished. Guiding and ensuring that this occurs will lead to major changes and improvements in technology usage, representing a truly *fundamental improvement in medical care for all*. Indeed, interoperability can be an extremely substantive element of TATRC's legacy over the next few years.

In addition, TATRC is the ideal organization to drive the development of hospital-based, multi-institutional organizations to maximize the intersection of medical care with engineering and computer science, ala CIMIT in Boston as the mature model.

Medicine is and will continue to change rapidly. Technology will be every more critical in the "Hospital of the Future" and in medicine overall. TATRC needs to focus on which technologies will be of *greatest value* and leverage its efforts in those areas. TATRC needs to be cognizant of certain *critical issues in the use of technology* to advance medical care in the future setting of cost constraints, professional shortages, need for quality and safety, responsiveness to patients while recognizing the developing shift from mostly episodic acute illness care to long term care of complex, chronic diseases and, with it, the need for disease-oriented, team-based care management. Technology, used strategically, can enhance productivity, enhance responsiveness to patients, assist in controlling cost, improve safety and quality, enhance access to distant patients, and improve care of complex, chronic illness.

Given attention to these directions in medical care and the critical issues surrounding provision of that care, TATRC should marshal its resources to accomplish the greatest good given the people and funding available. This will require strategic planning, critical choices and commitment from leadership and staff.

REPORT

1] The Megatrends in Healthcare –

Over the coming five to fifteen years, there are six megatrends that will almost certainly develop as a result of forces underway at this time.

- Customized Tailored Medicine [Personalized Medicine]
- Greater Emphasis on Prevention
- Marked Advancement in Repair, Restoration and Replacement of Organs, Tissues, Cells
- Fully Digitized Medical Information with Instant Access, Anytime, Anyplace
- Safety and Quality Profoundly Improved
- Initial Steps to Realistically Address Rapidly Rising Costs

These megatrends can be expected to *fundamentally* alter our approach to medical care as we know it today.

With the exception of addressing rising costs, the current national debate related to “Healthcare Reform” will neither accelerate nor slow the development of these megatrends.

2] Driving Forces to Achieve Megatrends in Medicine

There are major forces that are driving these megatrends to fruition.

Biomedical Research Advances – The incredible output of the basic sciences, largely driven by the National Institutes of Health, the pharmaceutical industry and the biotechnology industry will have a major impact on the development of the megatrends. Among the key drivers are advances in the following areas

- Genomics – A truly new era revolutionizing medicine
 - Pharmacogenomics –
 - Creating targeted therapies
 - Allowing prescriptions that will be effective and safe – predicting individual's response
 - Disease prediction [e.g., cardiac, diabetes, cancer, autoimmune] years in advance
 - Disease prognostication [e.g., will cancer recur?]
 - Fast, reliable diagnostics from minimal samples
 - Major driver of custom-tailored [personalized] medicine
- Stem Cells – Much still to be learned means that advances here are still a promise for the future
- Immunology – Advances here are allowing new approaches for
 - Vaccines [infections and soon for chronic conditions such as atherosclerosis and Alzheimer's]
 - Transplantation [including Xenotransplantation]
- Pharmaceuticals – Major advances continue to come forth, with assistance from genomics, proteomics
- Diagnostics – New technologies, many related to genomics

Driving Forces to Achieve Megatrends in Medicine [Continued]

Engineering and Computer Science Advances – Largely unheralded, advances here are having a profound impact on the medicine of the future.

- Imaging –
 - o Exquisite anatomic images
 - o Molecular function converted to images
 - o Imaging techniques used to allow less invasive interventions
 - o All images digitized.
- Medical Devices –
 - o Engineering and computer advances allowing for smaller, more powerful, more useful devices
 - o Science of nanotechnology advancing
- OR Advances –
 - o Surgery unnecessary for many conditions in future
 - o Many procedures can be done outside OR [e.g., interventional radiology]
 - o OR technologies make OR more functional [e.g., situational awareness, OR management]
 - o Room with a New View – Electronic medical record, simulation, robotics, less invasive surgery, image guided surgery, natural orifice surgery, telesurgery
- Digitized Medical Information –
 - o Electronic Medical Record Will Mean Instant Access Anytime, Anyplace
 - o Improve Quality and Safety Of Care
 - o Distance Medicine Will Become Routine
 - o Personal Access to Your Own Data
 - o Cognitive Simulation to Improve Clinical Judgment
 - o Data Mining to Improve The Public's Health

Driving Forces to Achieve Megatrends in Medicine [Continued]

There will be a very large growth in demand for medical services, driven, at least, by

- Increasing and Aging Population – “Old parts wear out”
- Shift From Acute to Chronic Diseases – Require More Care Over Longer term
- Chronic Diseases That are Life Long and Complex [Diabetes, Heart Failure, Chronic Lung Disease]
- Effective Medical Care Drives More Patients to Expect More Care

Consumerism is beginning to have an impact that will spread rapidly and increase exponentially with resultant patient expectations changing. No longer will patient be willing to be “patient.”

- Expectation for Safety, Quality
- Expectation for Convenience, Service, Responsiveness, Respect
- Expectation for Prompt, Effective Communication

A dissatisfied patient will be quick in the future to seek care elsewhere. No longer “wedded” to same provider[s] or institution[s]

Driving Forces to Achieve Megatrends in Medicine [Continued]

The Costs of Medical Care Are High and Rising and Will Need to be Constrained. Current medical care in USA accounts for 16% of the gross domestic product. Costs have been rising about 10% per year, well above general inflation. No indication that this inflationary process will slacken. The pressures from business [major payers of health insurance], individuals [now expected to participate in major way in cost of care] and the government [Medicare, Medicaid, DoD and Veterans Administration] will drive attempts to reign in costs. Expect efforts to direct

- Increases in Productivity
- Less Costly Procedures or Reduced Total Cost of Care
- More Rapid Diagnosis and Treatment
- Improved Prevention to Reduce Overall Need for Medical Care

But unfortunately, the basic approach of payers to reduce costs is to simply cut payments [for procedure, visit] or ration care [e.g., denied days, day limits, and various restrictions.]

- Hospitals and physicians ill equipped alone to respond effectively
- Need new approaches to care management in order to have effective cost management

Government, Insurers and Regulators [e.g. JCAHO] Will Mandate Change on Multiple Fronts

- Quality and Safety
 - Pay for Performance & Other Mechanisms to Drive Change
- Will Place Greater Responsibility on Hospital Trustees
 - New Focus on Safety and Quality – From State and Federal Government, JCAHO
 - Increased Attentiveness To Consumerism
 - Maintenance of Not For Profit Status – IRS Will Evaluate Hospital's Charity Care Activities
 - Addressing Increasingly Difficult Financial Circumstances

3] Barriers to Implementation of Medical Megatrends

Despite the drivers of change and the strength of effort behind those drivers, there are at least as many barriers to prevent change, slow change or modify it.

Many Are Financial Barriers – These Will Be Important in Slowing the Pace of Advances

Health care financing is fragmented at best and pays for care in a manner that does not encourage primary care, preventive care, care management, disease management or team-based care. Nor does it pay for eMedicine such as email, distance medicine or other virtual means of patient care that can in fact reduce costs and improve quality of care. Current financing systems:

- Pays for Procedures and Visits but Inadequately for Cognitive Encounters
- Underpays Primary Care Providers; Encourages SOM Graduates to Seek Careers as Specialists
- Little/No Pay for Preventive Care, Genetic Counseling, Other approaches that reduce costs long term
- Government Pays Less Than Full Share - Leads to Cost Shifting and Increases for all others

Rising costs of medical care [16% GDP, 10% Inflation per Year] making insurance coverage simply too expensive for many, if not most, businesses and the government payers. The result

- Businesses Pay Less As A Percentage Of Insurance Costs
 - Patients/ Individuals Expected To Accept Greater And Greater Costs
- Many Businesses, Especially Those In The Service Industry, Opt Not To Offer Health Insurance
 - Many Individuals Opt To Be Uninsured Or Underinsured
- Federal Government Pays Less Than Its Fair Share Of Costs via Medicare and Medicaid
 - Leads To Cost Shifting By Hospitals And Physicians driving up costs to all others

High Costs Impede Implementation of many desirable technology advances

- Costs of Technology High and Rising -
- Access to Capital Shrinking [Forcing Hospital Consolidations]

Barriers to Implementation of Medical Megatrends [Continued]

Professional Shortages and Changed Professional Work Expectations Will Have a Marked Impact on Medical Practice into the Future

- There is a physician shortage in the USA today yet the need for physicians is increasing. This shortage will grow rapidly since there has been no substantive growth in numbers of medical school graduates in the past few decades.
- Physician Shortages in Primary Care Will Rapidly Compound
 - Generalists Underpaid by Payers
 - Large Debts Encourage Selection of Specialty Care
- Physician Shortages in Urban Poor and Rural Areas Will Grow
 - Same Drivers As Above
- Surveys of Physicians in Training Indicate That Upon Completion They Will Opt For
 - Employed Status , Including Malpractice Coverage
 - Reduced Work Schedules
 - ER Call Only If With Pay
 - No/ Little Administrative Duties [Office Management, etc]
- Fifty Percent Of Graduates Are Women. In Addition to Above, Women Physicians
 - Will Want Time for Raising Family, Effectively Reducing Workforce Numbers

Barriers to Implementation of Medical Megatrends [Continued]

Professional shortages and changed professional work expectations will have a marked impact on medical practice into the future

- Nurse Shortages Growing Despite Pay Increases
 - Work Expectations Changing
 - Work Content Changing
- Pharmacist Shortages Growing
 - Compounded by Switch from MS to PharmD Degree

Barriers to Implementation of Medical Megatrends [Continued]

Lack of Standards Hinders Preferred Advances in Medical Care

- Interoperability of Equipment, Instruments and Information Technology – So that all Can Use equipment and Devices Interchangeably and Connect the Data from Each to Each Other.
- For Packaging Medications to Reduce Errors

Culture of Blame and Autonomy Impede Progress in Safety and Quality

- Need an institutional commitment from the Board and CEO along with resources of people, time and dollars
- Need a non punitive attitude toward medical errors
- Need an openness to communicate about errors
- Need error and near miss data collection with root cause analysis and to a systems approach to change.

A Malpractice System That Does Not Improve Care But Costs Far Too Much–

Today's system is a disaster and does everything wrong.

- It encourages secrecy
- It slows the payment
- It discourages apology
- It does nothing to prevent the same error from occurring in the future
- In short, it is the opposite of what is needed to reduce harm and promptly support and compensate the patient who was harmed.

4] Over Arching Perspectives

America spends more per capita than any other country for health care, yet we do not have the best health status, by a wide margin. What do we have?

- America Has a Sick-care System, Not a Healthcare System
 - Medicine Focuses on “Disease and Pestilence”, not Health
- Little Emphasis on Prevention and Health Maintenance – No Incentives To Do So
 - No Incentives for Physicians
 - No Incentives for Population
- American Medical Care Is Very Expensive Without Achieving Peer Standards
 - E.g., Infant Mortality Lags Many Countries That Spend Less Per Capita
- The Medical “Industry” Is Strongly Protective of Its Financial Well Being
- Professionalism Is Eroding
- Aging Population Means That More Illness Will Be Encountered In The Future
- Unhealthy Life Styles Rampant And Leading to More Illness
 - Obesity, Lack of Exercise, Poor Nutrition, Over Stressed
 - Tobacco Usage, Alcohol and Driving, Lack of Seat Belts
 - Vaccines not Obtained by Many – Children and Adults
 - Basic Screening Not Obtained – Blood Pressure, Cholesterol, Cancer
- Science Is Addressing Illness but Not Health
 - NIH focuses on Disease Mechanisms
- The Public Health System Is In Disrepair
 - Funding for Public Health is Limited at Best
- “Healthcare Reform” Does Not Address Health – Rather It Addresses Medical Care Financing
- Change Tends to Be Incremental In American Medicine
 - Do Not Anticipate Radical Change
 - Absent Crisis That Forces Change
 - Absent Major Shift In Political Will Power

5] Major Trends Into the Future – The Hospital of the Future Overview

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years in the development of the “Hospital of the Future?”

Hospitalized Patients Will Be Different From Today

- Older – the population is aging
- Sicker – with multiple chronic conditions which require ongoing complex care
- More in Number – The population is growing and shifting toward older age

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Hospital Systems Will Grow

Access to capital severely constricted today because technology and facility costs have escalated dramatically and will continue to do so. This means that smaller hospital is severely limited in opportunities to grow and develop new programs, build or renovate and purchase technology. This will lead to

- Major Wave of Hospital Consolidations Will Occur to Achieve Access to Capital Markets
 - Access To Dollars for Construction
 - Access To Dollars for Technology
- Specialty Hospitals Will Be Significantly Affected
 - Expect To See Persistence Of Children's, Cancer, And Psychiatric Hospitals
 - But Not Physician-Owned Cardiac And Similar, Largely Because Government Will Limit Development
- Capital Restrictions, In The Absence Of Hospital Mergers, Might Lead To The Development Of Cooperative Ventures Among Hospitals Or Current Hospital Systems In A Defined Geographic Area.
 - Rehabilitation,
 - Home Care,
 - Hospice Care,
 - Purchasing, Human Resources and Other Functions Related to Staffing
- Ideally Will Have Cooperatives for
 - Emergency Medical Care [Trauma, Stroke, Heart Attack] with Transport to Nearest Most Appropriate Hospital Specialty Center

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Levels of Care Will Intensify

- Expect Consolidation of Advanced Care Into Tertiary Centers
 - Higher and Higher Intensity Means Not Practical in Smaller Hospitals with Limited Means
- Hospital Care Will Increasingly Utilize Technologies
- Hospitalists Will Do Most Inpatient Care
- Yet, More and More Care Performed At Less Intense Sites Including Home

Hospital Beds Will Increase in Number, Intensity and Format

- More Hospital Beds Will Be Constructed To Serve Added Needs of Aging, Growing Population with Complex Chronic Diseases
- Anticipate Multiple Approaches to “Marry” Specialists & Technology
- eICU Commonplace
 - Specialist Present
 - Physically Some of The time
 - Virtually All of The Time
 - Will
 - Improve Care
 - Reduce Costs
 - Reduce Staffing Needs

Major Trends Into The Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Rehabilitation, Sub Acute Care, Home Health, Hospice Care Will Expand

- More Rehabilitation Hospitals may be constructed, especially as part of hospital systems
 - Best Rehabilitation Care is given When Rehab is Done in a Separate Hospital
 - One Rehab Hospital Can Service Large Region/ Many General Hospitals
- More Sub Acute Units of General Hospitals may be Developed
 - Subacute Works Well Inside of a General Hospital
 - Allows Early Discharge of Patient From More Expensive General Hospital Acute Bed
 - Requires Change In Current Reimbursement Patterns to make Financially Feasible
- Enhanced Home Health Care
 - Requires Better Reimbursement
- More Hospice – Institutional and Home
 - Logical But Will Payers Accept?

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Professional Issues – Significant Shortage of Physicians

- Professional Shortages Will Lead to the Use of NPs, PAs, Optometrists, Psychologists, Social Workers, Others
 - Use For High Prevalence Conditions Especially Where Physicians in Short Supply
 - Use As Adjunct Caregivers in Highly Complex Cases, e.g., Cancer
 - Use In Chronic Care Disease Management
- New Forms of Generalists will Emerge
 - Doctorate of Nurse Practitioner as example – Developing at Some Nursing Schools
- Physician Professional Expectations Will Lead to Large Group Practices or Hospital Employment
 - Work Ethic Has Changed
 - Want Setting Where Office “Management” Not An Issue
 - Less Call; Flexible Hours; Reduced Hours
 - Other QOL Issues
 - Want Malpractice Covered
 - BUT – Retention Will Be An Issue – Physicians Will Be Consumer Driven [As Well As Patients] and Will Move to Other Group or Hospital Readily [Limited Loyalty]

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Professional Issues – Shortage of Other Healthcare Providers

- **Nurses**
 - Serious Shortage Exists Now and Will Only Exacerbate Over Time
 - Salaries Are Up But Satisfaction is Down
 - Quality of Life Expectations Are Paramount
 - Nurses Feel Overburdened With Mandates and Documentation

- **Pharmacists**
 - Serious Shortage Exists Now and Will Only Exacerbate Over Time
 - Switch to PharmD Degree From Master's Degree Leads to Different Professional Expectations

- **Social Workers**
 - 50 Percent of the Burden of Disease Can Be “Directly Connected To Behavioral, Social, and Environmental Issues, Which Have Grown in Importance”
 - Complex Chronic Conditions Lead to Need for Many More Social Workers
 - Social Workers Critical to Health Education
 - Mental Health Issues on The Rise – Benefit From Social Work Interventions

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Payment Issues

- Two Classes of Medical Care Exist Today and Will Tomorrow
 - Universal Coverage Will Not Eliminate Two Classes Of Care
 - Unless healthcare providers are available, universal coverage is moot
 - Inadequate Numbers of Providers in Rural and Inner City Areas
 - Generalists underpaid so will not work in those settings where payment is even less
- Development of Concierge Medicine
 - Physicians Limit Practice Numbers, Offer Immediate Access and Longer Visits in Return for
 - Annual Payment of Fee Directly by Patient.
- Off Shore Hospitals Compete for Tertiary Care – Insurers increasingly will send patients, paying for transport, housing, food for self and significant other with no deductibles or co pays – because it is cheaper yet with high quality service and outcomes
 - Cheaper To Go Off Shore Than To Get Major Care At Home
 - Same or Better Outcomes and Quality
 - Service Issues – Substantially Better
 - Off Shore Physicians often trained in USA and Often Board Certified in USA
 - Will have Continued Success Unless USA Costs Decline
 - Not Unlike Other “Outsourcing” of Professional Activities

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Physician Organization in the Hospital

- Medical Staff Organizations
 - Expect More Employed Physicians, especially
 - Hospitalists
 - Intensivists
 - Expect More Specialists On Employed Staff for Critical Service Needs [e.g., Neurosurgery, Orthopedics]
- Anticipate More Physician Leaders At All Levels To Assure Better Interaction and Relationships with Medical Staff
- Possibly See More Physician CEOs of Hospitals

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Disease vs. Discipline – For over 100 years, medicine has organized itself based on the physician's discipline training such as Medicine and Surgery, or their subspecialties of cardiology and cardiac surgery. But the patient who needs care from multiple specialists from multiple disciplines is not interested in the old organization; he or she wants to know that the physicians are working as a team for the patient's immediate benefit. As more and more disease is chronic and requires many physicians for its treatment, then the patient wants a team approach, wants a single unified plan of care and is not interested in the physician's or the institution's organization around disciples. This is a fundamental shift and will need to be addressed. Once it is the result will be:

Medicine Will Be Disease Oriented with Care by Multi-Disciplinary Teams

- Concept of Multidisciplinary Disease-Oriented Team Approach to Care
 - o All Involved See Patient Together Initially
 - o Render Single, Unified Plan of Care
 - o Work Together on Executing Plan of Care
- Four Themes Drive Disease/ Team Approach
 - o Increased Complexity of Care Will Demand a Disease/Team Approach
 - o Technology Escalation Means Team Must Work Together to Maximize Technology Value
 - o Diffusion of Technology Into Community by Vendors Will Encourage Formation of Team-Based Care
 - o Ultimately, Patients Will Expect It and Demand It
- Research Funding Will Also Be Increasingly Disease, Not Discipline, Based
 - o Traditional Departments – Phased Out
 - o Departmental Chairs – Phased Out
- Centers of Cardiac, Cancer, Stroke, Trauma Will Become Predominant
 - o Research Funding Helps Drive This Conversion
 - o Payment Mechanisms Currently Impede Development

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Disease vs. Discipline -

- Regional Echelons of Care
 - Trauma Good Example – Best systems in USA have an integrated EMS, transport and Care Arrangement To Get Patient to Most Appropriate Level of Trauma Care in Shortest Possible Timeframe
 - Requires statewide agreements and regional or national accreditation to function properly
 - Acute Myocardial Infarction – With new approaches to care [Rapid diagnosis, angioplasty, stent placement] comes need for rapid transport of patient to regional center for high level care. Major change to current approach of taking patient with suspected AMI to nearest emergency room.
 - Requires statewide agreements and regional or national accreditation to function properly
 - Psychiatry – Most community hospitals are not well equipped to deal with major psychiatric problems. Some contract out to major psychiatric hospitals to provide needed ER coverage, local inpatient care and referral as needed.
 - [Will Need Statewide Bodies To Credential Centers for Stroke, AMI, Trauma]

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Digitized Medical Information – Once the *two key barriers* [standardization and physician documentation] are eventually overcome:

- All Data Will Be in Digital Format
- Patient Will “Own” Their Data and Control Its Access
- Data Will Be Easily Accessed, Transmitted, Secure
- EMR Will Be Designed Around Physician Work Flow – Implies That It Will Enhance Productivity , Not Impede It
- ePrescriptions and Computer Physician Order Entry [CPOE] Will Be The Norm

This will have a fundamental impact on medical care, care quality and safety, costs, and opportunities for effective research with data mining

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Digitized Medical Information – Will allow for other important opportunities not possible without digitized information

- Automated Image Analysis – Send Image to Best Reviewer at Best Center
 - Mammogram or Other Diagnostic Image
 - Pathology Specimen
- Hospitals Will Develop Incentives To Share Information
 - So That Discharge From One Hospital And Admission To Another Will Be Seamless
- Surviving Hospital/ Healthcare Systems Will Be Those That Work With Data/Info In New Ways
- Artificial Intelligence Will Come to the Fore
 - Effectively Acquire Information
 - Effectively Interpret for Use In Diagnosis and Treatment
 - Drive Cognitive Simulation Systems For Teaching, Certifying And Continuing Education
- Artificial Intelligence Will Assist in
 - History and Physical Examination
 - Imaging Selection via algorithms
 - Test Selection via algorithms

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

Given the status of American healthcare today, the anticipated megatrends in medical care, the drivers of change, the overarching perspectives and the barriers to achieving changes that will enable these megatrends, what then can we expect to occur over the next five to fifteen years?

Technology Will Be a Major Factor in the Hospital of the Future

- Major Shift is Occurring in How Medicine Advances
 - More and More Related to Advances in Engineering and Computer Science
 - Basic Science Still Important but Technology Will Take its Place as an Equal
- Technology – [a major driver of increasing costs]- May Serve as a Means to Reduce the Rising Costs of Health Care
 - Reduce Workload
 - Improve Productivity
 - Account for the Shortage of Professionals
 - Make Hospital Care more Affordable [But Not Cheap]
- Technology Drives Staffing Issues
 - Demands Highly Trained Staff
 - Implies Need for More, Not Less, Professionals
 - But Can Reduce Staff Workload in Some Circumstances
 - Adage – Technology Only as Good as the Workforce to Operate It
- Some Key Technology Areas
 - Imaging
 - Anatomic and Functional Imaging
 - Interventional Radiology
 - Operating Room
 - Telemedicine, Telesurgery, Telemanipulation
 - Simulation
 - Robotics

Major Trends Into the Future – The Hospital of the Future Overview [Continued]

- o Medical Devices
 - Smaller, More Effective, Long Lasting
- o Radiation Oncology
 - Has Become Technology Intense
- o Electronic Medical Record
- o Distance Medicine
- Simulation Technology Will Fundamentally Alter the Approach to Training, Practice and Certification of Procedural Based Skills
 - o Decrease Training time
 - Increase Competency
 - o Measure Decision- Making Skills
 - o Measure Technical Expertise
 - o Measure Team-based Skills of Team Members Working Together
- Robotics Offer Major Opportunity to Improve Medical Procedures and Improve Effectiveness and Efficiency
 - o Robotic Surgery
 - o Robotic Scrub Nurse
 - o Robotic Distance Consult with Patient – e.g., “Robodoc”
 - o Pharmacy Robots
 - o Pill Selection, Infusion Preparation, Unit Delivery From Pharmacy
 - o Supply Chain Robots
 - o Central Sterile Supply Robots
- Identification Devices [RFID, Others]
 - o Locator of patient, staff, instrument, device, equipment and medications
 - o Improved supply chain
 - o Enhanced safety and quality
 - o Cost reductions

- Increased Emphasis on Technology Advances
 - Suggests the Need for National Impartial Technology Assessment and Evaluation Organizations
 - Ala Consumer Reports
 - Only Current Organization is ECRI
 - Recommends the Creation of Hospital-based Technology Assessment and Development Institutes
 - Ala CIMIT
 - “Bringing together those from a problem-rich environment with those from a solution-rich environment”
- Consumerism, Complex Chronic Diseases and Technology Availability Together Will Drive Physicians to
 - Use Technology for Information Access and Information Communication with Patients
 - Emails
 - Telemedicine with Patients at Home
 - Home Diagnostic Devices Connected with Communication Devices [e.g., Glucose, Weight or BP Monitoring at Home]
 - More
 - Hospitalists for Inpatient Care
 - Intensivists for ICU Care
 - While Using
 - Technology to Aid Effectiveness
 - eICU

6] Hospital of the Future – Summary of the Megatrends

Considering all of the research reviewed above, the following represent a summation of the key megatrends that will affect the “Hospital of the Future:

- There Will Be Major Attempts to Ensure That Medical Costs Rise More Slowly
 - Due to Government Mandates
 - Due to Insurer Requirements
 - Due to Consumer Requirements
- There Will Be a Shift from Treating Acute Illness to More Complex, Chronic Illness
 - Diabetes, Heart Failure, Cancer, Autoimmune Diseases, etc
- Care Patterns Will Transform from Discipline-Based To Disease-Based
 - Disease and Care Management Will Become Commonplace
 - Centers Will Develop for Care of Complex, Chronic Diseases [ala Cancer Centers]
 - More Use of Rehab Hospitals, Subacute Units, Home Care & Hospice Will Occur
- Medical Care of Chronic Illness Will Demand More Use of Advanced Technologies
- Hospitals Will Need to Upgrade Facilities and Technologies
 - ICUs, ORs, Procedure and Diagnostic Suites, Laboratories, IT and EHRs
- Wave of Hospital Mergers Will Occur to Gain Access to Capital Markets
- Echelons of Care Will Develop With Care Concentrated In Specialized Hospital Units
 - Complex Care Will Be Delivered At Selected Tertiary Centers
 - Community Hospitals Will Initiate Triaging and Transport of patients with critical illnesses [AMI, trauma, stroke]to Specialized Care Centers
- Distance Medicine Will Allow Virtual Presence of Specialist in eICU, OR, & Consults
- Technology Advances Must Lead to
 - Improved Quality and Safety
 - Increased Professional Productivity, and hence
 - Reduced Expenditures, yet
 - Need For More Professional Training and Experience
- Medical Data Will Be Digital and Accessible
 - EHRs Will Become Ubiquitous

- o Patient Will “Own” and Control Record
 - o Data Mining Will Become Routine
- Professional Shortages Will Accelerate and Life Style Requirements Are Changing, Leading To
 - o Inadequate Numbers of PCPs Especially In Rural and Urban Poor Areas
 - o Need For More Adjunct Providers – NPs, PAs, Pharmacists, MSWs, Others
 - o Hospitals Will Employ/Contract for Intensivists, Hospitalists, & Specialists
 - o Most MDs Will Be Employed Rather In Solo or Small Group Practice
- Consumerism Will Become a Major Force and It Will Drive
 - o Enhanced Quality and Safety
 - o Major Cost Control Efforts
 - o Enhanced Responsiveness and Professionalism From Caregivers
 - o Development of Patient-Centric Care
 - o Development of eMedicine [email, ePrescriptions, Telemedicine, TeleDevices]
- Medicine Will Dramatically Change as a Result of Basic Science plus Engineering and Computer Science Advances
 - o Genomics, Stem Cells, Transplantation, Vaccines and Pharmaceuticals
 - o Anatomic and Functional Imaging,
 - o Miniaturized Devices Including Nanodevices and Bioengineered Tissues
 - o New Instruments and Equipment in ORs, Procedure Rooms and Clinical Labs
 - o Simulation Will Become Critical to Training, Practice and Certification.
 - o Digitization of All Medical Data, Accessible Anytime, Anyplace
 - o Further Use of Complementary and Alternative Medical Approaches
- All of the Above Working Together Will Lead to
 - o Customized-Tailored Medical Care
 - o Major Attention to Prevention
 - o Enhanced Repair, Restoration or Replacement of Organs, Tissues, & Cells
 - o Fully Digitized Medical Information with Instant Access, Anytime, Anyplace
 - o Safety and Quality Profoundly Improved
 - o Initial Steps to Realistically Address Rapidly Rising Costs

7] TATRC's Hospital of the Future Vision

Turning from a review of the changes that can be expected to occur and to direct the organization and function of the "Hospital of the Future" in the coming years, consider now TATRC and its place in the development and promulgation of technologies into this evolving and emerging new state of medical and health care. TATRC has a vision for the "Hospital of the Future," and it has certain core competencies that position it as a key driver of activity.

TATRC's vision and its "Hospital of the Future" vision

TATRC's vision for the Hospital of the Future is to *"be a dominant agent of change to transform health care to a safe, cost effective, predictive, preventative, evidence based, and participatory system."*¹

This is closely allied with its overall vision² to *"be the model of government enablement of technology transfer to use"*

Process

To achieve this vision, TATRC will work to:

- Have emerging medical technology solutions integrated into DOD healthcare facility and systems planning
- Have emerging medical technology solutions integrated into DOD programs for patient safety.
- Encourage its partners and collaborators to engage in the Healthcare System of the Future agenda
- Leverage the DOD, Industry, Academia and Healthcare Institutions to assist in achieving the vision.
- Broadly disseminate the vision through appropriate journal articles, meetings and other outlets.

Relative Importance within TATRC

This will be a major priority of TATRC now and in the coming years as healthcare undergoes a momentous change

¹ COL R Poropatich and LTC H Pak, January, 2008

² COL K Friedl, November, 2007

8] TATRC's Core Competencies³

Core competencies define what an organization or institution can best accomplish.

TATRC brings a set of core competencies to bear on technology development and commercialization. These include:

- Program Management
- Scientific Integration across Diverse Portfolios
 - Can select partners in specific area of interest
- Research and Development in Key areas
 - With a focus on meeting specific needs
- Power to convene and develop networking
 - Few will deny a request to meet
- Partnerships
 - TATRC brings knowledge, recognition to others
 - TATRC can tap into those resources at short notice
- Collaborations
 - TATRC can leverage its partners to collaborate with each other and with TATRC
- Power of the Purse
 - Can use set-asides for strategic innovations
- Government Agent [creates an ability to interact with other agencies]
 - DOD has an extensive acquisition process which can force change

³ Based on interviews with COL R Poropatich and LTC H Pak, January, 2008

9] “Hospital of the Future” Megatrends will have an Impact on TATRC – It’s Organization, Functions and Programs

TATRC must marshal its resources to accomplish the greatest good with the people and funding available; it must make critical choices and be prepared to follow those decisions.

Although general medicine is moving from acute illness and trauma care to the care of complex, chronic illness – military medicine must still attend to battlefield acute medical needs.

But military medicine is also more and more focused on complex, chronic conditions resulting from warfare such as traumatic brain injury, spinal cord injury, complications of amputation, burns, and post traumatic stress disorder.

These caveats notwithstanding,

Technology will be ever more critical in the Hospital of the Future.

TATRC needs to focus on which technologies will be of *greatest value* and leverage its efforts in those areas.

TATRC needs to be cognizant of certain *critical issues in the use of technology* to advance medical care in the future setting of cost constraints, professional shortages, need for quality and safety, responsiveness to patients while recognizing the developing shift from mostly episodic acute illness care to long term care of complex, chronic diseases and, with it, the need for disease-oriented, team-based care management:

- Using technology to enhance professional productivity
- Using technology to enhance responsiveness to patients
- Using technology to control cost escalation
- Using technology to enhance quality and safety
- Using technology to enhance specialist access to distant patients
- Using technology to enhance PCP access to distant patients
- Using technology to enhance effectiveness of complex, chronic disease management medical teams [of physician generalists and specialists, NPs, PAs, pharmacists, others]
- Using technology to assist rapid triage and transport of patients with acute illness [e.g., acute myocardial infarction, stroke, and trauma] to specialized centers
- Using technology for rapid diagnosis, advanced treatment and augmented rehabilitation care.

10] TATRC Leadership Should React to Defined Megatrends and Critical Issues

In order to be effective and successful in advancing the selected technologies, there are actions that the TATRC Leadership should consider.

Leadership should:

- Understand the *megatrends* and the *critical issues* they create for TATRC
- Consider TATRC's organizational structure and adjust as needed to maximize value
- Develop a strategic plan based on megatrends and critical issues
- Assign megatrends and critical issues to individuals and/ or teams to design approaches for TATRC's future work efforts.
- Use IRT approach, or similar, to develop consensus with staff and key partners/collaborators on critical issues and use this consensus to address megatrends
- Determine future programs for attention from results of IRTs and strategic planning process.
- Focus on *orchestration*, not on individual tactics, intervention or processes.

Process notes:

TATRC leadership needs time for strategic thinking, brain storming and reflection

This implies a reorganization of time commitments and possibly a change of organizational structure to allow for more efficient management

Funding Considerations:

- TATRC should focus its available discretionary funds on the most important strategic issues as determined from the planning process.
- Success of innovative funded projects should be measured based on value delivered, not on process followed.
- TATRC should advocate for added funds for innovative, medically disruptive approaches, i.e., request direct DOD budget funding with the concept that if *only* 20% of invested projects are successful, that will be of great value to the United States.

11] Implications for TATRC

Given the forces that will create the “Hospital of the Future”, how can TATRC have a major impact?

Technologies will become ever more important in medicine and the “Hospital of the Future”, both military and civilian and for both acute medical care and care of complex, chronic disease. Not only will new technologies advance medicine but if used properly they can improve quality and safety and function to lower the cost of care. Further, technologies can potentially offset the coming shortage of professionals.

Technology development is the heart of TATRC activities, both internally and especially via its partners and collaborators. TATRC’s vision is to *“be the model of government enablement of technology transfer to use”* and its mission is to *“execute a congressional special interest program of medical science and engineering technology research that maximizes benefits to military medicine.”* TATRC’s vision for the “Hospital of the Future” is to *“be a dominant agent of change to transform health care to a safe, cost effective, predictive, preventative, evidence based, and participatory system.”*

There are three approaches that are suggested for TATRC leadership’s attention and action:

1] Select Technologies for the Hospital of the Future Relative to TATRC Portfolio.

Given the overall TATRC vision and mission and the TATRC “Hospital of the Future” vision, TATRC is well positioned to lead the nation in the *development, acceptance and eventual mainstream use* of, at least, the following technologies:

- Simulation
- Distance Medicine
- Digital Medical Information / Informatics
- Operating Room of the Future
- Technologies to Enhance Safety and Quality
- Robotics
- Identification Devices [RFID, Bar Coding, Other]

Each of these technologies fit the TATRC Hospital of the Future vision; they can be instrumental in advancing safer medicine, more cost effective medicine, developing a more preventive approach to medicine, aiding the advance of evidence-based medicine and making medicine more participatory such as the evolution to a disease-based care system that focuses on the emerging problems of complex, chronic illness in an ever growing older population.

2] Interoperability

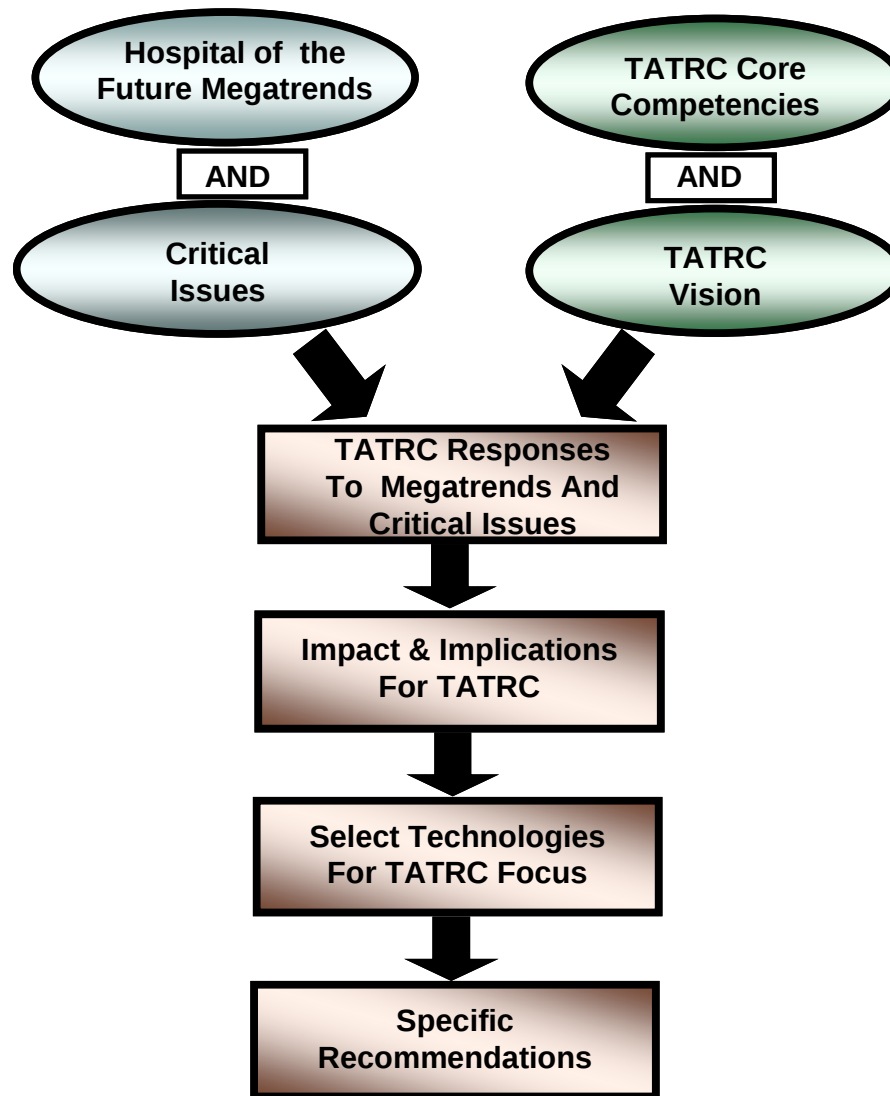
Further, TATRC is exceedingly well positioned to ensure that certain “infrastructure” developments occur which will lead to major and fundamental changes and improvements in technology usage. In particular, TATRC can advance the development of interoperability of medical devices and the electronic medical record.

3] Encouraging Development of Innovative Technology R&D Centers

In addition, TATRC is the ideal organization to drive the development of hospital-based, multi-institutional organizations to maximize the intersection of medical care with engineering and computer science, ala CIMIT.

Action on these three fronts can have a *major, effective and disruptive impact on medical technology* in this country and around the world. TATRC’s opportunity to have a lasting impact is very high if the leadership grasps the key issues and drives them to successful completion.

Graphic Representation of How Megatrends and Critical Issues Interact With TATRC's Vision and Core Competencies To Suggest Recommendations for the Future Activities Within TATRC and Its Partners/Collaborators



12] Recommendations - Next Steps for TATRC

Based on the implications in the prior section, three avenues of action are recommended.

A] Select Technologies for the “Hospital of the Future” Relative to TATRC Portfolio

The combination of the megatrends, the expected directions for development of the Hospital of the Future and TATRC’s vision suggest that the following seven technology areas, all part of the TATRC portfolio, are ripe for export. Many are at various stages of commercialization; others are still in development but will be ready in a relatively short time frame and others will be under continuing development as they are tested in real life settings.

1] Simulation

Procedural Simulation

The past decade has witnessed the rise of simulation as an important adjunct to medical training. The refinement of technologies related to simulation led to improvements in the realism of simulators and a series of validation studies contributed to a growing acceptance of their use. Today, simulation is accepted by leading authorities as essential to training, as seen by the requirement of simulation in medical curricula, notably those determined by American College of Surgeons, American College of OB-Gyn, American College of Anesthesiologists, Nursing Associations, AORN, and many others. We expect that various National Boards will require that simulation be integrated into training of procedural skills, and further that simulation be used during the examination process for certification. The rise of procedural simulation as a necessary adjunct to medical training was spurred also by activists pushing to stop surgical training on animals and - with the rise of consumerism - by patients who will no longer tolerate being "practice models" if an alternative exists. The old adage "see one, do one, teach one" has been replaced with "see one, do many". Clearly, the use of procedural simulation has had enormous impact upon the safety of medical care for patients.

Advantages –

Simulation can provide elements of training without the necessity of waiting for a clinical challenge to arrive via ER, etc.

Simulation shortens the training time required for competency development. This is especially important in this era of reduced hours for resident work.

Simulation can provide both repeatability of “same case” and variation of “similar case.” Simulation can contain curriculum and measure performance against established metrics.

Disadvantages –

Simulation is now much improved but the technologies will need to have much greater refinement. One might say that simulation is still in the “technology age” and needs to advance to the “information age” and then to the “knowledge age” before it will reach its peak of value – ala simulation in the airline cockpit setting.

Further Needs -

Although many educators are working on enhancing the training opportunities with simulation equipment as it exists today, there is a need to further enhance the technical underpinning of simulation equipment. The key elements are:

- Visualization [The real or generated display]
- Graphics [That generated by the computer that provides a visual image]
- Haptics – [The sense of touch built into the simulator]
- Tissue Measurement – [This is the ability of the simulator to appreciate the tissue displaced by a movement. It is this ability that allows the trainee to “suspend disbelief” that this is a simulator and not a real setting.]
- Tool-Tissue Interaction [Allows the simulator to give a realistic graphic representation of an action by the operator, such as what happens from cutting or cauterizing tissue.]

Cognitive Simulation

Although most medical simulation relates to procedural training activities, simulation can be adapted for and applied to training cognitive function. This can enhance medical decision making. The whole concept of cognitive simulation is new and represents another of the disruptive technologies that can have a major impact on medical training and hence on medical care, quality and safety. Prototype cognitive simulation programs have been developed to lead physicians through the myriad steps and challenges of LERD/GERD and other digestive disorders. Programs can be made to behave much like patients, to include the variability of medical disorders and occurrence of errors or misrepresentations in patient response to physician questions.

One of the steps includes converting language or text into computable symbols – akin to natural language processing – a key step in the development of cognitive simulators. This work is critical to many applications and is hence broadly applicable to the field of clinical informatics [See “natural language processing” under Informatics/ Digital Medical Information below]

Still in very early development, refinements in cognitive simulation will have a fundamental impact on medical education. The critical issues to be addressed in the future include

- the time required of content experts to formulate the nature and order of appearance of the many events in a realistic course of treatment of a disease,
- the computation of a model of progression of a disease and treatment pattern,
- the incorporation of appropriate medical language into a simulation model based upon artificial intelligence, and
- the content verification and validation of the cognitive simulation system by panels of medical experts.

This process is one of high expert cost but with very high payoff.

Issue for TATRC

Both procedural and cognitive simulation have developed in the USA in large measure as a result of efforts by TATRC, its partners and its collaborators over the past ten years. If any one organization can take credit for advancing simulation research it is TATRC. It is now time for TATRC to push for widespread adoption of procedural simulation in military hospitals for several important reasons⁴; including

- supporting residency and other training programs,
- developing assessment of competency,
- improving patient outcomes especially for surgical and high-risk treatments,
- developing pre-surgical modeling of patient anatomy and physiology, and
- providing pre-surgical rehearsal.

⁴ In other military settings simulation can provide combat medic training for life-saving procedures, i.e., airway management, hemorrhage control, tension pneumothorax.

HFPA is *not* currently planning simulation into its building or renovation programs. TATRC needs to educate HFPA on the need and the requirements and establish a set of standards for HFPA to utilize:

- Co-location of simulation laboratories near to procedural activities [i.e., near the OR, the endoscopy labs, etc]
- Adequate space for today's and tomorrow's simulation devices
- Adequate space for team-based training

Recommendations:

TATRC should

Convene a Working Group to establish guidelines for
Procedural Simulation

Simulation use in procedural training
Simulation use in competency certification
Simulation use procedural development and practice
Standardized elements of curriculum

Continue its efforts via its partners and collaborators to develop the continuing requirements for

Visualization

Graphics

Haptics

Tissue measurement

Tool-tissue interaction

Expand the activities via its partners and collaborators for development of

Cognitive simulation

Including the work on processing language into computable form

Assist HFPA to appreciate the need for and the requirements for

Simulation in all facilities that train residents in procedure-based medicine

Important Technologies for the Hospital of the Future Relative to TATRC Portfolio [Continued]

2] Auto-ID technologies (AITs)

The following, taken from a report about safety in the OR of the Future, can be extrapolated to the Hospital of the Future.

“In the ideal OR of the Future, the process of delivering surgical care occurs in an environment which automatically tracks patient progress along a defined process trajectory, aware of the presence or absence of all tools, equipment, personnel, and materiel. The individual patient care map is part of the larger system process map that considers each individual surgical process as part of a larger integrated process, the OR schedule for the day.....Automatic event detection, comparison to process models, and automatic annunciation of errors to those who can intervene are seamlessly woven into the desired OR of the Future. Materiel and equipment are easily available and usable at the point of care. Any foreign body or substance that can cause harm to the patient (drugs, blood products) or foreign objects that might be retained in the patient (sponges, instruments) are tagged before arrival in the care environment, identified as present once there and excluded (or included) automatically depending on the patient’s unique needs. ...The systems that provide this level of system readiness are seamless, integrated and almost invisible to the users while allowing them to respond quickly to process exceptions. They provide real-time information on the status and location of all the vital “inputs” of the patient care processes – personnel, equipment, materials, and supplies.”⁵

The synchronization of information, supplies and equipment is one of the greatest challenges in fully realizing the OR of the Future. The perioperative environment is high technology, high intensity, high complexity, and time compressed. Today’s ORs are usually from designs of many years ago. Storage space is limited at best and staffs are challenged to deliver materiel effectively and efficiently to the point of use. Minimally invasive approaches add a significant level of technological crowding and complexity. Patients now arrive not with the acute illnesses of former years such as appendicitis but with complex, chronic conditions such as heart failure with decompensation, diabetes with multiple complications or cancer. Almost all patients now arrive at the hospital the same day eliminating the cushion of in-hospital time for preparation. Combined, these factors tax the cognitive capacity of even the most proficient personnel.

⁵ Auto ID Technology and its Impact on Patient Safety in the OR of the Future, Marie Egan, R.N., M.S. and Warren S. Sandberg, M.D., Ph.D., *Surgical Innovation*, Vol. 14, No. 1, 41-50 (2007) and personal communication, Massachusetts General Hospital and CIMIT, 2008

Concept:

Auto-ID technologies (AITs) are designed to automatically identify physical objects with no manual notation or keyboard data entry necessary. This allows coupling objects (people, equipment, supplies) to data or to information (allergies, scheduled surgery, OR location) and ultimately creating knowledge such as the need to get a particular device or supply [e.g., particular sized porcine aortic valve] to the OR in time for the scheduled surgery or the need to examine the abdomen to extract a retained sponge at the end of surgery.

Advantages:

The AITs in use for determining identity and location include bar coding, RFID and other newer technologies in R&D. Bar-codes can be either one-dimensional or two-dimensional and RFID can be passive, semi-passive or active. Each technology has unique attributes (see Table 1 below from Egan and Sandberg, Footnote 4) and each can offer distinct roles and advantages in the OR of the Future and the Hospital of the Future.

Disadvantages:

Each of the different AIT types has their own advantages and their own vendors so a hospital will need to rely on multiple vendors. Since the highest value will accrue when data from all systems are integrated for tracking patients, supplies, equipment, medications and instruments, the hospital will need to create its own software integration system, not an insignificant challenge.

Key Issues to Address

- User Expectations – The systems employed must address the needs of the staff and patients such as reducing workload and reducing frustrations while improving situational awareness and ensuring on time performance.
- Readiness – The system must be able to integrate with the systems in use in the perioperative environment.
- Workflow – the employed systems must address workflow issues in a manner that improves rather than degrades time and energy.
- Training – Staff must be adequately trained so that the systems can produce the maximum of value.

Issue for TATRC:

AutoID technologies have developed as a result of industry needs such as bar coding foods for grocery stores, RFID tagged pallets for Wal-Mart supply chain controls, and developing rapid toll collection procedures [“EZ Pass”.] Medical related AIT technologies began with bar-coding some packaging such as bulk medication containers but its use for clinical care improvement has been slow to evolve. The technologies however are commercially available from multiple vendors. TATRC has played a key role in stimulating the development of AIT in medicine through its partners such as CIMIT. It is now appropriate for TATRC to emphasize AIT value for the military hospital system.

Recommendation:

TATRC should

- Convene a Working Group to establish guidelines for
 - Use of AITs in the Perioperative Environment for
 - Patient tracking
 - Staff tracking
 - Instrument tracking
 - Equipment tracking
 - Medication Tracking
 - This should be done with the expectation that use in the perioperative environment will serve as a prelude to hospital-wide implementation over time.
- Continue efforts via its partners and collaborators to develop the continuing requirements for
 - Expectations
 - Readiness
 - Workflow
 - Training
- Emphasize the need for the following specific infrastructure requirement

- These devices need a power supply which can be obtained by having “power over Ethernet” with drops for network connectivity in each OR, ICU bay, etc. [Note that power over Ethernet is not the usual standard since most devices that use the Ethernet such as PCs have a built in power supply.]
- Assist HFPA to appreciate the need for and the requirements for AutoID technologies, especially in high technology, high intensity, high complexity environments such as the perioperative arena.

TABLE: Examples of AITs in Healthcare

Technology	Characteristics	Pros	Cons	General use	Healthcare use
1D Barcode	Alpha and alphanumeric data, 20-25 characters	Cheap, ubiquitous	Limited data capacity, reader requires line of sight	Ubiquitous; virtually all commodity items in everyday life have a 1D barcode on the package.	Patient ID bands (limited penetration); Drugs (limited penetration)
2D Barcode	100-2000 characters	Can hold large amounts of data	Requires special reader and line of sight		Patient ID bands (limited penetration)
WiFi	Uses WiFi for location – can locate PC's, handhelds and tags.	Multitasking, global trend to ubiquitous deployment of networks	Tags need batteries, RF can impact performance. Security issues	Data transfer from portable computing devices	HIS data to PDAs, laptops and computers on wheels (limited penetration)
Passive RFID	Label is energized by a reader and transmits data to reader	Relatively small and cheap	Short read range, very limited data capacity, doesn't provide unique ID, location and time data only as good as last read.	Electronic Article Security (EAS), clothing tags in stores.	Staff IDs, medium & large sized items such as implantable prostheses, blood products, patients (all experimental)
Semi-active RFID	Battery powered tag, passive reader activates tag	Longer range (~40ft)	Same cost and battery issue as active tags but no location data – portal application	E-Z pass on highway	
Active RFID	Battery powered tags that transmit radio signals	Provide ID and location, long range(30 ft), real time data	Battery life, blocking of RF, tag cost and size, some require infrastructure		Location in time and space of assets moving through the covered area.

Courtesy of Marie Egan, R.N., M.S. and Warren S. Sandberg, M.D., Ph.D., personal communication, Massachusetts General Hospital and CIMIT, 2008

Important Technologies for the Hospital of the Future Relative to TATRC Portfolio [Continued]

3] Informatics/ Digital Medical Information

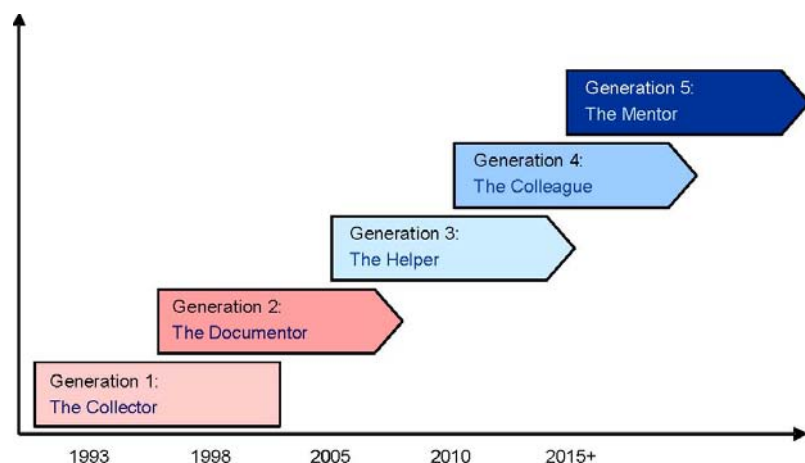
Compared to many industries such as banking and finance, medicine has been late to arrive at the information age. Largely this is due to two factors: a slowness to recognize the value of digitized information to care giving and the complexity of the information, especially the digitization of physician and nurse documentation. Most physicians find that the available electronic health record systems are useful for order entry, results reporting and other functions but not for medical documentation. Documentation systems are either designed counter to the way physicians actually work or are far too complex for easy usage. Further, medical professionals still think concretely about many elements of medical care - “a ‘thing’ is what it looks like.” For example, a CT scanner is thought of as providing anatomic images of the body but it can be more completely thought of as an “information system with eyes.” Similarly, a surgical robot is not an autonomous machine but an “information system with arms.”

Medical informatics, i.e., the intersection of information science, computer science, and health care, is the overarching discipline needed to reach a state where each individual is empowered via an access to both a secure, private electronic health record enabling coordinated medical care and concurrently to the healthcare system. The eventual integration of clinical data with genomic and proteomic data will allow medicine to achieve the vision of personalized health where it will be possible to predict, prevent, and preemptively treat future patients.

One of the basic premises of medical informatics is to support improved decision-making by the clinician and/or clinical researchers, which can then lead to improvements in healthcare delivery (access, availability, acceptability, continuity, cost-effectiveness, patient safety, or quality) over time. Medical informatics also focuses on the development and use of data mining, decision support systems and technologies to augment the value of electronic digitized information such as e-visits, e-prescribing, natural language processing and cognitive simulation. With the use of enhanced critical pathways, informatics can assist in the care of patients with chronic, complex diseases, especially those with multiple diagnoses and ongoing treatments.

Clinical informatics therefore consists not just of computers and embedded software but also clinical guidelines, various decision support systems, the ability to do data mining all while supporting the practice of medicine to deliver the best possible healthcare based on current evidence-based knowledge.

As suggested by Gartner, Inc., over time, the electronic health record will progress from being just a collector and documenter of information, to a tool that can actually assist the clinician in treating the patient, and eventually serve as a mentor to the clinician. The evolution will continue to progress through five generations, transforming from the very simple early systems that provided results reporting to future very complex, fully integrated systems. Those integrated systems will provide comprehensive support for the tasks directly related to promoting wellness and providing medical care for individuals across the entire healthcare continuum. The five steps or generations have been termed “The Collector” [collects data with ability to display it back to user,] “The Documentor” [creates a structured document], “The Helper” [adds clinical practice guidelines], “The Colleague” and “The Mentor” [clinical data reporting, graphical access to data, extensive algorithms for clinical decision support.]⁶



A few vendors have systems that have advanced to the “Helper” generation 3 which can revolutionize support for clinical activities in part by providing a tool to bring evidence-based medicine to the point of care. Very few medical centers have generation 3 systems in place and operating as of yet. AHLTA is essentially a Generation 1-2 system. The “Colleague” and the “Mentor” systems are still some years away. Eventually, artificial intelligence will create systems to not only assist but to some degree to substitute for human

⁶ Handler, TJ, Enterprise CPR system generation evaluation, Gartner Industry Research, #G00137441, 2006

decision-making. This will require the development of complex, automated clinical practice guidelines that permit numerous combinations, exceptions, and permutations, and support predictive modeling and recommendations for treatment.

All of this implies the widespread adoption of electronic records, interoperability standards, patient access to and control of his or her personal records, internet access, data warehousing, and data mining. In short, medicine needs to move from the “*information age*” to the “*knowledge age*” [e.g. clinical decision support which comes about as the informatics abilities convert from current “collectors” of data to systems that actually assist physicians and then ultimately to true artificial intelligence]. This requires creating a bridge between technology and clinical activities with the assistance of trained clinical informaticians, [i.e., individuals with clinical background yet strong technical training] along with newer technologies and tools [i.e., GRID] to handle the exploding information from genomics/proteomics and clinical decision support plus the needed analytical tools for rapid, effective evaluations. It also encompasses various algorithms for test or imaging selection, cognitive simulation and situational awareness. Natural language processing will convert text to structure computable data.

Medical informatics and healthcare information technology are not one and the same. Hence informaticians are not the same as those who develop and manage information technology systems. Informaticians work on emerging and enabling healthcare information management technologies and, to be competent and successful, of necessity, must have a medical or nursing background. An emerging professional field, it can be expected to expand rapidly as the EHR and other electronic forms of healthcare, ie, e-visits, e-prescribing, etc develop in the coming years.

In considering the megatrends to be expected [Section 9 above] for the “Hospital of the Future,” informatics can have an important impact upon:

- Using technology to enhance professional activity
- Using technology to enhance responsiveness to patients
- Using technology to control cost escalation
- Using technology to enhance quality and safety
- Using technology to enhance specialist and PCP access to distant patients
- Using technology to enhance effectiveness of care of complex, chronic diseases

Investments in healthcare information technology should be made based on its probable impact on improving healthcare delivery, including access, availability, or acceptability of services, continuity of care, or quality, which are not always easily

quantified in a strict return on investment [ROI] analysis. But IT can and should be used to reduce costs, save providers time, and overall increase provider efficiency while concurrently improving quality and safety.

The increasing prevalence of complex, chronic conditions with the need for care management, disease management and team based care demands a growth of e-medicine [including email, telemedicine, telesurgery, telediagnosis, etc] which will empower patients to better manage their conditions and assist caregivers to interact with patients in a convenient, time sensitive manner.

Military populations and their dependents are mobile, moving from duty station to duty station every few years. This suggests a need for e-medicine technologies to overcome this constant movement of both patients and providers.

The trend to consumerism and consumer-focused care may spur new development in personal health records, patient portals, and the capability for patients to search for trusted medical information. The trend also points to a potential need for integrated self-reported data with clinician observations, and the integration of data across the spectrum of care from outpatient to inpatient to rehabilitation to home based care. Eventually, all concerned will recognize that patients own their health information, not the doctor, hospital or clinic, and as a result the patient will come to control its access and use.

Selected Informatics Technologies Sponsored by TATRC

TATRC has a very wide and deep set of informatics and informatics-related projects in place. A few highlights are given here, chosen for their importance to the Hospital of the Future.

Electronic Health Record [EHR] –

There are a series of TATRC sponsored projects aimed at the improved usability of the Electronic Health Record (including AHLTA) so as to increase clinician acceptance and usability. Representative projects include speech recognition [below], alternative input methods (AIM), and new mobile display capture technologies, along with Natural Language Processing to transform free text in AHLTA [or any EHR] to coded concepts.

Voice recognition systems

Issue – Current physician documentation of history, exam, and progress notes or procedures are usually hand written and hence not entered into the EMR. Typing for many physicians is time consuming and laborious and hence not readily used by many. Voice recognition systems can overcome these obstacles and allow for rapid data input. Until recently, however, most voice recognition systems were limited in vocabulary, required extensive user training and extensive user “education” of

the system. Newer systems are overcoming these obstacles and are close to being able to accept medical dictation, any time, any place for placement into the electronic medical record.

Example - Dragon Naturally Speaking VR has been tested by TATRC partners in the military and found to be effective. As a result of that research, the Army medical department is making this technology available enterprise wide with the purchase of 10,000 copies.

Natural language Processing –

Despite the implementation of EHR enterprise wide, there is and will be a significant amount of free text, whether entered by typing, by scanning, via dictation or by VR. TATRC is evaluating natural language processing, which converts free text into structured computable data. The current focus is on coding, decision support and usability/documentation.

Cognitive Simulation – See “Simulation” section

An essential element of cognitive simulation is to use a form of natural language processing to convert text or speech into symbolic concepts that can be computer managed. Key to this work is the development of an ontology of medical vocabulary.

Data warehousing/ Data Mining

“Clinical Looking Glass” – This is an analytic tool with an easy to use interface and structured data warehouse developed and in use at Montifiore Medical System. It can be used for outcomes analysis and can provide “report cards” for individual providers, a unit or an entire facility. The system is designed that a trained clinician can do analyses readily. It has been validated at Montifiore and there is now an active collaboration with TATRC to develop an analytic capability for the military hospital system using its longitudinal clinical data. The concept is to improve quality of care, provide automated reporting based on internally developed analytics, preserve the patient’s privacy and have the reports made available in real time to all levels of the healthcare system – clinicians, department heads and system leaders. The initial efforts of integrating it into the AHLTA system have been productive and the process is advancing such that there may be a functional system within a year.

Advanced Clinical Research Information System (ACRIS)-

The growth of data is exponentially increasing and the need to manage that data is also growing. There is broad consensus that aggregated quality clinical data would serve a significant public good by advancing science (e.g. cancer treatment). Healthcare delivery organizations, especially large distributed networks, are struggling to aggregate, standardize and manage this data, especially as it relates to secondary use for research. The military has a unique role and a responsibility in setting and changing policies to ensure that the data collected for care purposes as part of the EHR can be leveraged via appropriate research into knowledge to improve the

quality of care and reduce costs for all. The DOD and the VA have a very large and very unique longitudinal clinical record. It is possible that that data set can be utilized for the public good in ways that the private sector cannot. ACRIS [previously known as the Research Data Cube] is a developing approach to rapidly pull together data from multiple sources to support clinical and translational research.

TATRC is working to: 1] establish a prototype integrated data warehouse for research which is economically sustainable; 2] develop a governance model which meets all policies and regulations and protects the patient's data and 3] facilitate a CRADA between USUHS and Northrop Grumman and its pharmaceutical partners.

Clinical Informatics

Informaticians - It is critical to have physicians and other healthcare providers trained in the concepts and techniques of clinical informatics. They are and will be essential to utilizing the vast data repositories of the DOD and the VA and converting that data into usable information for both immediate health care decision making and for retrospective analysis of longitudinal care. Partnerships with the National Library of Medicine will create the trained cadre necessary.

GRID Technology

"GRID" is an analogy to the power grid across the country that allows smooth movement of electricity to wherever it is needed on a regional and local basis. The concept is to use large scale distributed computer processing to manage complex data sets such as the exploding information arriving from genomics and proteomics research. Further, the concept is to have analytical tools available to any approved researcher in a fashion that allows use without extensive technical training.

Algorithms for assistance in decision support

Algorithms for assistance in decision support should be tied to evidence-based standards. Some of the most useful algorithms for the immediate future would be for selecting diagnostic laboratory tests and imaging and the selection of drugs or procedures based on data available and evidence-based guidelines. It will be necessary to have inter-vendor standards or open source systems to allow interdigitation with organizational-based computer systems.

Computer-Mediated Medicine

See "Distance Medicine" section

See "Robotics" section

Situational Awareness

See “OR of the Future” section

Surgical Informatics

Issue – Surgical informatics can be broadly defined as management and use of critical data in a timely, useful manner. It can be used to improve situational awareness for the OR team and to improve productivity and optimization of OR management team while enhancing quality and patient safety. Two examples of current TATRC supported efforts are:

Wall of Knowledge [Live Data] is in regular use at Massachusetts General Hospital ORs. This visual integration solution delivers relevant, patient-centric information to the entire clinical team, automatically and precisely when needed. The Wall of Knowledge captures data from diverse medical devices and hospital information systems—such as patient record, OR scheduling, anesthesia information management, sterile supplies, PACS, physiological monitors, insufflators, endoscopes—and presents it on displays, in step with OR workflow. It is commercially available however it must be integrated into each hospital’s individual systems so as to accept the various inputs from monitors, EHRs, anesthesia devices, etc.

University of Maryland Surgical “Dashboard” - It is critical to establish knowledge of *what* and *who* are *where* and *when* and thereby improves situational awareness. This is at the crux of where many medical errors occur. The “dashboard” is a display that tells the clinician, the department chair, or the surgical OR director [as the case may be] what is the progress and status of each case in each OR. It includes information of *what* is transpiring, *who* is doing it *where*, *when* it should be done, *what* has happened to delay completion on time, etc. It makes use of the business process monitoring in real time concepts noted below. Not commercially available.

Issue for TATRC

Informatics is at the heart of the Hospital of the Future and all of medical care into the future. The lack of an accessible, integrated, portable EHR that is acceptable to physicians and ultimately controlled by the patient is a drag on all of health care; it limits productivity, safety initiatives and evidence based care. An effective EHR will assist in controlling the rise of medical care expenditures while enhancing quality and reducing medical errors. There is no more critical area for attention in medicine today than the EHR specifically, and clinical informatics overall. In short, it is relevant to each of the “critical issues” outlined above in Section 10] “TATRC Leadership Should React to Defined Megatrends and Critical Issues.”

Recommendations – TATRC should:

- Encourage the MHS to adopt the Gartner “5 generation” EHR model and invest to reach Generation 5 [“The Mentor”] as soon as practicable.
- Encourage the integration of the following technologies that are now commercially available and would benefit the EHR and clinical informatics immediately in the military hospital system.
 - Voice recognition for physician input of history, examinations, progress notes, operative and procedure reports and consultations.
 - Wall of Knowledge for automatic visual integration of relevant patient information for easy viewing by all members of OR team.
- Continue to pursue research on key elements of informatics
 - Natural language processing
 - Cognitive simulation
 - Decision support algorithms
 - Data Mining, On-line analytical processing and text mining
 - Clinical Looking Glass
 - Research Data Cube
 - GRID technologies
 - Methodology for development of user interface in healthcare
 - Methodology for doing rapid software development
- Continue to advocate for
 - Interoperability of healthcare information systems within and outside the enterprise, in part through participation in the national health information network [NHIN].
 - Development of standards for healthcare devices in the hospital
 - Wireless systems, including standardization
 - Creation of a knowledge repository for encoded clinical practice guidelines
 - Creation of a research data warehouse as a national asset.

- Creation of a innovative EHR laboratory where academia, industry, and government can participate to bring about creative solutions in an open and competitive fashion
 - Development of clinical informatics workforce in the DOD
- Routinely reevaluate the Gartner high and moderate transformational strategies with short timeframes to adoption and invest as appropriate. TATRC projects are mostly the result of congressional special interest allocations [“opportunity-based”] which limit TATRC’s ability to drive scope. A lesser number of projects are via SBIR or STTR funding where TATRC can have a greater degree of influence in the scope development. As a result there are gaps in the TATRC portfolio of informatics activities that would be of high investment value. The listings below have been selected and modified from the Gartner, Inc. analysis of technologies, applications and systems that have high to moderate transformational value and are within five years of mainstream adoption.⁷ These criteria were chosen consistent with TATRC’s history of addressing healthcare issues that are both transformational or disruptive and of direct medical value within a timeframe of years, not decades. TATRC may wish to consider some of these for either direct investment or for encouraging its partners and collaborators to seek congressional funding for further research and development.
 - Medical device integration – the basic concept is integrate the outputs of various devices such monitors, infusion pumps, respirators, etc into the EHR directly, thus saving massive amounts of nurse charting time, improving nurse work satisfaction, having data available in real time and hence improving accuracy and hence quality and safety. The major barriers are lack of interoperability standards along with individual vendor proprietary issues.
 - Healthcare workflow using business process management suites – A shift from analysis after the fact to real time data capture, immediate analysis and hence immediate action to improve efficiency, quality or safety. Managers can use the graphical process models to see and monitor actions so as to make immediate adjustments in activities. Business process management suites can support the improvement cycle beginning with definition, then to implementation, along with monitoring, analysis and optimization. [See University of Maryland surgical information analysis above.] AHLTA does include business process management.
 - Natural language processing [Document classification] - These systems classify a document to enable proper indexing such as medical literature but they have been little used in healthcare settings. The opportunity exists to use NLP to

⁷ Barry R, Rishel, W, Hieb, B, etal Hype Cycle for Healthcare Provider Technologies and Standards, Gartner Industry Research, # G00148328, 2007

index images, scanned documents and other records to better organize the medical record and make it available for easy and efficient searching along with rapid content retrieval from large bodies of medical information. NPL document classification could materially assist in post discharge coding and abstracting.

- o Natural Language Processing [Text to Facts] – Here NPL is the process of converting text into structured, encoded data for use in decision support systems and computer algorithms. The major problem is a lack of standard ontologies which is impeding adoption. The technology will be able to use typed data, scanned data or dictated data and convert into computer usable information, bypassing the need for “hand-coding.” Its value will be in data mining, decision support, and clinical care research. Ontologies are also critical to cognitive simulation advances [see section of Cognitive Simulation above.]
- o Voice Over Internet Protocol – VoIP uses an IP standard to transport both voice and data packets over the same network. This is a slowly evolving technology within healthcare. Concerns include voice quality, scalability and quality of services, just as in the residential sector. But the convergence of voice and data will allow for new applications and business processes such as replacing overhead paging systems, nurse call systems and emergency department hands free systems. All will potentially improve collaboration, communication, information sharing and hence improve quality and safety. Security and privacy are critical issues to resolve, however.
- o Personal Health Record [5-10 years] – The concept is that the patient, not the provider, should be the holder and controller of his or her own health record, from birth to death and be able to make it available to whatever provider [or payer] the individual deems appropriate. This is a major paradigm shift from the current provider controlled medical record. An example of a PHR is the army’s PIC although the individual does not control access by providers. PHRs have not gained much traction as of yet but the rise of consumerism in healthcare, the ubiquity of chronic diseases that require visits to multiple providers and institutions and the need to have immediate access in case of emergency will all drive adoption. It is clearly a technology that will be required in the not to distant future. Both Google and Microsoft are aggressively entering this market and will give the patient control of their data.
- o Emergency department information systems – These are systems that automate the documentation of clinical activates, patient status and the status of various orders, laboratory and imaging tests along with charge capture and other billing information. Their value lies in reduced work for staff, better communication of information, improved patient throughput and hence improved quality and safety. They can be potentially adopted for other high intensity care settings such as ICUs. Although developed by the major vendors, most systems have various limitations today. AHLTA was not designed for critical care or ER use and will need upgrades.
- o Computer physician order entry of drugs – This is a very high value addition to the EHR but currently only about 20% of hospitals have a usable, functioning system. Only some of those systems have built in alerts [such as allergies or

drug-drug interactions] and very few have embedded “knowledge” applications. AHLTA has CPOE capability but it is not widely utilized nor is it state of the art.

- e-Prescribing – Similar to CPOE, e-prescribing allows the physician direct entry of the prescription for transmittal to the pharmacy. As with CPOE, its value increases dramatically if it is linked to the EHR record of allergies, etc and has embedded knowledge. Either way, it enhances physician productivity, decreases wait times for drugs, improves patient satisfaction, reduces handwriting errors and hence improves safety and decreases pharmacist time to check back with the physician. It is particularly valuable for patients with complex, chronic diseases that often need prescription adjustments or changes and can be linked to e-visits. Although AHLTA can support e-prescribing within the MHS, it cannot be used for sending a prescription to an outside pharmacy.
- e-Visits – Consumerism, the needs of patients with complex, chronic diseases and physician time constraints will drive toward the use of e-visits. Key issues are security and privacy. The major barrier to implementation, other than physician traditions of work, is the lack of reimbursement for e-visits by most payers. The value of reducing the number of visits [travel, expense], improving patient access to their physician, and reducing expenses will mean improved patient satisfaction and increased physician productivity. The MHS is an ideal venue for e-visit proof of concept since reimbursement is not a barrier to acceptance.
- Patient Portals (Clinical) – Patient portals allow for secure electronic interactions between physician and patient as part of e-visits, e-prescribing, reporting on laboratory or imaging results, etc. They can save physician time, increase patient satisfaction and overall improve communications thereby enhancing quality of care. Some current EHRs have patient portals built-in but they have not been extensively utilized.

Important Technologies for the Hospital of the Future Relative to TATRC Portfolio [Continued]

4] Operating Room of the Future

The OR of the Future activities will influence the care of all US citizens and beyond because the OR [and procedure suites in general] are at the heart of any hospital. As a result, attention here will benefit the hospital as a whole in addition to the specifics of the OR environment. These technologies can enhance professional productivity, enhance responsiveness to patients, enhance control of cost escalation, and enhance quality and safety. Telesurgery technologies can enhance specialist access to distant patients, all key elements that derive directly from the Hospital of the Future Megatrends.

The operating room and the associated perioperative environment share certain common features

- ORs are expensive yet inefficient
- ORs are the procedural “heart” and also the economic “engine” of any major hospital
- ORs require extensive technology – equipment, instruments and information technology – frequently updated
- Teamwork is critical yet usually under developed
- ORs are
 - High Velocity
 - High Intensity
 - High Complexity

TATRC, in 2001, embarked on a multiyear year research agenda devoted to the Operating Room of the Future.⁸ The outcomes of this effort will influence care of patients throughout the country and beyond. The research agenda has five major elements,

- Patient Safety
- Telemedicine/ telesurgery
- Informatics
- Advanced Devices
- Perioperative Systems Design

⁸ Merrell, Ronald C, “Operating Room of the Future,” *Seminars in Laparoscopic Surgery*, 10: 55-56, 2003

Among the many Operating Room of the Future technology areas evaluated since 2001 are the following:

A] *AutoID technology* – See Separate Section

B] *Surgical Informatics* –

Issue – Surgical informatics can be broadly defined as management and use of critical data in a timely, useful manner. It can be used to improve situational awareness for the OR team and to improve productivity and optimization of the OR management team while enhancing quality and patient safety.

Information can improve quality by improving processes and can thereby reduce costs, increase efficiency and reduce errors – all among the *critical factors* for TATRC’s attention.

More specifically, surgical informatics can be used to address:

Documentation

Scheduling

Materials management

Sterile processing

Tracking

Unfortunately, like other elements of IT, surgical informatics systems do not readily interact with each other. Interoperability is therefore critical to the future and would greatly expand functionality. Once interoperability is in place, surgical informatics can, and should, lead to an organizational transformation [provided processes are addressed, redefined and reimplemented as appropriate] that produces a more efficient, safer and cost effective OR environment.

Examples –

1] Process Control and Process Monitoring – Under evaluation at Massachusetts General Hospital/ CIMIT, this work leverages documentation from various systems to provide useful information in a prompt manner to the correct individual who can effect a remediation when an “exception” is noted. [For example, patient has been taken to the wrong operating room as detected by AIT and relayed to the anesthesiologist by pager; or, patient has not been given preoperative antibiotics yet surgical incision is about to commence. In the first example, time and confusion is saved; in the latter example, remediation can prevent an adverse event from occurring.]

2] Wall of Knowledge [Live Data] is in regular use at Massachusetts General Hospital ORs. This visual integration solution delivers relevant, patient-centric information to the entire clinical team, automatically and precisely when needed. The Wall of

Knowledge captures data from diverse medical devices and hospital information systems—such as patient record, OR scheduling, anesthesia information management, sterile supplies, PACS, physiological monitors, insufflators, endoscopes—and presents it on displays, in step with OR workflow. It is commercially available however it must be integrated into each hospital’s individual systems so as to accept the various inputs from monitors, EHRs, anesthesia devices, etc.

3] “Surgical Dashboard” [University of Maryland]- It is critical to establish knowledge of *what* and *who* are *where* and *when* and thereby improve situational awareness. This is at the crux of where many medical errors occur. The “dashboard” is a display that tells the clinician, the department chair, or the surgical OR director [as the case may be] what is the progress and status of each case in each OR. It includes information of *what* is transpiring, *who* is doing it *where*, *when* it should be done, *what* has happened to delay completion on time, etc.

In the “age of analytics”, the need is for information to be more abundant, for data to be used extensively and for statistical and quantitative analysis allowing explanatory and predictive modeling with the end result of fact-based decision making. With appropriate IT systems it becomes possible to move from the usual “retrospective” reports of today to real time alerts and reports that point to a problem and allow for remediation before an adverse event occurs, before valuable time is wasted and even allowing for forecasting into the future.

The surgical dashboard includes key relevant data in a useful and useable format, easily visible. Equally important, it avoids the tendency to place more than the vital few data elements into the display as that leads to cognitive overload.

The “Surgical Dashboard” being developed at the University of Maryland of School of Medicine is far more sophisticated than the video whiteboard but the two can be used together for added value.

It is not commercially available.

C] Simulation - See Separate Section

D] Robotics - See Separate Section

E] Device Interoperability – See Separate Section

F] Natural Orifice Surgery

CIMIT and others are evaluating new technologies that combine laparoscopic principles and technologies with robotic end effectors and endoscopic approaches to complete surgeries such as cholecystectomy via a gastroscopic, through-the-stomach wall approach. These approaches, known as “NOTES”, are still in early stage development. During the development of this new approach to surgery, much attention and research are directed toward the development of new instruments with the

requisite flexibility and precision for trans-gastric procedures. Little attention has been directed to the unique and demanding training aspects of this novel approach to surgery. The University of Maryland is exploring the use of simulation for NOTES training by combining clinical expertise with current and evolving simulation platforms.

Recommendation to TATRC;

Continue sponsoring research, including research related to the refinement of simulation training but not yet ready for commercialization or introduction into the military hospital system.

G] Perioperative Systems Design - New OR Design⁹

Designed for parallel rather than the standard serial processing of today's ORs
Improved ergonomics to decrease clutter and align monitors

This approach at Massachusetts General Hospital has resulted in increased throughput, less between case downtime, and improved functionality of the Operating Room. It has been tested extensively with real world caseloads for multiple years and found to be efficient and cost effective.

This approach has been very functional at MGH with its use by a dedicated team of surgeons, anesthesiologists, and nurses. Time will tell if MGH chooses to expand this concept to other parts of its OR suite. Meanwhile, the project has demonstrated that work traditionally done serially can be done in parallel. Whether this is practical for introduction into the military hospital system is problematic.

Recommendation to TATRC:

Educate HFPA on the concepts involved. Talk to key OR personnel at individual military hospitals that might have an interest. However, recognize that some have a concern that the military system of professional duty station rotation may negate the added productivity of this approach and indeed might lead to reduced rather than enhanced productivity.

H] Image Guided Surgical Activity

⁹ Sandberg WS, Ganous TJ, Steiner C. OR of the Future - Setting the Research Agenda for Perioperative Systems Design, *Seminars in Laparoscopic Surgery*, 10: 57-70, 2003

Pre surgical Evaluation and Surgical Planning/ Rehearsal -

Increasingly sophisticated imaging offers surgeon a presurgical evaluation of anatomy – “No surprises.” Next the surgeon can take this image and use it for presurgery rehearsal of critical aspects of the surgical procedure – via the surgical simulator.

Smart Image –

This is an approach to combine various images into one view. An example is taking a CT scan and overlapping it with a view from the laparoscopic surgery monitor. The surgeon can now look “deeper” than what the real time image from the laparoscope camera of the case illustrates – what tissues, nerves, vessels, etc are just below the visual level on the monitor. Use in “real time” to view current work on monitor by superimposing CT image over visual image of surgery. Well beyond the capability of the “Stealth” neurosurgical or otolaryngeal image guided surgery technology

Recommendation to TATRC:

Continue to sponsor this type of research and encourage HFPA to incorporate the necessary imaging equipment into newly designed OR and to retrofit some ORs in major military hospitals to utilize these technologies as they become available. The sponsoring of research for “Smart Image” is a wise investment with a high potential payoff. When current challenges (such as refinement of low-dose CT) are overcome, the resultant improvement in patient safety and surgeon effectiveness will be enormous.

I] Video Technologies to Improve Safety and Productivity¹⁰

There are at least five avenues of research in progress via TATRC sponsorship

- Room Cameras - Suite Command And Control
- Light Source Cameras - Train, Teach, Record Data
- Scope Cameras - Train, Teach, Record Data

¹⁰ Xiao Y, Schimpff S, Mackenzie CF, Merrell R, Entin E, Voigt R, Jarrell B. Video technology to advance safety in the operating room and perioperative environment, *Surgical Innovation*, 2007, 14: 52-61

- Combined - Teleconsult/ TeleMedicine/ Safety Review
- PACU/ ICU Cameras - Electronic Monitoring And Care

Video is a powerful medium for: education, real-time consultation, process improvement, research, and workflow coordination. Video can be included in the room, in the light source, in the laparoscope, in the PACU or ICU or in some combination. A few of the video technologies that have been tried and tested with success are as follows:

- Video can capture team performance, document technical skills, and analyze systems factors.
- Through video a surgeon can call a colleague to look in on a difficult procedure without the need for traveling to the OR and “scrubbing in.”
- Video of OR activities can assist the medical and nursing management teams to utilize the ORs in a suite, i.e., “command and control function” for video. Similarly, a video white board allows rapid situational awareness about what is happening in any OR.
- Video of a procedure or case can allow “after action” review of technique, identifying both problems and solutions that may not have previously been appreciated. Video record of an entire surgical or medical procedure could be incorporated with the electronic medical record to allow in depth review after the procedure is completed. By analogy, every Monday, each NFL team critically studies the videos of yesterday’s game to detect errors and plan improvements.

Recommendation to TATRC:

- Continue sponsoring ORF video technology research, especially as it relates to patient safety.
- Introduce video technologies to the military hospital system, via HFPA and interactive sessions with interested individual hospital representatives.
-

J] Ergonomics/ Human Factors

Cognitive ergonomics, or human factors, research studies the compatibility of the human mind and the information environment in which it must function. The ability of humans as information processors is now well understood and hence facilitates technology design in a way to maximize human strengths while minimizing human weaknesses [adopted from F. Jacob Seagull, PhD., University of Maryland] Aviation is a good example of human factors at work – consider the controls and displays; communication and teamwork within the cockpit; and the training and simulation experiences – all developed to assist the pilot fly safely and effectively. Cognitive ergonomics demonstrates that humans are excellent at pattern recognition,

good at perception and good at understanding complex contexts but poor at vigilance, often biased by expectations and relatively poor at 3-D spatial visualization. All of these factors need to be incorporated into planning for OR design, equipment placement, and information presentation.

Physical ergonomics is equally important in the OR. For example, surgical fatigue muscle fatigue or mental fatigue must be avoided by proper equipment and instrument design and placement.

Research is under way at the University of Maryland in both physical and cognitive ergonomics.

Recommendation to TATRC:

Continue to sponsor physical and cognitive ergonomics research.

Summary of OR of the Future Technologies

Issue for TATRC:

Attention to the “OR of the Future” will benefit the hospital as a whole in addition to the specifics of the OR environment. There are technologies that TATRC is promulgating that will clearly enhance professional productivity, improve responsiveness to patients, slow the escalation of costs and improve safety and quality – all key among the critical issues in the use of technology addressed in Section 9 [“The Future of Medicine Megatrends will have an Impact on TATRC.”] Further, some technologies under development will enhance access by physicians with distant patients, such as telesurgery. Focusing on the key technologies in this portfolio will have some of the greatest leverage and value opportunities for military and civilian medicine.

Recommendation

TATRC should:

- Continue to sponsor research into all five original areas of the ORF strategic plan.
- Work with HFPA to incorporate the commercially available technologies into ORs where appropriate in the military hospital system.
- Place special attention to
 - AutoID technologies
 - Surgical Informatics
 - Simulation, both procedural and cognitive
 - Surgical Robotics

- Device Interoperability
- Image Guided Surgical Activity
- Video Technologies
- Perioperative Design
- Ergonomics, both physical and cognitive

Important Technologies for the Hospital of the Future Relative to TATRC Portfolio [Continued]

5] Robotics

Robotic Surgery

The promise of robotic surgery includes^{11 12}:

- Leverage the particular strengths of computers such as tremor- filtered precision and repeatability to enhance the capability of the average surgeon.
- Import data from devices (especially imaging) in the operating room for information augmentation.
- Reduce the occupational environment hazard for surgeons by removing the surgeon from biohazards, for example, radiation exposure.
- Enable extension of surgical care into hostile or geographically remote areas , providing ‘console to bedside’ care.
- With endoscopic surgery, advantages include: improved ergonomics, increased dexterity, sharper spatial mapping, enhanced visualization and stereoscopic depth perception, removed fulcrum effect, motion scaling, tremor reduction, faster patient recovery
- Indefatigable – don’t get tired and don’t get back pain
- Virtual fixture or ‘no fly zone’ -protective algorithms can be inserted into the software to prohibit undesirable motion.

Combined, this allows:

- Integrate Patient Specific Data
- Less Invasive Surgery (e.g., CABG)

¹¹ Lai F, Louw, D, Surgical Robotics for Patient Safety in the Perioperative Environment: Realizing the Promise, *Surgical Innovation*, Vol. 14, No. 2, 77-82 (2007)

¹² Lanfranco, A.R., Castellanos, A.E., Desai, J.P. (2004). Robotic surgery: A current perspective. *Ann Surg* 239(1): 14-21, 2004. Lippincott Williams & Wilkins.

- More Accurate Surgery (e.g., Craniotomy)
- Preplanned And Rehearsed Surgery
- Built-In Alerts And Detectors

Only one surgical robot is currently commercially available – daVinci. It has found wide interest and acceptance by many surgeons especially for prostate surgery, cardiac surgery and gynecologic surgery. Most institutions indicate that the combination of initial price, annual maintenance fees, training time, and other costs make for either a very long pay back time or, more often, never achieving a return on the investment.

Telesurgery over geographical distances has been conducted using Zeus System (developed by Computer Motion). The very first telesurgery was the transatlantic Lindbergh Project between NY and Strasbourg, France.

Robotic Surgical Scrub Assistant

“Penelope” has been developed at Columbia University and proven to be effective in assisting the surgeon. It is not yet commercially available.

Robotic Pharmacy Assistance

Three types of hospital-based pharmacy robots are commercially available:

Solid medication or “pill” dispensers – these robots stock their own storage area using bar-coded medication containers. They then prepare a patient’s daily “drawer” of medications based on the pharmacy information system [ideally driven in turn by CPOE physician ordering system]. The advantages are speed and accuracy while freeing up pharmacist and pharmacy technician time for other functions.

Liquid medication preparation – these computer-assisted robots select a vial, adds diluent, remove the prescribed dosage into a syringe or add it to an intravenous infusion bag. Driven by a hospital-based CPOE and pharmacy information system, they save time, increase accuracy and free up both pharmacist and pharmacy technician time for high level functions.

Robotic delivery of medication drawers to individual hospital nursing units – these robots are loaded with the patients’ medication drawers and are sent by command to individual nursing units. The robot can “call” an elevator wirelessly and likewise indicate the

proper floor. Upon reaching the unit, it announces “medications available” for nurse removal before moving on to the next unit of the hospital. Advantages are efficiency, speed of delivery of critical medications to units and freeing up time for pharmacy personnel.

Robotic Physician-Patient Interaction Devices

The increasing complexity of healthcare and shortage of clinical specialists needs to be addressed through communication, collaboration and coordination of resources to ensure timely delivery of clinical expertise. The ability for a physician to “be at two places at the same time” is an intriguing notion and is now a reality. One of the robotic systems that enable this new paradigm is the commercially available Remote Presence device from InTouch with other similar concepts under development. The Remote Presence device combines the power of robotics, wireless, and the internet to bring physicians and patients together over the spectrum of distance and time. It has wide-ranging mobility on both ends of the interaction, the ability to be fully controlled by a remote operator (the physician), the quality of its two-way audio-visual system, the user-friendly interface design, and the software architecture which allows connections from anywhere with internet access. This system enables healthcare professionals to provide high quality clinical expertise to both patients and hospital staff in a more timely and efficient manner than was ever previously possible. The benefits include geographical reach of scarce medical experts, improved patient safety and outcomes, capacity management and efficiency, enhanced physician and patient satisfaction and availability of clinical mentoring, training and education, telementoring

Issue for TATRC

- Robotics has the potential to revolutionize the delivery of healthcare
- Robotics can help extend the delivery of information, expertise and clinical care across time and geographical space barriers
- Robotics offers to enhance quality of care through extension of clinical expertise and leveraging of integrated datasets and best practices.
- Robotics can be used across the continuum--from the hospital scenario (e.g. OR, ED, etc.) into primary care offices and even into the home.
- Robotics offers opportunities for telementoring, training, education using robotics and telemedicine.

TATRC has been a major innovator of robotic technology directly and through its partners and collaborators. TATRC has long been a champion of robotics and at the vanguard of robotics innovation. Robotics innovation that has military relevance will also have significant application and contribution to civilian health care.

Computer-assisted or “robotic” surgery has important potential implications for military medicine when combined with distance medicine technologies for delivery of specialized surgery. It has proven itself in mainstream surgical situations although the limit of only one manufacturer has reduced innovation and options and maintained a high price. The robotic scrub assistant has potential utility. The pharmacy robots are in relatively wide use. The robotic physician-patient interaction devices can also be of real value for bringing expertise to anywhere needed despite the location of the physician. They have the capability to enable expert physicians to connect or “beam-in” into a robot in the OR or angiosuite and essentially be “present” during a procedure to provide real-time mentoring.

All of these technologies can increase efficiency and quality, reduce errors and improve patient care. Some can reduce personnel time and hence costs [These all fit the criteria in Section 9 on critical issues that derive from the Megatrends.] All require substantial personnel experience and training.

TATRC should:

- Continue to sponsor robotic technology innovation and development

- Encourage selective use of robotic technologies in military hospitals, especially pharmacy robots and robotic physician-patient interaction devices. Selected use of the daVinci surgical robot in carefully selected institutions may have utility as well.

Important Technologies for the Hospital of the Future Relative to TATRC Portfolio [Continued]

6] Distance Medicine

Distance medicine has the potential to fundamentally change the practice of medicine. Restated distance medicine technologies can be disruptive in the way physicians and other care givers interact with patients and with each other and can fundamentally change how patients are able to interact with the entire health care system. This is of increasing relevance as medicine gravitates toward complex, chronic illnesses and as the shortage of professionals is exacerbated in the coming years. There are many opportunities of the use of distance medicine technologies; a few are listed below.

1] A methodology to receive information from others

Flawlessly

Accurately

Promptly

Example: Patient sees PCP for cough at office site #1, has CT scan at hospital site #2; has biopsy at site #3, pathology report of lung cancer done at another hospital or site #4, patient then has visit to surgeon at site #5, sent for PET scan at hospital site #5, has visit to major cancer center at site #6 where patient is told he needs to bring all of the information from the previous five sites of care. He is thus required to serve as his own “Federal Express.”

But this should not be necessary since all data is or could be digitized and sent, with appropriate security, over the internet with commercially available technology which is available today. Issue is to have this happen using today’s technology.

2] A methodology to transmit information about patient and patient’s condition so that it can be monitored and acted upon from a distance.

Example: VISICU, and similar technologies, allows a physician at a distant site to observe in real time multiple patients in multiple ICUs. The physician can observe physiologic parameters, review laboratory data in addition to seeing and talking to the patient via tele-technology, examining the patient via electronic stethoscope, etc and interacting with the nursing or resident staff. The result is better medicine with fewer errors, shorter hospital stays and improved patient and staff satisfaction. VISICU is commercially available.

3] A methodology to submit prescriptions to pharmacy in electronic form to

- Increase efficiency
- Increase accuracy
- Improve safety
- A methodology to submit hospital-based medication orders via CPOE
 - Same reasons
 - With alerts and knowledge built in.
- The technology to accomplish these needs is currently available commercially.

4] A methodology to obtain patient information that is of critical or urgent importance and transmit to care giver for rapid action

Examples:

- Home blood glucose monitoring connected to provider's office via internet
- Home scale connected to provider's office for patient with heart failure
- Portable and/or home heart rhythm monitoring for patient with unstable cardiac arrhythmia.
- "Pacemaker" equivalent monitors patient's internal ECG and reports via wireless technology at first evidence of AMI, even before patient feels pain developing.

The former three are currently available with commercially available technology and the latter is under final R&D.

5] A methodology to create "Distributed patient care" - Immediate access to consultative service

Example: Surgeon finds self in a difficult situation during surgery and cannot stop bleeding; calls senior surgeon at home at night; senior surgeon cannot appreciate problem via spoken word so drives to distant hospital to assist where is now able to visualize the problem. Rather than that scenario, a video in the OR light source, the room wall and/ or the laparoscopic instruments could be transmitted to the senior surgeon's PC thereby eliminating the need for a lengthy drive and the time related. This will allow for expert consultation at short notice.

Commercially available technology available today

In the near future, the senior surgeon will be able, via telementoring, methodologies to

- Level 1: Advise on next steps in procedure
- Level 2: Assist via telesurgery devices
- Level 3: Demonstrate via telesurgery devices

The needed technology could be available shortly.

6] A methodology to create distributed Learning – Rather than expect every military post to have its own educational programs, allow for expert training and education via telementoring methodologies. It is better to build an excellent central source with expert educators and trainers and distribute their expertise via various telementoring devices including the internet, DVDs, CDs, cell phones, ipods, PCs, etc.

7] A methodology to access the patient from a distance.

Example: Saturday morning and the physician has but one patient in the hospital who is not critically ill. Rather than visit the hospital to see the patient or, worse, not visiting patient until Monday morning, the physician can send “Robodoc” to visit patient. This allows for verbal and visual interaction, electronic stethoscope examination, etc. It saves the physician time yet allows the patient the courtesy of a visit. Overall, this improves access, meets patient’s consumerism expectations and allows for good medicine.

The technology is commercially available.

Issue for TATRC:

The “Hospital of the Future” and medicine in the future overall must respond to these needs: the rising costs of medical care, the need to reduce costs, the desire of patients and their families to have greater responsiveness from their health care providers, the shift to illnesses that are life long and very complex and the fact that there will be fewer professionals, all in need of assistance in their daily activities. Distance medicine is one of the key technologies that can indeed address all of these critical issues into the future. Further Distance Medicine [“telemedicine”] has been a part of TATRC’s fundamental activities since its inception and so TATRC is in an excellent position to use its capabilities to move this field forward.

Many aspects of distance medicine are not paid for in the civilian arena given current reimbursement methodology. TATRC can show distinct leadership by advancing the use of distance medicine techniques in the military setting and hence demonstrate the cost savings opportunities along with the improvements of patient care, patient safety and responsiveness possible. This can be a disruptive change that will have a major impact on how medicine is practiced into the future.

Recommendation

TATRC should:

- Continue to work with its partners and collaborators to advance distance medicine technologies.
- Maximize the opportunity in the military medicine system to use distance medicine without need to address payment issues.
- Interact, via HFPA, with various military hospitals willing to serve as test beds for the introduction of distance medicine techniques.

Important Technologies for the Hospital of the Future Relative to TATRC Portfolio [Continued]

7] Technologies to Enhance Safety and Quality

The 1999 Institute of Medicine report, “To Err is Human,”¹³ put a spotlight on death from preventable medical errors. Procedure and surgically related errors are second only to medication errors as the most frequent cause of error-related death. The focus of safety efforts logically starts in those two domains.

Improving safety concurrently can substantially improve productivity and reduce costs. The rise of consumerism will demand a greater attention to safety as will regulations by JCAHO and others. Trustees will feel compelled to attend to safety just as they currently attend to hospital finances. This will lead to pressure on hospital management to significantly improve efforts and results related to safety measures.

There are three elements to an effective safety program: 1] culture, 2] human factors considerations, and 3] technologies.

In order to improve safety, the hospital must first create a culture [environment] of safety and then address both human factors and technology factors. The culture of safety must include an institutional commitment from the Board and CEO along with resources of people, time and dollars; a non punitive attitude toward medical errors; an openness to communicate about errors; to error and near miss data collection with root cause analysis and, finally, to a systems approach to change.

Human factors that can improve safety include effectively enhancing leadership and management of the pharmacy or OR/procedure suite, improving communication and information transfer, enhancing training, and utilizing an effective system such as crew resource management to improve teamwork.

A few technologies appear ripe to have major short and long term impact on medication and OR safety. Computer order entry of medications along with alerts and embedded knowledge will reduce medication errors. Pharmacy robots today can select medications ordered by CPOE and checked by the pharmacist via the pharmacy information system; can produce injectables and can

¹³ Kohn, LT, Corrigan, JM, Donaldson, MS for the Institute of Medicine, “To Err is Human: Building a Safer Health Care System,” National Academy Press, Washington, DC, 1999

dispense outpatient medications – all with less personnel time and with greater speed and accuracy. Unit or OR cabinets that release medication only upon password entry by staff and concurrence with the CPOE ordered medication followed by positive identification of drug and patient by barcode or RFID will add to the safety of administration. Identification devices such as RFID can be used to track medications from receipt at the loading dock to final administration to the patient.

Improved EMRs with wireless access to all digitized data can reduce the problem of inadequate patient data on the OR or procedure suite. Efficient aggregation of critical data in an easy to read and ergonomically accessible “white board” can improve OR staff situational awareness. Identification devices such as RFID can track patients, staff, equipment and instruments to ensure that all are in the right place at the right time. Video can assist in command and control, training, recordation and recall of events in the OR. Technical mastery on simulation should be an integral part of all surgical training programs and should become the requirement for procedure-based physicians’ credentialing and continuing certification. Longer range, OR robotics will reduce errors by increasing accuracy, reducing tremor and other movements, creating “no fly” zones and interacting with imaging and simulators to create an individualized operative plan for each patient.

TATRC’s forte is technology so only technologies will be addressed here. However, it is critical to understand that the best technology advances are of little value unless and until the first two areas are effectively addressed.¹⁴

Medication Safety:

CPOE is available with most commercially purchased clinical information systems such as those from Cerner, Epic and Eclipsys. It is not clear that AHLTA has a viable CPOE function at this time but TATRC has at least one project addressing this issue. AHLTA needs to have CPOE so this should continue to be addressed.

Pharmacy robots are discussed in more detail under “Robotics.” They are commercially available and every major military hospital should have them installed and in use.

Medication cabinets that store, dispense and record the drug and who it is to be administered to are commercially available [Omniceil and Pyxis]. They should be interconnected to the pharmacy information system which in turn connects to the CPOE system.

¹⁴ Schimpff, SC. Improving operating room and perioperative safety: background and specific recommendations, Surgical Innovation, Jun 2007; 14: 127 - 135

Bar-coding and RFID technology has been mandated by the FDA for at least the level of bulk medication packages and will undoubtedly be mandated for the “pill” level in the future. The technology is commercially available. In conjunction with the robots, most medications can be packaged in plastic containers, syringes, or fluid bags, coded and directed to the specific patient. These commercially available technologies should be in use now.

OR and Procedure Suite Safety:

Video technologies are off the shelf and can be incorporated into the light sources, on the wall or via the laparoscope.

Electronic medical records are available commercially. The issue, as noted elsewhere, is to create an opportunity for the provider to enter history, exam, progress notes and consultation notes in an effective, efficient manner. Today most documentation systems create a loss of productivity and hence physicians will not use them. [At a later time, natural language processing will be able to convert text into data that can be manipulated.] Once all data is in the EMR, it will be instantly available in the OR or procedure room – a major safety advance.

Simulation [see “Simulation” section] is critical to training surgical residents [or any procedural trainee]. The various residency review boards currently do or soon will demand it as part of the training programs and certification boards will shortly begin using simulators as part of the testing process. Simulators are commercially available and every major teaching institution needs to develop the appropriate training facilities.

Simulation can also be used for pre-procedure practice or for testing approaches based on entered anatomic and or functional data from imaging modalities. This can markedly improve patient safety and procedural quality.

Robotic surgical assist devices can improve safety by reducing tremor, creating no fly zones, etc [see “Robotics” section]. The daVinci robot is commercially available.

“*Robodoc*” [see “Robotics” section] approaches can bring the patient and the provider together over time and distance, improving communication and hence safety. It is commercially available.

Auto-identification device technology [AIT – see “AIT” section] is commercially available and can be used to monitor and track equipment, instruments, patients and staff. They can improve efficiency/productivity, enhance safety and reduce supply chain costs

Issue for TATRC

In the near future, there will be a demand for safer, higher quality medicine emanating from regulatory mandates, patient’s expectations, and hospital board of trustees dictates. To respond to these expectations, the “Hospital of the Future” will need to address fundamental issues of culture and human factors and then incorporate new technologies.

In addition to improving safety, these technologies have the potential to also address many of the other critical issues that derive from the Megatrends [See section 9 above.] These critical factors include enhancing professional productivity, enhancing responsiveness to patients, controlling cost escalation, and improving quality of care overall. They are especially helpful in enhancing the effectiveness of medical care in treating complex, chronic diseases.

TATRC has invested substantial effort in technologies that can improve safety, most of which are commercially available, and is therefore in an ideal position to influence the development of the safety agenda in this country.

Recommendation

TATRC should:

- Assign one high level leader – with sufficient time to invest - to oversee the safety portfolio from a strategic perspective at TATRC, with assistance from others.
- Aggressively encourage the MHS to utilize these technologies as part of a comprehensive patient safety program.

12] Recommendations – Next Steps for TATRC

In addition to the seven technology areas described above, there are two additional areas for TATRC attention - interoperability and the creation of innovative technology R&D centers:

B] Interoperability

In a strategic view, the purpose of technology is to empower systems to improve patient care outcomes and safety. A technology is only as good as its ability to interdigitate with other technologies. Lacking this ability, many technology advances will be for naught. Many very excellent technologies are being brought forth to the clinical marketplace, but each needs to interface with other technologies to share data in order to reach its fullest potential. Interoperability [often termed as “Plug and Play”] means that there is no need to create a custom interface between two or more instruments, pieces of equipment, etc. In addition to interoperating for basic data transfer, it is essential that equipment include the capability of exporting rich data to support more complete data analyses, and limited external control capability to implement safety interlocks and closed loop control.

Some medical devices utilize open networking standards for data communication, such as DICOM to provide real-time data for the health record. Medical devices can also utilize closed networks for system integration. However, neither of these approaches provides the comprehensive integration capabilities necessary for safe, cross-manufacturer interoperability, error resistance, and improvements in patient safety, treatment efficacy and workflow efficiency envisioned by a fully integrated clinical environment.

If standards and technologies are not widely adopted, the utility of many technologies will remain hampered, at best, and often under utilized, if not un-utilized at all. Development of standards and related technology (and end-user demand to drive adoption), would have a profound, beneficial and lasting value. TATRC is ideally situated to drive the adoption of the needed standards.

Areas for attention are as follows:

- Interoperability standards and supporting technologies (including, for example, an open platform)
- Equipment/ Devices performance requirements
- Information technology
- Wireless Access and Wireless Standards and Wireless Coexistence (interference)

- Wireless device connectivity

The key steps are to evaluate and cause adoption of standards and technologies which allow and encourage the networking of medical devices to increase safety and increase efficiency. Adoption of such standards would allow for

- Automaton of system-readiness assessments
- Physiological closed-loop control of medication delivery, ventilation equipment and fluid delivery
- Improved decision support¹⁵

It is important to recognize that interoperability does not address the technology itself. A technology can be very effective and efficient in its stated purpose or task but still lack interoperability advantages. This issue here is to address interoperability, not the fundamental technologies themselves. Of course, interoperability could provide the means to improve the safety of *using* a technology. For example, although an intravenous medication infusion pump may operate safely independently, the safety of the *system* (and patient) may be improved if the infusion pump and blood pressure monitor were networked so that the infusion could be automatically adjusted to minimize blood pressure instability.

What will be the driver to establish interoperability? Some combination of healthcare delivery organizations and government agencies will probably become the force that creates impetus for companies to accept a standard, to allow interface or “plug and play.” DOD with its huge procurement power can force this issue - although it may be politically difficult given the lobbying power of industry.

TATRC is the ideal organization within the military to encourage the development of the standards needed, bring fourth the procurement language for acquisition officers to utilize and present the arguments required to overcome resistance by vendors. TATRC is exceedingly well positioned to ensure that the development of interoperability standards occurs. This will lead to major and fundamental changes and improvements in technology usage. In particular, TATRC can advance the development of interoperability of medical devices and the electronic medical record and the standardization of wireless technology.

TATRC has sponsored interoperability efforts via CIMIT for the past several years. A work group has been formed within the past year and initial standards and language have been developed, largely under the guidance of Dr Julian Goldman. These standards, while not agreed to by all parties because of competitive proprietary concerns of individual companies, are now ready for inclusion in acquisition documents by DOD through the HFPA process. HFPA has indicated verbally to TATRC its readiness to utilize such

¹⁵ Goldman JM: MD PnP White Paper, <http://mdpnp.org/uploads/MD>, April, 2008

language. A high-level “umbrella” standard for the plug-and-play integration of medical devices into high-reliability networks to create an “Integrated Clinical Environment” is being convened by Dr. Goldman under ANSI/ASTM, with an expected publication date of 2009.

Addressing interoperability is critical to effectively move many elements of the TATRC technology portfolio into the Hospital of the Future [via HFPA, Civilian Hospitals, and others]

Recommendation:

TATRC should

- Continue to sponsor the interoperability workgroup, under the guidance of Dr Goldman.
- Arrange for appropriate funding to maintain interoperability actions and progress.
- Work with CIMIT/ Dr Goldman to insert the proposed language into the DOD procurement documents.
- Work with HFPA and the procurement branches of the military to insure that purchased products are consistent with the interoperability standards devised.

12] Recommendations – Next Steps for TATRC [continued]

C] Encouraging Development of Innovative Technology R&D Centers

America had a set of “industrial labs” in the recent past such as RCA labs, Bell Labs, IBM Labs, etc. These laboratories encouraged innovative idea development, funded promising concepts but would quickly stop a project if it was not progressing toward a useful solution. Innovators were encouraged and “failure” was rewarded as a “good try” plaque and with encouragement to develop another new concept or project. According to Reuben Mezrich, MD, EED, a former RCA Labs staff member, later a CIMIT staff member and now Chairman of Radiology at the University of Maryland, the underlying premise was that “The only sin was the failure to have a new idea.”¹⁶

Most of these industrial-based innovation labs are now gone due to corporate mergers and acquisitions, short term financial considerations and especially a national progressive change of corporate management philosophy – no longer looking out over the long term but rather a short term orientation. Corporations have a low tolerance for failure; managers expect a rapid high return on investment [ROI] in every investment so failure cannot be tolerated. Research is thus driven similarly – only fund research that has a very high potential for payoff in the near future. This loss, per Dr. Mezrich, is a major loss to American inventiveness for which we as a society will eventually pay.

An organization begun at Massachusetts General Hospital, CIMIT, embodies the concepts of the former national business laboratories. The Center for Integration of Medicine and Innovative Technology [CIMIT] is an organization encompassing multiple entities [Massachusetts General Hospital, Massachusetts Institute of Technology, and Harvard School of Medicine, among others]. It was founded in 1997 “to improve patient care by facilitating collaboration among scientists, engineers, and clinicians to catalyze the discovery, development, and implementation of innovative technologies.” It operates with four assumptions:

- 1] With active effort, sophisticated technology in other industries could be applied in healthcare to improve the quality and safety of patient care.
- 2] Early-stage, high risk, high-reward ideas have no access to funding.
- 3] The solution to many of the problems in healthcare today is best achieved through active collaboration between clinical and engineering research communities.

¹⁶ Reuben Mezrich, MD, Personal Communication, November, 2007

4] Facilitation and coaching at every stage of the innovation process adds value and produces better researchers.¹⁷

A key element for success was bridging the cultures of a school of medicine and its associated hospitals and a school of engineering.

One of CIMIT's other key success factors was the enthusiastic commitment of a local congressman able to arrange for congressional earmarks to start and maintain momentum after the initial funding by Massachusetts General Hospital.

CIMIT leadership has recognized what makes innovation successful: Having a great idea; having a flexible laboratory funded like a center; trying the idea; stopping the project if it does not prove quickly to be viable; developing intellectual property rights; publishing the results and doing the initial work needed to for technology transfer that will allow a new device, technique, drug, etc to survive the "Valley of Death" and reach commercialization.

Over its first ten years, CIMIT was successful in facilitating multiple cross-disciplinary and cross-institutional collaborations. Researchers had obtained multiple grants from the NIH and other government and nongovernment organizations. Many early stage ideas had progressed to useful projects that otherwise would not have save for CIMIT. Over 500 peer reviewed papers had been published, there were 60 patent applications and 20 patents granted and 12 small businesses had been formed to further the initial work funded by CIMIT. There were nine new devices in use for patient care, sixteen in clinical trials and about 30 more in the pipeline. This record demonstrates the return on investment and the value that CIMIT has created with its unique brand of activities.

CIMIT has been an outstanding success and now others are trying to emulate CIMIT such as CASIT and Rutgers – both developed as organizations within one university (UCLA and Rutgers University, respectively) as compared to the many organizations that make up CIMIT. Stanford and Cleveland Clinic have also made substantial progress in creating such an organization. Having a school of medicine and a school of engineering under one university roof makes the development process easier but as CIMIT demonstrated, different organizations can effectively come together.

There is a strong consensus across the country that the CIMIT approach is excellent and that others should follow that approach. Stated differently, it is finally becoming recognized that although basic biomedical science has been and will continue to be critical to the advancement of medical knowledge and patient care, it is the intersection of medicine with engineering and computer science that

¹⁷ Bowen, HK and Purrington, C Center for Integration of Medicine and Innovative Technology [CIMIT], *Harvard Business School Case Study 9-608-036*, November 27, 2007

will equally drive patient care advancements and improvements into the future. Therefore technology-oriented institutes, with CIMIT as the role model, should be developed across the country.

Issue for TATRC:

TATRC is the ideal organization to drive the development of hospital-based organizations to maximize the intersection of medical care with engineering and computer science, ala CIMIT.

Recommendation

TATRC should:

Consider the strengths and weaknesses of its various partners and collaborators and from that analysis, select a few that might effectively create CIMIT-like structures

- Meet with those chosen institutions and key leaders and determine their potential interest.
- From the subset that seem genuinely ready to proceed-
 - Facilitate interactions of key leaders from the various institutions that might make up the consortium.
 - Emphasize the importance of
 - Collaborations, not of control.
 - Cross fertilization, not dominance
 - A focus on engineering and computer science, not basic laboratory science
 - Recognition that success will not be measured in new NIH grants but on devices, patents, publications, industry interest, and philanthropy.
 - The need for each member institution to invest upfront and on a continuing basis.
 - Facilitate interactions of these key leaders with the leadership of CIMIT
 - Assist those that obtain funding to use it most effectively.

13] Recommendations – Next Steps for TATRC [continued]

Given the processes for military hospital construction and renovation, it is important for TATRC to interact with the Army's Health Facility Planning Agency

D] Working with Health Facility Planning Agency [HFPA]

HFPA is responsible for creating the framework for design of new and renovated facilities. It sets out certain standards for design and equipment but does not select specific medical equipment; that being the prerogative and responsibility of the individual facility managers. HFPA does, however, establish certain requirements such as the size of a suite, the type of equipment that it will hold [“laser eye surgery”] and the relationship of that suite to other elements of the facility [“near the OR”, for example].

Although HFPA does not select equipment, it is aware of institutions within the Army that are willing and anxious to serve as “test beds” for new technologies.

Recommendation:

TATRC should maximize these test bed opportunities to insert TATRC-preferred technologies into the military hospital system.

Process:

- TATRC senior management should select the technologies that it most prefers to have enter the military hospital system.
- Meet with HFPA to ascertain which hospitals are willing to serve as test beds and to determine their major interests.
- Meet with Project managers and task them to
 - Interact with their counterpart manager at the individual hospitals to select technologies,
 - Arrange for the commercial vendor to meet with the hospital manager in concert with the Project Manager
 - Follow-up with the hospital manager as to the results of the test bed evaluation

Funding:

Many technologies are commercialized and can be inserted directly through the acquisition process as noted above.

Others are near commercialization or are commercially available but never tested in a military hospital setting. HFPA indicates that it has no funding for such testing but that many of the military hospitals have indicated a desire and willingness to serve as “test beds”. TATRC should consider limited funding to bring a favored technology into the hospital test bed setting for evaluation and modification, if needed, to test whether that technology will meet that particular military hospital’s needs and requirements.

Brief Summary

Medicine is and will continue to change rapidly. Technology will be ever more critical in the “Hospital of the Future” and in medicine overall. TATRC needs to focus on which technologies will be of *greatest value* in the Hospital of the Future and leverage its efforts in those areas. TATRC needs to be cognizant of certain *critical issues in the use of technology* to advance medical care in the future setting of cost constraints, professional shortages, need for quality and safety, responsiveness to patients while recognizing the developing shift from mostly episodic acute illness care to long term care of complex, chronic diseases and, with it, the need for disease-oriented, team-based care management. Technology, used strategically, can enhance productivity, enhance responsiveness to patients, assist in controlling cost, improve safety and quality, enhance access to distant patients, and improve care of complex, chronic illness. TATRC has the opportunity to have a major effect on the future practice of medicine through the application of disruptive technologies which it champions.

Given attention to these directions in medical care and the critical issues surrounding provision of that care, TATRC should marshal its resources to accomplish the greatest good given the people and funding available. This will require strategic planning, critical choices and commitment from leadership and staff.