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Workshop: Healthcare Engineering and Health Services Research: Building Bridges, Breaking Barriers;

Stephen Roberts
North Carolina State University

Reha Uzsoy
North Carolina State University

Julie Ivy
North Carolina State University

Brian Denton
North Carolina State University

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Final Report

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Principal Investigator: Stephen Roberts
Co-PIs: Reha Uzsoy, Julie Ivy, Brian Denton
Organization: North Carolina State University
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EXECUTIVE SUMMARY

On April 6-8, 2008 a workshop was held in Research Triangle Park, North Carolina entitled “Healthcare Engineering and Health Services Research: Building Bridges, Breaking Barriers.” The workshop organizers were North Carolina State University, North Carolina A & T State University, and the Cecil G. Sheps Center for Health Services Research at the University of North Carolina at Chapel Hill. This conference is also the First Annual Symposium sponsored by the Healthcare Engineering Alliance (HEA), whose members are Purdue University, University of South Florida, University of Arkansas, North Carolina State University and North Carolina A & T State University. The workshop was attended by about 150 people from the healthcare systems engineering (HSE) and health services research (HSR) communities from both the local area and nationally.

The two day symposium was launched with presentations by outstanding members of the healthcare systems engineering and health services research communities as well as representatives of the Veteran’s Administration (VA), the Agency for Healthcare Research and Quality (AHRQ), and the National Science Foundation (NSF). During the workshop, presentations encompassed the quality imperative, the effectiveness and efficiency of health care delivery, promoting access, and improving operations. Additional lunch and dinner talks focused on the challenges of how to enhance collaboration between the communities, and how to enhance their contribution to improving healthcare delivery. The formal structure of the conference program supported interaction among participants and provided valuable networking opportunities. Each talk was assigned a discussant who commented upon the talk, creating opportunities for questions and answers. Presenters and discussants were selected from HSE and HSR to encourage contrasting viewpoints.

The general conclusions of the symposium address four fundamental questions. The first is what do HSE and HSR have in common? Clearly both groups have a shared understanding of problems, shared common intellectual assets, shared beliefs in data-driven analysis and decisions, and complementary research methods and tools. In particular, both communities share the goal of helping to achieve a safe, accessible, efficient, patient-centric healthcare system.

The second question is what can HSE learn from HSR? Responses include the recognition that HSR is inherently multi-disciplinary, that health care goals are multi-
dimensional, that data is critical to understanding health care, clinical trials are critical, and in order to have impact scholarship must address many communities and stakeholders.

The third, and possibly the most important, question addressed at the symposium was what can HSR learn from HSE? More generally, how can HSE contribute to the transformation of health care? The most important contribution of HSE is its intrinsic “systems” perspective, with a focus on understanding the operation of large, complex systems in terms of the interactions between their components. In the domain of healthcare delivery, this approach leads to the concept of the care cycle, the set of all preventive and therapeutic care episodes a patient undergoes for a specific condition over time, as the basic unit of analysis. By their nature, care cycles are large, complex, and subject to many different kinds of uncertainties. The methods of HSE provide the HSR community with means to represent uncertainty and to optimize care cycles, instead of focusing on individual care episodes. The traditional application areas of HSE such as operations analysis and management can contribute to improved health care delivery without radical changes to current policy or health care organizations. However, the HSE focus on supporting decision making and decision makers with data-driven, testable models and analysis at the care cycle level emphasizes the need for change agents at the regional and national levels.

The fourth question addressed how the Veteran’s Administration healthcare system (or any health care system) can take the lead in making HSE an active contributor to the HSR community. Because the VA is a unique, self-contained, government sponsored system, it provides an ideal environment for HSE researchers to collaborate with HSR in analyzing entire care cycles for broad populations. This arrangement would allow both communities to jointly demonstrate the value of analysis at the care cycle level, which is a prerequisite for its broader adoption at the national level.

Finally, based on general sentiment of the conference attendees through presentation, discussant commentary, and information conversations, several recommendations are made to the National Science Foundation (NSF) that will incorporate healthcare engineering and its mission into the engineering profession. The recommendations are:

**Recommendation #1:** The National Science Foundation (NSF) should adopt the application of science and engineering to improving the healthcare delivery system as one of its missions,
representing and supporting the engineering community in its efforts to contribute to what is possibly the most important societal problem of our time.

**Recommendation #2:** NSF should create interdisciplinary engineering and science initiatives that complement current “translational research programs” in the NIH and “evidence-based programs” in AHRQ.

**Recommendation #3:** NSF should encourage doctoral students, post-doctoral students, and junior faculty to take up careers in this area by providing Graduate Fellowships and early career funding.

**Recommendation #4:** NSF should direct substantial research in the behavioral sciences towards understanding the problems of effective collaboration between scientific, engineering, clinical and health services disciplines.

**Recommendation #5:** NSF should reach out to other government agencies such as the Veteran’s Administration (VA), the Department of Defense, and the National Institutes of Health to establish a long-term, interdisciplinary funding program directed explicitly at the healthcare delivery system.

**Recommendation #6:** NSF should provide funding opportunities for engineering schools to develop long-term collaborative relationships with academic medical centers (such as the Veteran’s Administration) to form a living laboratory for the multidisciplinary study of problems of importance to national health policy that extend systems engineering methodology.

**Recommendation #7:** As part of its funding opportunities NSF should encourage the study of international health systems and collaboration with international investigators to develop sound options for a health care delivery system design in the U.S.
Introduction

Few would dispute that the rapidly escalating cost of healthcare is one of the most pressing issues facing our nation today. Even a cursory review of the media reveals intense public concern over a healthcare system that can use the most advanced technology to miraculous therapeutic effect, but whose emergent behavior is far from ideal. A number of observations suffice to make the point:

1. The cost of healthcare is more than 15% of the U.S. economy - these costs are growing at more than three times the rate of inflation;
2. Tens of thousands of Americans die and many more are harmed each year by disjointed, malfunctioning healthcare processes;
3. Waste accounts for perhaps as much as 40% of healthcare costs;
4. 46 million citizens lack access to basic care;
5. Fragmentation limits performance; and
6. The healthcare delivery system is complex to the point of straining human comprehension.

Rapidly rising healthcare costs threaten the competitiveness of U.S. manufacturing and service companies in the global economy, creating intense pressure to move offshore. Indeed one can make the case that the best way to help competitiveness prospects for U.S. industries as a whole is to improve healthcare delivery.

The joint National Academy of Engineering/Institute of Medicine (NAE/IOM)\textsuperscript{1} report “Building a Better Healthcare System” makes a compelling, thoroughly documented case for deploying engineering methodology and research in partnership with the health care provider community to improve the delivery of health care. It calls for the establishment of thirty research centers around the country to realize this vision of the engineering profession as an active partner in addressing this burning national issue. While engineers have been actively involved in health care delivery for many years, especially in the development of key technologies in areas such as

imaging, biomedical devices, and information technology, their contributions to the delivery of health care have been much more limited. While many leading hospitals introduced industrial or management engineering groups to improve their operations, these groups were largely phased out over the last two decades due to rising cost pressures and administrative complexity. However, the impact of rising health care costs on the U. S. economy is creating a turning point where health care provider incentives are aligning with the need for cost reduction. The time is ripe for the body of engineering knowledge on designing, modeling, and controlling complex systems to be applied to health care delivery. Currently, this is being done mostly by individual researchers or, at best, small, largely disconnected research groups.

The field of health services research has developed a large following and a substantial body of knowledge, based mostly in medical, public health, and health policy programs. This discipline has focused on issues associated with the equitable and effective delivery of healthcare services. The basic paradigm has been the use of statistical techniques, with the randomized clinical trial forming the main basis for progress. This familiarity with the use of quantitative models to analyze questions related to health care delivery makes the health services research community well suited as an anchor point for collaboration with systems engineers. The use of mathematical and statistical modeling as a predictive tool to support the design of more effective clinical trials, or in some cases even to obviate the need for them, is at extremely early stage. In contrast, the use of advanced models and computational techniques to solve them for optimal policies or resource allocations, the stock in trade of the HSE community, has been common in industrial/systems engineering and operations research for decades. The development, implementation, and transfer into clinical practice of data-driven models to support decisions at different levels of patient care is an area in which industrial and systems engineers and operations researchers can make major contributions, as illustrated by several examples described in this symposium.

**Design of the Symposium**

The discussion above shows a clear need to bring together health services researchers and healthcare systems engineers for them to become familiar with each other’s work, and to discuss how more effective collaboration can be built. The Research Triangle area of North Carolina,
comprising the cities of Durham, Chapel Hill and Raleigh, is an ideal location for several reasons. It is home to two major medical schools, at Duke University and the University of North Carolina at Chapel Hill; major health services research efforts in the School of Health Policy and Administration at UNC, the Cecil G. Sheps Center for Health Services Research at UNC; the Center for Clinical Policy Research at Duke University; the Veterans Administration Center for Health Services Research in Primary Care, located at Duke University; a number of large acute-care hospitals, including WakeMed, the Duke Health network, and the Moses Cone Health Systems. It is also home to North Carolina State University and North Carolina State A&T University, North Carolina’s primary engineering programs, and the two main industrial and systems engineering programs in the state.

Having a large, well-recognized local HSR community is important since many such people are unlikely to travel to attend a workshop they may perceive to be outside their immediate interest, but may be more willing to come if it is in their immediate area. The importance of these groups being nationally recognized is that this enhanced our ability to attract other HSR researchers from around the country, and to disseminate the results of the discussions to the national health services community. Indeed, the efforts of our HSR collaborators were instrumental in bringing to the symposium a number of HSR colleagues from around the country, as well as a number of prominent speakers who greatly enhanced the quality of the symposium.

On the HSE side, the core group invited was drawn from the members of the Healthcare Engineering Alliance (HEA). This is a group is composed of North Carolina State University, Purdue University, the University of Arkansas, the University of South Florida and North Carolina State A&T University whose mission is to develop collaborative research and education programs in healthcare engineering among both the member engineering schools and their various partners in the health care delivery sector. This alliance had already held two workshops among its own members - one at Purdue University in July 2007, another at the University of South Florida in October 2007. The Alliance gives its member institutions access to a truly national network of engineering and health service researchers across four states, incorporating a number of different initiatives in healthcare engineering. These include the Regenstrief Center for Healthcare Engineering at Purdue University; the Cancer Care Engineering Center at Purdue University; and the Center for Improvement in Healthcare Logistics at the University of Arkansas.
While a number of related workshops have been held with National Science Foundation (NSF) support in recent years, none have directly addressed the theme of this workshop, that of bringing together the healthcare engineering and health services research communities. The most closely related is the Health Systems Engineering Workshop organized by Prof. Ronald Rardin at the NSF Headquarters on June 15-16, 2006. The agenda of this meeting was closely aligned with the interests of the health systems engineering community, with limited health services participation. A number of other recent workshops, such as the NIBIB/NHLBI/NSF Workshop on Improving Health Care Accessibility through Point of Care Technologies (April 11-12, 2006), or the NCI-NSF Workshop on Operations Research Applied to Radiation Therapy (February 7-9, 2002), have focused on specific areas of engineering technology addressing health care needs. These have generally not considered the broad system-level issues that are the domain of health services research and which were the focus of this workshop, in order to promote the effective collaboration between researchers in health services and healthcare engineering that is critical to implementing the NAE/IOM Report’s recommendations.

The organizing committee was co-chaired by Professors Stephen Roberts and Reha Uzsoy of North Carolina State University, representing the HEA, and Dr. Tim Carey of the Sheps Center for Health Services Research at the University of North Carolina along with Professor Paul Stanfield of North Carolina A & T State University. Assisting with the local organization were Professors Brian Denton and Julie Ivy of the NC State Edward P. Fitts Department of Industrial and Systems. Help was also solicited from engineering faculty associated with the HEA members, and health services researchers among our partners named above.

**Organization of the Symposium**

The Symposium was organized over three days (an evening, one full day, and one half day). The first evening was a “Pig Pickin’” social event at the NC State campus. Busses brought participants to and from the campus. All other workshop activities took place at the hotel. A single track organization was used to ensure that all attendees could attend all talks, with the intent of promoting discussion among attendees.

Each session lasted 90 minutes, with three 30 minute slots devoted to the speaker, the discussant, and questions/answers from the audience. The speaker presented the assigned topic
during the first 20 minutes allocated. The discussant then had 5 minutes to expound on the topic, in some case with previously formulated remarks, but in most cases responding to the presentation. Each session was assigned a moderator to keep the events in the session on time.

**Session Content**

The Symposium’s sessions were organized about basic health care themes and methods. The Final Program for the Symposium is contained in Appendix A. Presentation materials for the great majority of the speakers are contained in Appendix B.

The first day was inaugurated by a welcome by the conference organizers, a brief description of the Health Care Engineering Alliance (HEA) and a welcome by the Dean of the College of Engineering at North Carolina State University. The first session of the day was aimed at introducing the audience to the two fields through tutorials by leaders in each. The HSE perspective was presented by Professor W. Dale Compton, a Distinguished Professor Emeritus of Industrial Engineering at Purdue University, Secretary of the National Academy of Engineering (NAE) and a primary author of the NAE/IOM report cited earlier. In the HSR area, we were fortunate to have Dr. Eugene Oddone, Vice-Dean of Research at Duke School of Medicine and Director of the Center for Health Services Research at Durham VA. These overviews motivated a number of questions from the audience and provided a clear picture of the two disciplines.

The second session of the morning featured speakers from three of the most important national organizations for Healthcare Engineering and Health Services Research: the Veteran’s Administration (VA), represented by its Director of Health Services Research and Development, Dr. Seth Eisen; the Agency for Healthcare Research and Quality (AHRQ), represented by their Director of Health Information Technology, Dr. Jon White; and the National Science Foundation (NSF), represented by Dr. Cerry Klein, Director of the Service Enterprise Engineering Program. These presentations supported the meeting mission by noting what these organizations are doing to promote the “interface” of HSE and HSR.

The “working lunch” focused on “The Quality Perspective“, an issue common to healthcare engineers and health services researchers. Professor James Benneyan, Director of the Quality and Productivity Laboratory at Northeastern University presented an excellent overview of the area that led to a lively discussion with the audience.

The afternoon session of the first day and the morning sessions of the second day were composed of talks on specific topics thought to be important both in healthcare engineering and
health services research. Each of these talks had “discussants” that could comment on the talk and bring other perspectives to the topic. Generally the discussants stimulated questions from the audience. The program tried to achieve a balance between the different disciplines among the speakers and the discussants, as well as between local and national speakers/discussants. Details of specific talks can be found in the program in Appendix B.

The evening dinner on April 7 provided an opportunity to hear from a distinguished healthcare engineer, Dr. Vinod Sahney, a member of both the National Academy of Engineering and the Institute of Medicine, and a long-time contributor to the healthcare engineering discipline. He focused on the challenges faced by both HSE and HSR in making a difference to health care delivery, and pointed out that uniform application of best-known practices would yield significant improvements in the national healthcare delivery performance. He cautioned, however, that incentives for accepting the status quo are strong and those for a radical transformation of the current system of care are limited.

The morning of April 8, 2008 was devoted to two very important topics: promoting access and improving operations. The “access” theme is often referred to in health services as one of the three principal attributes of health care delivery, along with cost and quality. Yet it is one of the most complex, incorporating not just care capacities but also geography, sociology, and culture along with disparities and diversity in health care. In order to represent as many different perspectives as possible, the access theme was addressed by a panel of participants in addition to individual speakers.

The second morning session of April 9, 2008 was devoted to improving operations, concentrating on the activities of organized health institutions like hospitals, nursing homes, rehabilitation centers, etc. Two themes were persistent. One addressed the methods for identifying and solving operational problems through “lean” and “six-sigma” techniques that emphasize data collection and team problem-solving. The second approach was the use of techniques employed by Industrial Engineers and Operations Researchers in addressing specific problems related to the delivery of health care, especially logistical support like infrastructure and operations scheduling.

The concluding “wrap-up” was offered by Professor Steve Witz, Director of Purdue University’s Regenstrief Center for Healthcare Engineering. He not only summarized several salient points relative to the interface of Healthcare Engineering and Health Services Research,
but also offered several challenges to both communities. We will incorporate some of his remarks later in this report relative to conclusions.

Overall, the symposium occupied one and one-half very full days. Judging by the liveliness of the question and answer sessions, and the difficulty encountered by the moderators in bringing the discussions to a timely close, the program succeeded in generating the discussions which were its primary objective.

**Poster Presentations**

Break times (10:00am – 10:30am on April 8 and April 9 and 3:30pm – 4:00pm on April 8, as well as times before and after lunch and dinner, and before the beginning of each day) were scheduled so that attendees could break briefly from the more formal presentation format. Refreshments were served during the session breaks to encourage more social interaction.

The break times during the conference afforded attendees the opportunities to view and discuss the research posters offered by students from various universities. Having the posters displayed in a separate room adjacent to the main symposium room encouraged attendees to interact with the students and, of course, gave the students a chance to learn from participants. Most of the students travel expenses were paid by the symposium (generally through the NSF support). The students, their institutional affiliations, and their poster titles are listed below:

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anita Vila-Parrish</td>
<td>North Carolina State University</td>
<td>Dynamic Inventory Management of Perishable Inventory with Applications in the Hospital Pharmacy</td>
</tr>
<tr>
<td>Ayca Erdogan</td>
<td>North Carolina State University</td>
<td>Stochastic Optimization of Appointment Based Health Systems with Uncertainty in Patient Demand</td>
</tr>
<tr>
<td>Bjorn Berg</td>
<td>Mayo Clinic</td>
<td>A Systems Engineering Approach to Improve Operational Performance in an Endoscopy Suite</td>
</tr>
<tr>
<td>Bo Zeng</td>
<td>Purdue University</td>
<td>Stochastic Overbooking with Heterogeneous No-show Patients in Clinic Scheduling</td>
</tr>
<tr>
<td>Chaitra Gopalappa</td>
<td>University of South Florida</td>
<td>A Strategy for Removal of Hybridization and Scanning Noise from Gene Expression Values obtained from Microarrays</td>
</tr>
<tr>
<td>Daiki Min</td>
<td>Purdue University</td>
<td>A Stochastic Optimization Model For Elective Surgery Scheduling Under Uncertainty</td>
</tr>
<tr>
<td>Daiki Min</td>
<td>Purdue University</td>
<td>Feasibility study of UHF Passive RFID technology for workflow analysis in a clinical environment</td>
</tr>
<tr>
<td>Eric Sherer</td>
<td>Purdue University</td>
<td>A Mutation Network Model For Predicting CRC Prevalence And Genetic Characteristics</td>
</tr>
</tbody>
</table>
Feng Lin  
Purdue University  
Optimal Implementation of Non-Pharmaceutical Interventions During Pandemic  

Jill Howard Iser  
North Carolina State University  
Hospital Planning: How many PACU beds?  

Jing Yu  
North Carolina State University  
PSA Screening for the Detection of Prostate Cancer  

Laila Cure  
Purdue University  
Near-Miss Dynamic Analysis for Risk Assessment and Error Prevention in Outpatient Settings  

Po-Ching DeLaurentis  
Purdue University  
Game Theoretical Approach for Hospital Stockpiling Problem  

Rebeca Sandino  
Purdue University  
Characterization of Clinical Environments for Patient Scheduling  

Renata Konrad  
Purdue University  
Using Information System Messages to Characterize Patient Flow  

Sejal Patel  
University of Michigan  
Childbirth and Pelvic Floor Dysfunction: An Integrated Decision Analysis  

Serhat Gul  
Arizona State University  
Simulation Based Surgery Scheduling for an Outpatient Procedure Center  

Shao-Jen Weng  
Arizona State University  
A Multi-Tool Integrated Methodology (MTIM) for Efficient Resource Allocation in Healthcare  

Tung Le  
Purdue University  
Kenya Nutrition Distribution System  

Additional information on the poster presentations, including abstracts, is found in Appendix C.

Attendance at the Conference

We made a special effort to promote attendance by students and young researchers at early stages of their careers in engineering and health services by offering to pay their travel expense. The announcement was also sent to the Industrial Engineering (IE) faculty list server, which reached most IE faculty in the country. It was also sent to the membership of the INFORMS Health Applications section.

There was no charge for the registration, but registration was required for attendance (we needed to know who was going to attend, so we could plan for food, refreshments, and space). Fortunately our space was somewhat flexible. We estimated about 150 registrations and actually received 154 registrants. We don’t have an exact count, but we estimate the maximum attendance at about 145, which varied from a low of about 95.

A listing of registrants and their Email addresses is found in Appendix D. However the following lists a number of the institutions represented during registration:
| Agency for Healthcare Research and Quality | North Carolina Hospital Association |
| Arizona State University | North Carolina State University |
| Clemson University | Northeastern University |
| Duke University | Penn State University |
| Duke University Health System | Perkins Eastman |
| Duke University Medical Center | President, BioWarn, LLC |
| Durham VA Medical Center | Purdue University |
| Forsyth County Department of Public Health | Purdue University, e-Enterprise Center |
| French|West|Vaughan | Purdue University, Industrial Engineering |
| Grupo Star Medica - MEXICO | Purdue/NAE |
| Healthcare Facilities and Design | PWI Consulting Engineers, Inc. |
| Hospira | Regenstrief Center for Healthcare Engineering |
| Hospital Star Medica | Regenstrief Institute for Health Care |
| HSBC | Richard L. Roudebush VAMC/HSR&D |
| Indiana University | Roudebush VAMC and IU Center for Health Services and Outcomes Research |
| Indiana University (IUPUI) | RTI Health Solutions |
| Indianapolis VAMC | Seoul National University |
| Mayo Clinic | Sheps Center UNC-CH |
| NC A&T State University, Industrial and Systems Engineering | State University of New York at Binghamton |
| NCSU - College of Textiles | Strayer University/DSP Technology |
| NCSU - OPERATIONS RESEARCH | UNC Chapel Hill MHA Program |
| NCSU - Research and Graduate Programs | UNC Department of Medicine |
| NCSU Dept. of Civil, Construction, and Environmental Engineering | UNC Family Medicine |
| NCSU Edward P. Fitts Department of Industrial Systems Engineering | UNC Hospitals |
| NCSU Industrial Extension | UNC School of Public Health |
| NCSU Economics Department | Univ. of Alabama at Huntsville |
| North Carolina A&T State University | Univ. of Michigan |
| | University of Alabama in Huntsville |
| | University of Michigan - Ann Arbor |
Symposium Sponsors

The symposium’s financial sponsors were:

- National Science Foundation
- Edward P. Fitts Department of Industrial and Systems Engineering
- Cecil G. Sheps Center for Health Services Research
- North Carolina State College of Engineering

Money from these sponsors paid for facilities and equipment rental, meals, refreshments, travel expenses, attendee gifts (ink pens, notepads, tote bags, portfolios, USB drive), symposium organization/management, and advertising/printed materials. Travel expenses for students and a few speakers, facilities and equipment rental, and some faculty time were largely paid from NSF funds. The other items were paid from the cash contributions of the other sponsors.

Summary Conclusions from the Symposium

As expected the symposium touched on many subjects and given the authority of the presenters, revealed many good ideas and observations. It is impossible to do justice to these authors, with their wide range of disciplinary backgrounds, experience and perspectives, in a necessarily brief set of summary conclusions. Consequently we have gleaned what we think are some of the most important conclusions to draw from the presentations. Obviously, these represent our personal viewpoints, but we have tried to express what we felt were widely, if not unanimously, held viewpoints from the conference. We have chosen to organize our summary conclusions around the following questions, similar to the form of the concluding presentation by Prof. Steve Witz of Purdue:

1. What do healthcare engineering and health services research have in common?
2. What can healthcare engineering learn from health services research?
3. What can health services research learn from healthcare engineering?
4. Why is the VA so important to healthcare engineering?

What do healthcare engineering and health services research have in common?

In his closing remarks, Professor Witz noted that Healthcare Engineering and Health Services Research have much in common:

- A shared understanding of problems with the current health care system including: disparity of services to the medically indigent, need for improved service distribution, need for improved quality, need to eliminate inefficiency, recognition of the fragmented health care delivery system, lack of appropriate financing, need for improved prevention, lack of cost containment, and better organization of services.
- Shared common assets with unparalleled depth of expertise
- A shared belief in data-based analysis and decisions
- Potential to share complementary research methodologies including identification and validation of issues of importance, integration of multiple variables into system analyses, clinical trials and hypothesis testing, and modeling.

There is also broad agreement on goals. The NSF/IOM study lists as the achievement of a safe, effective, patient-centered, timely, efficient, and equitable healthcare delivery system as the objectives of HSE research. These goals are shared by health services researchers who cite access, quality, and cost as their primary concerns. Of special interest was the Tuesday morning session on “Promoting Access” which consisted of a Panel on Access and Disparities, a presentation by Jeffrey Spade of the North Carolina Hospital Association on access to healthcare in rural areas, followed by a discussion by Mark Lawley of Purdue University of actual patient scheduling. These discussions ranged from the broad issues of making health care available to creating a way to bring patients into facilities through scheduling. Disparities in health care represent a complex of issues, which should be understood and addressed by healthcare engineers.

What can healthcare engineering learn from health services research?

Although the excitement in healthcare engineering appears as a new phenomenon, the field has been evolving for some time. There appear to be some clear imperatives for healthcare systems engineering that arise from health services research:
• *Health services are inherently multi-disciplinary.* Most health services research programs are multi-disciplinary. The Cecil G. Sheps Center for Health Services Research, co-sponsor of this symposium, is an excellent example, including providers (physicians, nurses, therapists, technicians, etc.) as well as researchers with backgrounds in statistics, epidemiology, sociology, psychology, economics, geography, anthropology, health policy and administration, just to name a few. Most effective health services research projects employ a multi-disciplinary team, not just providers or social scientists. Engineers can take their place on these teams and make valuable contributions, but they will need to learn how to work effectively on teams whose “science” base is different from their own (such as in the social sciences).

• *Health care goals are multi-dimensional.* Health services research often addresses several dimensions of health care such as access, quality, and cost; engineers too often focus on only one of these dimensions. In order to contribute to healthcare delivery, engineers will need to become more comfortable with multicriteria decision problems under uncertainty, which is an active research area with considerable history, but definitely not part of every engineer’s day to day toolkit. For example, determining value for cost is not a single dimensional problem or method. This is an excellent illustration of how work in healthcare delivery can motivate the development of new engineering methodologies, and broadens the skills of engineers.

• *Data is critical to understanding health care.* Health services research recognizes the central role of data and most HSR programs “warehouse” data. For example, the Sheps Centers maintains data bases from Medicare, Medicaid, and some public insurance/finance programs. They are also active in the design and maintenance of administrative and clinical data bases for the various hospitals, clinics, and centers within the University of North Carolina medical system. Their faculty and staff regularly interrogate national data bases maintained by the Center for Medicare and Medicaid Services, the National Center for Health Statistics, and various data warehousing groups in the National Institutes for Health. Engineering rarely attempts to house and maintain data bases. Engineers must use data in model-building and for analytics, but rarely contribute to medical informatics. Clearly the engineering community will have to give
greater attention to the sources of data and methodologies for compiling and integrating data in order to contribute effectively to healthcare delivery.

- **The central role of the clinical trial.** Perhaps the most important means of discovery and “proof” in health services research is the clinical trial, an experiment which has a clearly stated hypothesis and whose results will be statistically examined. This experiment will be an actual trial of the innovative or belief, tested with real patients in a real health system. If properly executed, the result of a clinical trial creates conclusive findings. So important are clinical trials that they are often repeated in order to confirm findings. The results of a well developed clinical trial changes the way health care is delivered and sends a powerful message to the stakeholders in the health care community. Engineers need to understand the issues in the design and implementation of clinical trials, and direct their efforts to complement and support their effective implementation.

- **Scholarship needs to be disseminated to a broad range of interested disciplines.** Health services research is published both within and outside the health services research community. For example, within the community are journals such as *Health Services Research, Medical Care, Medical Decision Making, American Journal of Public Health,* and *Health Economics.* However health services research is found in virtually every health and medical disciplinary journal. It is this willingness to publish “outside” the academic discipline that makes health services research quite different from engineering. Engineers typically publish in “engineering” journals and are academically encouraged to maintain a strong disciplinary presence. It will be important that healthcare engineering research appear in a variety of health care journals if the discipline is to become widely recognized and if it is to influence health care.

*What can health services research learn from healthcare engineering?*

In considering this question, the issue of “hubris” was raised by one of the speakers, suggesting that that engineering needs to “earn” a role in health care research. There can be no argument that the engineer’s role in medical technology development has been critical and continues to be so, with the advent of better imaging, nano-technology, and computing. Biomedical engineering in devices and equipment is a source of innovation and better adaptation for human use such as biomaterials and in rehabilitation. However the issue is whether
engineering can contribute to the discussion of health care delivery and, if so, how? It was the position of almost all the presenters in this conference that healthcare engineering could contribute in several important ways, including:

- **The “systems” perspective or “care cycle”**. Peter Fabri of the University of South Florida, who is both a surgeon and an engineer, illustrated this perspective with the following diagram:

  ![Diagram of the Care Cycle](image1)

  ![Diagram of Episode of Care](image2)

  ![Diagram of Interventions](image3)

Most health care perspectives are at level 2, the episode of care, or level 3, the individual intervention. Some care perspectives are even focused on aspects within an individual intervention, such as the function of an individual nurse or doctor. Systems engineers would advocate a “care cycle” perspective, from the “onset” to the “resolution”. At this level, “onset” should be the consideration of the conditions of onset (etiopathy) as well as the onset itself. Analysis should include all episodes and interventions. The point of this systems perspective is that “care” can be limited as in the case of a episodic illness, but is often continuous, as in the case of a “chronic” illness, lasting even until death. It is important to note that an increasing portion of the U. S. expenditure on health care is due to chronic diseases, underlining the importance of the care cycle perspective to the national wellbeing.

- **Care cycle models provide augmented insight**. Numerous presenters, especially those on Monday afternoon, demonstrated that mathematical, statistical, and computer models can generate insights and information not obtainable from clinical trials. This model-based method may be the greatest contribution provided by the healthcare systems engineering
community. In his presentation, José Zayas-Castro of the University of South Florida offered the following interpretation:

Here “modeling” is the output of the basic health care research and leads to improved health care, which, in turn, causes new problems to be identified and eventually become the subject of research.

- **Healthcare engineering methods.** In her presentation at the Symposium, Anita Brogan of the Research Triangle Institute described healthcare engineering in their firm as involving (1) Operations Research/Industrial Engineering, (2) Public Health/Health Services Research/ Medicine, and (3) Economics. A major means of evaluation is cost-effectiveness models, which are certainly not exclusive to healthcare engineering. However these models incorporate decision analysis, regression, Bayesian analysis, and/or life-table analysis, which are techniques more closely associated with healthcare engineering. Julie Ivy of NC State, offered the following list of modeling tools: (1) stochastic modeling, (2) Markov Decision Processes (MDP), (3) Partially observable (hidden) MDP, and (4) optimization as ways to handle decision making under conditions of uncertainty. It is clear that uncertainty describes many of the problems in health care, related to the disease and to the care delivery process. Means to simulate and to optimize systems under uncertainty play a prominent role in healthcare methods.

- **Decision Making and Decision Makers.** One of the features that distinguish healthcare systems engineering is the emphasis on decisions and decision-making. The implication of this interest is that healthcare systems engineering produces change through a
decision-maker. But who are the decision makers in health care delivery? The presentation by Julie Ivy of North Carolina State University and the discussion by Jennifer Wu of Duke University show that healthcare engineering models change depending on the decision maker. Decision makers can be patients who desire health care in order to maximize their health and longevity. Alternatively, they may be doctors and health care providers who give service to patients and whose income provides for their own families and the operation of a facility. The managers of health care institutions and health care systems whose care for a wider group of patients means larger influence in the health care community and the opportunity to take advantage of economies to scale are another such constituency. Another group of decision makers may be third party payers, including governmental entities, who reimburse providers and institutions for services rendered, but must be constrained to some “bottom line” that maintains the economic viability of their organization. In his presentation, Vinod Sahney from Blue-Cross Blue-Shield, described the many attempts at healthcare engineering that were ignored simply because the “incentives” of the decision makers were not consistent with the goals of the healthcare engineering activity. It is sometimes argued that the rise and fall of “hospital industrial engineering” can be related to the lack of adequate financial incentives in health care, in which reimbursement does not benefit the cost conscious. It has been argued that environments that “pay for performance” or provide “capitation” might be more receptive.

- **Implementing Healthcare Engineering.** Without question, one of the most significant challenges in transforming health care is the implementation of healthcare engineering. Few models better demonstrate the success than the presentation by Heather Woodward-Hagg of the Indianapolis Veterans Administration, on “Creating Sustained Quality Improvement in Healthcare Organizations.” She discussed the “focus on partnership with hospitals and healthcare providers to provide facilitation in the application of systems engineering methods to enable sustainable change.” Her work represented over 40 projects completed, 5 on-going, in 23 hospitals, and 9 hospital systems. Her results are astounding in that she experienced a: 80% implementation rate, 81% implemented projects sustained at 9-12 months, and 65% of implemented projects showed good spread. She argues that there are three concepts central to system transformation: (1)
Integration: training, aligning reinforcements with new behaviors, or assigning responsibilities, (2) Sustainability: maintaining gains in safety and quality as well as maintaining support for change, and (3) Spread: requires supportive infrastructure for sharing successful redesign experiences. For her, the key factors were:

- Focus on enabling the cultural transformation, rather than building technical skills
  - Simplify, Simplify, Simplify
  - Require immediate application
  - Use readily accessible materials
  - Use healthcare terms and examples rather than those from Lean Manufacturing

- Facilitate through repeated applications of tools for at least 2 additional cycles

Her work (and that of the discussant William Burton) demonstrates that change can be accomplished. However, creating a culture of change requires a commitment to that change through interdisciplinary partnerships and doing whatever is needed (even if it goes beyond your disciplinary boundaries).

- **Operational Analysis and Management.** A traditional emphasis in Industrial Engineering has been the analysis and management of operations or processes. In fact, the term “operations research” was invented to refer to the analysis of operations. Over many years the study of operations has resulted in a large body of knowledge relative to operations and processes for many industries. Ron Rardin of the University of Arkansas highlighted the theme of improving healthcare supply chains and logistics, which he called the “back office of healthcare.” Examples included patient safety through unit-dose medications, healthcare supply chain simplification, improvements in healthcare logistics, dock-to-patient hospital supply chain digitalization, procedure pack supply chains and customization, and logistical support of rural and home care. He pointed out that many of these changes do not require transformational changes to health care and, while different from those encountered in other industries, the problems share many aspects. Likewise, considering the cost of health care, hospitalization costs compose the highest single segment, and within the hospital, surgery is the highest cost unit. Consequently the use of surgical facilities and their related support units like PACU pose significant challenging problems. Brian Denton presented a series of open problems
related to the design and operation of surgical care delivery systems, such as the creation of a new generation of reconfigurable surgical suites. He highlighted opportunities for the use of stochastic optimization methods to study these problems.

*Why is the VA so important to Healthcare Engineering?* Presentations by Dr. Eugene Oddone from the Durham VA and Dr. Seth Eisen from the national VA provided numerous references to “systems” problems within the VA services. It is significant that the VA is the only “self contained” US government health care system. There are many private systems like Mayo Clinics, Kaiser-Permanente, etc. that have a panel of patients who look to that system for their care. Yet probably none of these provide all the care that person obtains. The VA system does serve a distinctive patient population and they have somewhat unique relationships with medical schools and doctors who provide much of the medical care. Nonetheless, this system is the closest thing to a national health system as exists at present in the US. As such it presents tremendous opportunity for healthcare engineering to develop and apply systems engineering technology and to demonstrate sustainable changes in an ongoing, important health care delivery system.

**Recommendations to the National Science Foundation (NSF)**

An important objective of the Symposium was to identify roadblocks to effective collaboration between healthcare systems engineering (HSE) and health services researchers (HSR) in addressing the widely recognized problems of the U. S. healthcare sector. These recommendations are intended to suggest direction and content for NSF, specifically how NSF can help facilitate interaction between different research communities and constituents to address the gap between health care capability and health care delivery.

While the U.S. has long been a world leader in research in medical, biomedical, informatics, and other areas of engineering, the U. S. healthcare system is widely recognized both at home and abroad as delivering lower quality care at higher cost than many other developed countries. This suggests, quite simply, that the massive research funding directed towards medicine, health services, the life sciences and disciplines such as biomedical engineering has,
while creating an enormous base of health care knowledge, not produced the effective, efficient, safe healthcare delivery system the nation desires and deserves. Something is missing.

Our discussions at this symposium, as well as several prior studies, suggest that at least part of the problem is that healthcare delivery is not understood as a system. The healthcare delivery environment in this country has emerged over the years from the collective actions of a wide range of different actors: regulators, providers, institutions, insurers, pharmaceutical firms, employers providing healthcare benefits for their employers, and patients. While each individual actor is often operating at the leading edge of their particular field, the overall process of healthcare delivery to patients has never been considered as a whole, leading to considerable waste and redundancy due to poor communication, suboptimization of individual components and sub-processes, and incompatible incentives between the different actors. The fragmented industrial organization of this sector, with a vast number of different entities operating for their own perceived benefit, militates against any attempt to understand the overall picture and try to improve it, which is precisely the domain of systems engineering. The successes of the engineering disciplines in designing, operating and continually improving large socioeconomic systems such as space missions, global supply chains, and the global air traffic system suggest that the systems engineering community has the potential to make substantial contributions to the delivery of health care. In any case, the systems viewpoint needs to be pursued.

There was broad consensus at the Symposium that lack of funding mechanisms was a major barrier to effective collaboration between healthcare systems engineering and health services researchers. The most natural funding agencies to support such collaborations are the National Science Foundation (NSF) and the National Institutes of Health (NIH). The broad charge in the formation of the National Science Foundation in 1950 was “to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...” (emphasis on “national health”). NIH (National Institutes of Health) was formed with a narrower mission, namely “to improve the health of the people of the US”. There are significant operational differences between the two agencies. NSF is an independent federal agency while NIH is a cabinet-level agency and therefore tends to be more influence by governmental directives. NSF has two grant submission/review cycles each year, while NIH has three. NSF does not typically issue Program Announcements or Requests for Applications as does NIH; NSF announcements tend to be restricted to broad programs. Finally, NSF research grants primarily
support graduate students and some summer faculty time, whereas NIH grants are much larger and investigators are expected to show significant effort. In 2007 the NSF budget was $6.2 billion, dwarfed by the NIH budget at $28.6 billion.

Despite the prominence of “health” in both their mission statements, neither agency has taken a leading role in supporting healthcare systems engineering. Each agency appears to perceive healthcare systems engineering to be more naturally part of the other’s mission. NSF has carefully avoided accepting any mission dealing with health. Furthermore, some in the NIH community regard its mission as “health” and not “health systems engineering.” Thus healthcare systems engineering is left in a no man’s land between these agencies. It is thus little wonder that when the NAE/IOM report called for the creation of multidisciplinary healthcare engineering centers, there was little governmental response. When another NSF-sponsored workshop held June 15-16, 2006 concerning “Research Agenda for Healthcare Systems Engineering” reiterated the need for such funding programs, there was again no response from government agencies.

It is not surprising that no individual agency is willing to accept the healthcare engineering charge. Since the healthcare delivery system is so fragmented, there is no powerful, unified constituency for a system-wide effort to understand and rationalize healthcare delivery. There are many different, vocal stakeholder groups, who often engage in active lobbying efforts for their particular interests. The problem is highly complex and multidisciplinary in nature, rendering it unlikely that any individual agency or discipline can contribute a transformative solution within its currently defined scope of operations; a truly multidisciplinary effort commensurate with the national urgency of the problem would require resources beyond the means of any individual agency, even one as large as NIH.

However, in this year of politics and introspection, the increasing cost of health care has emerged as one of the nation’s most prevalent concerns, spanning many different segments of society. The increasing cost of healthcare has become a burden on U.S. companies, limiting their ability to compete in the global economy and creating significant pressure to move jobs offshore. The problem is simply too important to leave any possible solution avenue unexplored. Hence the current, indeterminate status of systems engineering efforts to contribute to the resolution of the healthcare problem is simply unacceptable in the long run. The magnitude of the problems faced by the nation’s healthcare sector, and the impact of those problems on the nation’s physical and economic wellbeing, are such that any sustainable solution must be reached by a national debate.
among all concerned stakeholders, conducted through the social and political processes that define this nation. In this environment, the role of the systems engineering community is to collaborate with other disciplines to help all of us understand the problem as a whole, and the possible consequences of different decisions on all the different parties concerned, so that this debate may take place with the best information available, based on data and transparent, testable assumptions. We are convinced that this effort would make significant contributions to the national wellbeing, and thus is completely consistent with the NSF’s larger mission.

We thus propose the following recommendations for the National Science Foundation, which we believe will position the NSF as a leader in initiating a concerted effort to address the current problems in healthcare delivery:

**Recommendation #1**: The National Science Foundation (NSF) should adopt the application of science and engineering to improving the healthcare delivery system as one of its missions, representing and supporting the engineering community in its efforts to contribute to what is possibly the most important societal problem of our time.

Many of the science and engineering disciplines currently supported by NSF can, and do, contribute to different aspects of healthcare on a regular basis. However, it is crucial that study of the larger healthcare delivery system, rather than individual episodes of care (e.g., radiation therapy for treating cancer) or system components (e.g., operations of hospitals or clinics) be the focus of a concerted, long-term interdisciplinary effort. Ideally healthcare engineering would reside at the “director” level within NSF and would span the NSF organizational chart, reflecting the fundamental interdisciplinary nature of its mission. NSF should use healthcare engineering to bring research attention to this national need and use this mission in its programs to enhance engineering in its service to the nation.

It is hard to imagine that a concerted effort to address such a crucial problem of national interest would not lead to significant advances in engineering and related disciplines. The active engagement of the engineering community in attacking a problem of such obvious societal relevance will also help recruit the best students and researchers to engineering. Good students who wish to contribute to society by addressing healthcare needs often do not see their solution
through engineering, and thus do not consider engineering for a career. This feeling is especially pronounced in women and minorities who compose a major target for engineering recruiters.

A specific mechanism by which NSF might initiate this effort would be through a two-phase initiative similar to that in Scalable Enterprise Systems (NSF99149) launched several years ago. This would involve a broad call for proposals by interdisciplinary groups focused on specific aspects of healthcare delivery. Initial awards of, say, $300,000 for two years would be made to a number of contenders. The winners of these initial awards would then compete for a few larger awards that would hopefully form the basis for a sustainable center effort in this area. The Engineering Research Center (ERC) and Science and Technology Center (STC) programs could also serve to support such an initiative.

**Recommendation #2:** NSF should create interdisciplinary engineering and science initiatives that complement current “translational research programs” in the NIH and “evidence-based programs” in AHRQ.

Throughout NIH there are a number of programs which focus on “translational” research – sometimes called “from bench to bedside” programs whose goal is to translate basic clinical research (“the bench”) into clinical practice (“the bedside”). Translation in this case closely corresponds to healthcare engineering. To complement the “bench to bedside”, healthcare engineering could initiate “from bedside to care system”. In other words, healthcare engineering would bring the system focus to the translational theme. Likewise the “evidence-based” research program within the Agency for Healthcare Research and Quality (AHRQ) could be complemented by a healthcare engineering component that takes evidence in clinical practice and translates it into evidence for health care system transformation. This activity would identify “best practices” and “implementation research” that could be replicated throughout the existing health care delivery system. Such NSF initiatives, some perhaps jointly funded with NIH and AHRQ, would leverage the work going on in health services disciplines and create teams of engineering and health services researchers that can collaborate effectively.

**Recommendation #3:** NSF should encourage doctoral students, post-doctoral students, and junior faculty to take up careers in this area by providing Graduate Fellowships and early career funding.
Disciplinary study and research provides the foundation of advances in science, engineering, and technology, yet disciplinary work can become myopic and sometimes miss the forest for the trees. Health care delivery is a forest of issues, but a forest of opportunity. The symposium demonstrated that engineering and health care can complement each other’s interests and lead to important advances in understanding the care cycle. However, incentives are needed for doctoral students and early career faculty to risk moving beyond traditional disciplinary boundaries. Hence funding for these individuals can have long-term consequences, gaining them professional recognition for their promotion and tenure and providing resources at the critical juncture of their careers where they establish a research program in healthcare systems engineering.

**Recommendation #4:** NSF should direct substantial research in the behavioral sciences towards understanding the problems of effective collaboration between scientific, engineering, clinical and health services disciplines.

It is no secret that past attempts by engineers to engage the health care delivery community have failed to live up to expectations. All too often the problem is how to generate effective collaboration. The strong science orientation of the scientific, engineering, and technical community combined with its tendency to rely on a clear decision-making process often leads to poor collaboration with health services disciplines whose practices require negotiation and compromise among decision-makers. Yet the evidence presented in the symposium demonstrates that effective collaboration is possible and suggests there is great potential. How can this success be duplicated? What are the elements that somehow bridges the gaps in health care delivery and allows the kind of work that can be done in science and engineering to impact the discussions surrounding health care delivery?

**Recommendation #5:** NSF should reach out to other government agencies such as the Veteran’s Administration (VA), the Department of Defense, and the National Institutes of Health, to establish a long-term, interdisciplinary funding program directed explicitly at the healthcare delivery system.

As discussed above, the magnitude of the problem in healthcare delivery is such that any individual agency is unlikely to be able to affect a transformative breakthrough within its routine
operations. Hence we recommend that NSF explore the creation of a long-term interagency funding program directed specifically at understanding and improving the healthcare delivery system. Ideally this would be funded jointly by several agencies, along the lines of the Small Business Innovative Research (SBIR) program; and governed jointly by these agencies. Another possible mode of organization, although more complex to organize and manage, would be a public-private consortium similar to SEMATECH, which was formed to enhance the competitiveness of the U.S. semiconductor industry in the face of heavy competition from the Far East. Such an interagency body could leverage the complementary capabilities of different agencies to carry out research programs that would be beyond the capability of any individual agency.

The creation of such an entity is clearly an involved, time-consuming process; but the urgency of the problem requires such a solution. NSF leadership in this process will place the engineering community in general, and the systems engineering community in particular, in a role they have played successfully in many domains – that of system integrators who collaborate with colleagues from many areas to produce an effective, efficient system whose operation is more than the sum of its parts.

**Recommendation #6:** NSF should provide funding opportunities for engineering schools to develop long-term collaborative relationships with academic medical centers (such as the Veteran’s Administration) to form a living laboratory for the multidisciplinary study of problems of importance to national health policy and that extend systems engineering methodology.

Unlike NSF, NIH has substantial intramural research including research laboratories, staff, and facilities. Nevertheless, there are many needs for “test beds” or “living laboratories” that provide opportunity to examine problems of importance to health policies and extend systems engineering methodology. Considerable opportunity exists at academic medical centers and Veteran’s Administration hospital systems. These facilities often exemplify the kinds of systems problems that need to be addressed.

The Veteran’s Administration would be an ideal initial partner for the establishment of actual healthcare engineering, especially though their Office of Research and Development, Health Services Research and Development Service. The relationship with the VA could be
further strengthened through the VA Office of Academic Affairs to create partnerships between various VA centers of excellence and local university engineering programs.

**Recommendation #7:** As part of its funding opportunities NSF should encourage the study of international health systems and collaboration with international investigators to develop sound options for a health care delivery system design in the U.S.

Care cycles in the U.S. tend to be similar to those in other developed countries. Yet the care systems are quite different and the integration of the care cycle within the care system can be quite dissimilar. Since the overall system performance characteristics of the U.S. health care system appears so inferior to other systems with similar care cycles, it would be highly beneficial to understand how the integration of the care cycles can be made more effective and efficient within the U.S.

All these recommendations incur many organizational and financial challenges since they require people to move out of their “comfort zone” and confront institutional boundaries. Yet if the health care delivery system is to be transformed, shouldn’t engineering be held to its historic mission of “service to the nation?”
Appendicies

A: Symposium Final Program
B: Symposium Speaker Slides
C: Symposium Posters
D: Symposium Registrants
Appendix A:
Symposium Final Program
The Healthcare Engineering Alliance (HEA)

First Annual Healthcare Engineering Symposium
on the Interface of Health Services Research and Healthcare Engineering

Organized locally by:

North Carolina State University Edward P. Fitts Department of Industrial and Systems Engineering
North Carolina A&T State University Department of Industrial and Systems Engineering
University of North Carolina at Chapel Hill Cecil G. Sheps Center for Health Services Research

Sponsored by:
### SYMPOSIUM SCHEDULE

**The Interface of Health Services Research and Healthcare Engineering**

#### Sunday, April 6, 2008

<table>
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| 5:00 p.m. | Pig Pickin' Evening Social Event  
NCSU Campus |

#### Monday, April 7, 2008 • Morning I Session: Fundamental Issues

**Moderator:** Stephen D. Roberts (PhD), Professor of Industrial and Systems Engineering, North Carolina State University

<table>
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<tr>
<td>8:00-8:15 a.m.</td>
<td>The Healthcare Engineering Alliance (HEA) and Local Organizers</td>
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| 8:15-8:30 a.m. | Welcome to Research Triangle Park  
Speaker: Louis Martin-Vega (PHD)  
Dean, College of Engineering  
Professor of Industrial and Systems Engineering  
North Carolina State University |
| 8:30-9:10 a.m. | Healthcare Engineering  
Speaker: Dale Compton (PhD)  
Professor Emeritus  
School of Industrial Engineering  
Purdue University |
| 9:10-9:50 a.m. | Health Services Research  
Speaker: Eugene Oddone (MD)  
Professor of Medicine  
Vice Dean for Research, Duke School of Medicine  
Director, Center for Health Services Research at Durham VAMC  
Duke University |
| 9:50-10:00 a.m. | Questions from the Audience |
| Break: | Poster Session :: Rooms D & E |

#### Morning II Session: National Perspectives

**Moderator:** Joe Pekny (PhD)  
Professor of Chemical Engineering  
Director, e-Enterprise Center  
Purdue University

<table>
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<tr>
<th>Time</th>
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| 10:30-10:55 a.m. | Veterans Administration (VA)  
Speaker: Seth Eisen (MD)  
Director of Health Services Research and Development  
Department of Veterans Affairs |
| 10:55-11:20 a.m. | Agency for Healthcare Research and Quality (AHRQ)  
Speaker: Jonathan White (MD)  
Director of Health Information Technology (Health IT) Portfolio  
Federal Agency for Healthcare Research and Quality (AHRQ) |
| 11:20-11:45 a.m. | National Science Foundation  
Speaker: Cerry Klein (PhD)  
Program Director for Service Enterprise Engineering  
National Science Foundation |
| 11:45-noon | Questions from the Audience |
### Afternoon I Session: Effectiveness of Healthcare Delivery

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<th>Time</th>
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| 12:15-1:15 p.m. | Working Lunch – The Quality Imperative :: Room H (3rd Floor) | Speaker: Jim Benneyan (PhD)  
Associate Professor of Mechanical and Industrial Engineering  
Director of Quality and Productivity Lab  
Northeastern University |
| 1:30-2:00 p.m. | Methods of Cost-Effectiveness               | Speaker: Anita Brogan (PhD)  
Senior Director of Health Economics  
RTI Health Solutions  
Research Triangle Park |
|               | Discussant: Peter Fabri (MD-PhD)            | Professor of Surgery, USF Health  
Associate Dean for Clinical Affairs and for Graduate Medical Education  
University of South Florida |
| 2:00-2:30 p.m. | Turning Results into Clinical Practice       | Speaker: Brad Doebbeling (MD)  
Professor of Health Services Research and Medicine, IU Medical School  
Director of Health Services Research at Regenstrief Institute  
Director of VA Health Service Research and Development at Roudebush VA  
Indiana University |
|               | Discussant: Reha Uzsoy (PhD)                | Clifton A. Anderson Distinguished Professor of Industrial and Systems Engineering  
North Carolina State University |
| 2:30-3:00 p.m. | Influencing Policy and Decision-Makers      | Speaker: David Matchar (MD)  
Professor of Medicine  
Director of Center for Clinical Health Policy Research  
Duke University |
|               | Discussant: Kristen Lich (PhD)              | Assistant Professor of Health Policy and Administration, School of Public Health  
University of North Carolina at Chapel Hill |
| Break         | Poster Session :: Rooms D & E                |                                                                         |
Afternoon II Session: Efficiency of Healthcare Delivery

Moderator: Brian Denton (PhD)
Assistant Professor of Industrial and Systems Engineering
North Carolina State University

3:30-4:00 p.m. Effectiveness and Efficiency in Healthcare
Speaker: Julie S. Ivy (PhD)
Assistant Professor of Industrial and Systems Engineering
North Carolina State University

Discussant: Jenifer Wu (MD, MPH)
Assistant Professor of Obstetrics and Gynecology
Duke University

4:00-4:30 p.m. Disease Management through Modeling
Speaker: José Zayas-Castro (PhD)
Professor and Chair of Industrial and Management Systems Engineering
University of South Florida

Discussant: Marie Davidian (PhD)
William Neal Reynolds Professor of Statistics
Director of the Center for Quantitative Sciences in Biomedicine
North Carolina State University

4:30-5:00 p.m. Making Treatment Decisions
Speaker: Michael Pignone (MD)
Associate Professor of Medicine
Director of Medical Practice and Prevention at Sheps Center for Health Services Research
University of North Carolina at Chapel Hill

Discussant: Hari Balasubramanian (PhD)
Research Associate for Healthcare Policy and Research
Mayo Clinic

6:30-8:30 p.m. Dinner – Challenges: What Needs to be Done? :: Room H (3rd Floor)
Introduction of Speaker: Paul Cohen (PhD)
Head and Edgar S. Woolard Distinguished Professor of the
Edward P. Fitts Department of Industrial and Systems Engineering
North Carolina State University

Speaker: Vinod Sahney (PhD)
Senior Vice President and Chief Strategy Officer
Blue Cross and Blue Shield of Massachusetts
Adjunct Professor of Health Policy and Management, Harvard University
Tuesday, April 8, 2008 · Morning I Session: Promoting Access

Moderator: Julie S. Ivy (PhD)
Assistant Professor of Industrial and Systems Engineering
North Carolina State University

8:00-9:00 a.m. Panel on Access and Disparities
Panel Leader: Paul Stanfield (PhD)
Chairperson and Associate Professor of Industrial and Systems Engineering
North Carolina A&T State University

Discussants:
Dorothy Browne (DrPH)
Director of the Institute for Public Health
North Carolina A&T State University

Robert Millikan (PhD, DVM)
Associate Professor of Epidemiology, School of Public Health
University of North Carolina at Chapel Hill

Peggye Dilworth-Anderson (PhD)
Professor of Health Policy and Administration, School of Public Health
Director, Center for Aging and Diversity
University of North Carolina at Chapel Hill

Alvin E. Headen, Jr. (PhD)
Associate Professor of Economics, College of Management
North Carolina State University

9:00-9:30 a.m. Improving Patient Access
Speaker: Jeffrey Spade (MHA)
Executive Director, NC Rural Health Center
North Carolina Hospital Association

Discussant: Fay Cobb Payton (PhD)
Associate Professor of Information Technology, College of Management
North Carolina State University

9:30-10:00 a.m. Patient Scheduling
Speaker: Mark Lawley (PhD)
Associate Professor of Biomedical Engineering
Purdue University

Discussant: Shelly Qu (PhD)
Assistant Professor of Industrial and Systems Engineering
North Carolina A&T State University

Break: Poster Session :: Rooms D & E
Morning II Session: Improving Operations

Moderator: Reha Uzsoy (PhD)
Clifton A. Anderson Distinguished Professor of Industrial and Systems Engineering
North Carolina State University

10:30-11:00 a.m. Methods and Models for Operations Improvement
Speaker: Heather Woodward-Hagg (PhD)
Research Scientist, VA HSR&D Center of Excellence on Implementing Evidence-based Practice
IU Center for Health Services and Outcomes Research
Regenstrief Center for Healthcare Engineering, Purdue University
Discussant: William Burton (MS)
Director of Performance Services
Duke University Hospital

11:00-11:30 a.m. Logistics and Supply Chain
Speaker: Ronald Rardin (PhD)
John and Mary Lib White Systems Integration Chair
Director of Center on Innovation in Healthcare Logistics
Distinguished Professor and Interim Head of Industrial Engineering
University of Arkansas
Discussant: Lauren Davis (PhD)
Assistant Professor of Industrial and Systems Engineering
North Carolina A&T State University

11:30-12:00 p.m. Design and Operation of Surgical Suites
Speaker: Brian Denton (PhD)
Assistant Professor of Industrial and Systems Engineering
North Carolina State University
Discussant: Sarah Root (PhD)
Assistant Professor of Industrial Engineering
University of Arkansas

12:00-12:30 p.m. Wrap-Up – Understanding Each Other
Speaker: Steve Witz (PhD)
Director of Regenstrief Center for Healthcare Engineering
Purdue University
### Monday, April 7, 2008, Morning I Session: Fundamental Issues

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#### Moderator: Stephen D. Roberts (PhD), Professor of Industrial and Systems Engineering, North Carolina State University

Stephen D. Roberts has been a Professor in the Edward P. Fitts Department of Industrial and Systems Engineering at NC State since 1990 and for nine years served as Head of the department. He spent four years on the faculty at the University of Florida, 18 years as a joint Professor at Purdue University School of Industrial Engineering and at Indiana University School of Medicine Department of Medicine and was Director of Health Systems Research Group at Regenstrief Institute for Healthcare. His general research interests are in discrete-event simulation and the modeling of medical decisions. He has conducted cost-effectiveness research on end stage renal disease, oxygen therapy, diabetes immunization, hypertension, chlamydia, renal revascularization, myocardial infarction, and renal artery stenosis, among others. His current research is in probabilistic cost-effectiveness of screening methods for colorectal cancer. He received his BSIE, MSIE, and PhD from Purdue University in IE.

#### 8:00 – 8:15 a.m.

**The Healthcare Engineering Alliance (HEA) and Local Organizers**

#### 8:15 – 8:30 a.m.

**Welcome to Research Triangle Park**

**Speaker:** Louis Martin-Vega (PhD), Dean, College of Engineering; Professor of Industrial and Systems Engineering, North Carolina State University

Dean Louis A. Martin-Vega came to NC State in 2006 after spending nearly five years as professor and Dean of Engineering at the University of South Florida. Prior to joining USF, Martin-Vega held several prestigious positions, including serving as acting Head of the Engineering Directorate at the National Science Foundation (NSF); Director of NSF's Division of Design, Manufacture and Industrial Innovation; and Chair of the Department of Industrial and Manufacturing Systems Engineering at Lehigh University. He also served as Lockheed Professor in the College of Engineering at the Florida Institute of Technology and directed the University of Florida's Center for Electronics Manufacturing, in addition to serving as a Professor in the ISE Department. He also held a tenured faculty position at the University of Puerto Rico at Mayaguez. His research and teaching interests are manufacturing, logistics and distribution, operations management, and production and service systems.

#### 8:30-9:10 a.m.

**Healthcare Engineering**

**Speaker:** Dale Compton (PhD), Professor Emeritus, School of Engineering, Purdue University

Dale Compton is the Lilian M. Gilbreth Distinguished Professor (Emeritus) of Industrial Engineering at Purdue University. From 1961-70, he was at the University of Illinois at Urbana-Champaign as a Professor of Physics. From 1965-1970, he was Director of the Coordinated Science Laboratory. From 1970-86, he was with the Research Laboratories of the Ford Motor Co.—the last 13 years as Vice-President Research. He was the first Senior Fellow of the National Academy of Engineering before joining Purdue. He is currently a member of St. Vincent Hospital (Indianapolis) Quality Committee and a past member of the IHI National Advisory Committee on Pursuing Perfection. Since 2000, he has served as Home Secretary for the National Academy of Engineering.
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<th>Time</th>
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| 9:10-9:50 a.m. | **Health Services Research**  
Speaker: Eugene Oddone (MD), Professor of Medicine and Vice Dean for Research, Duke School of Medicine; Director, Center for Health Services Research at Durham VAMC, Duke University  
Eugene Z. Oddone, MD, MHSc, is the Director of the Center for Health Services Research in Primary Care at the Durham VAMC and Professor of Medicine and Vice Dean for Research at Duke University School of Medicine. Dr. Oddone’s research interests include health services research focusing on access and disparities in healthcare as well as testing novel interventions designed to improve process and outcomes of care for patients with chronic medical illness. He was the recipient of the VA’s Undersecretary’s Award for distinguished achievement in health services research. |
| 9:50-10 a.m. | **Questions from the Audience**  
Monday, April 7, 2008, Morning II Session: National Perspectives |
| 10:30-10:55 a.m. | **Veterans Administration (VA)**  
Speaker: Seth Eisen (MD), Director of Health Services Research and Development, Department of Veterans Affairs  
Seth Eisen, MD, MSc, an internist and epidemiologist, has been the Director of the VA’s Health Services Research and Development (HSR&D) Service for the past year, is Professor of Internal Medicine and Psychiatry and a member of the Divisions of Rheumatology and General Medical Sciences at Washington University School of Medicine, and is a Staff Physician at the St. Louis Veterans Affairs Medical Center. Dr. Eisen’s primary research interests are psychiatric epidemiology, pharmacovigilance, and the impact of war on psychiatric and physical health. In his current VA research leadership position, he has developed initiatives in medical informatics, health services genomics, and transforming healthcare provider education to improved patient outcomes. He has over 120 peer-reviewed publications. |
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<th>Time</th>
<th>Session Title</th>
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| 10:55-11:20 a.m. | Agency for Healthcare Research and Quality (AHRQ)      | Speaker: Jonathan White (MD), Director of Health Information Technology (Health IT) Portfolio, Federal Agency for Healthcare Research and Quality (AHRQ)  
Jon White, MD, directs the Health IT Portfolio at the Federal Agency for Healthcare Research and Quality (AHRQ). Dr. White is responsible for setting the programmatic direction of AHRQ’s Health IT projects. He has directly managed numerous projects, which have advanced the field of knowledge, and he participates in several national initiatives to improve the quality of American healthcare. A board-certified family physician, Dr. White received his medical degree from the University of Virginia. Prior to his tenure at AHRQ, he was Chief Medical Information Officer and Associate Residency Director of Lancaster General Hospital. |
| 11:20-11:45 a.m. | National Science Foundation                           | Speaker: Cerry Klein (PhD), Program Director for Service Enterprise Engineering, National Science Foundation (NSF)  
Cerry Klein is the Program Director for the Service Enterprise Engineering and Manufacturing Enterprise Systems programs at the NSF. He is also the Lapierre Professor and past Chair of the Department of Industrial and Manufacturing Systems Engineering at the University of Missouri. Dr. Klein’s research interests include healthcare, logistics, entrepreneurship, optimization, and decision-making. He has received over $5.0 million in funding from various sources and has published over 160 technical publications. Dr. Klein is a graduate of Purdue University with his PhD in Industrial Engineering and was an Office of Naval Research Young Investigator. He has also received numerous teaching awards. |
| 11:45-noon    | Questions from the Audience                           |                                                                        |
| 12:15-1:15 p.m. | Working Lunch – The Quality Imperative               | Speaker: James C. Benneyan (PhD), Associate Professor of Mechanical and Industrial Engineering; Director of Quality and Productivity Laboratory, Northeastern University  
James C. Benneyan is an Associate Professor in the Department of Mechanical and Industrial Engineering at Northeastern and the Director of the Quality and Productivity Laboratory (QPL). He has worked with the Agency for Healthcare Research and Quality, NIH, and industry partners. Various QPL members hold joint appointments, board positions, associations or editorial positions with the Institute of Industrial Engineers, Society for Health Systems, Raytheon’s Six Sigma Institute, Institute for Healthcare Improvement, and numerous professional journals. Dr. Benneyan received his BA in Mathematics from Hamilton College, and his MS and PhD in Industrial Engineering and Operations Research from the University of Massachusetts. |
### Monday, April 7, 2008, Afternoon I Session: Effectiveness of Healthcare Delivery

<table>
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<tr>
<th>Moderator: Kenneth Musselman (PhD), Director of Strategic Collaboration, Regenstrief Center for Healthcare Engineering, Purdue University</th>
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<tr>
<td>Kenneth Musselman, PhD, is the Strategic Collaboration Director for the Regenstrief Center for Healthcare Engineering at Purdue, where he serves as the center’s Managing Director and is responsible for fostering, building, and managing the relationships with key healthcare partners. He is also currently serving as President of the Institute of Industrial Engineers, which is the world’s largest professional membership association dedicated solely to the support of the industrial engineering profession and individuals involved with improving quality and productivity. For over 30 years, Dr. Musselman has actively consulted in the design, monitoring, planning and scheduling of manufacturing and healthcare systems through business activity monitoring and response, simulation and advanced planning and scheduling.</td>
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<th>1:30-2:00 p.m. Methods of Cost-Effectiveness</th>
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<tr>
<td>Speaker: Anita Brogan (PhD), Senior Director of Health Economics, RTI Health Solutions, Research Triangle Park</td>
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<td>Anita Brogan, PhD, is a Senior Director of Health Economics at RTI Health Solutions. Her research focuses on the application of operations research and other analytical techniques to the construction of cost-effectiveness, cost-utility, and budget-impact models for emerging pharmaceutical and biotechnology products in a variety of therapeutic areas. Dr. Brogan completed her doctoral degree in Operations Research at the University of North Carolina at Chapel Hill, and her research has been presented at various professional conferences and published in <em>Value in Health</em>, the <em>European Journal of Operational Research</em>, <em>IIE Transactions</em>, and the <em>Journal of Parenteral and Enteral Nutrition</em>.</td>
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<th>Discussant: Peter J. Fabri (MD, PhD), Professor of Surgery, USF Health; Associate Dean for Clinical Affairs and Graduate Medical Education, University of South Florida</th>
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<tr>
<td>Peter J. Fabri, MD, PhD, has been Professor of Surgery at the University of South Florida College of Medicine since 1986 and the Associate Dean for Graduate Medical Education since 1993. Dr. Fabri has served as dissertation advisor for three PhDs granted at USF (education/medical informatics, industrial organizational psychology) and previously for two PhDs granted at OSU (biochemistry). Dr. Fabri recently completed a PhD in Industrial Engineering at USF and advises doctoral and masters students in the emerging field of Healthcare Engineering. His primary research interests are in healthcare systems, patient safety and medical error.</td>
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### 2:00-2:30 p.m.  
**Turning Results into Clinical Practice**

**Speaker:** Brad Doebbeling (MD), Professor of Health Services Research and Medicine, IU Medical School; Director of Health Services Research at Regenstrief Institute; Director of VA Health Service Research and Development at Roudebush VA, Indiana University  
Nationally recognized health services researcher, Bradley N. Doebbeling, MD, MSc, holds academic appointments in health services research, epidemiology and biomedical engineering respectively at Indiana University School of Medicine, University of Iowa College of Public Health and Purdue University. A leader in research methodology and collaborations and mentorship, he directs both the VA HSR&D Center of Excellence in Implementing Evidence-based Practice at the Indianapolis VA Medical Center and the IU Center for Health Services & Outcomes Research of Regenstrief Institute, Inc. By integrating health information technology, systems engineering and organizational change approaches, his research focus to transform healthcare delivery has influenced national policy in patient safety, quality improvement, antimicrobial resistance, implementation science, organizational change and system redesign.

**Discussant:** Reha Uzsoy (PhD), Clifton A. Anderson Distinguished Professor of Industrial and Systems Engineering, North Carolina State University  
Reha Uzsoy is the inaugural Clifton A. Anderson Distinguished Professor in the Edward P. Fitts Department of Industrial and Systems Engineering at NC State. He holds BS degrees in Industrial Engineering and Mathematics and an MS in Industrial Engineering from Bogazici University, Istanbul, Turkey. He received his PhD in Industrial and Systems Engineering in 1990 from the University of Florida. His teaching and research interests are in production planning, scheduling, supply chain management and healthcare. He is a Fellow of the Institute of Industrial Engineers and serves on the Editorial Boards of *IIE Transactions on Scheduling and Logistics* and *International Journal of Computer-Integrated Manufacturing*.

### 2:30-3:00 p.m.  
**Influencing Policy and Decision-Makers**

**Speaker:** David Matchar (MD), Professor of Medicine; Director of the Center for Clinical Health Policy Research, Duke University  
After completing his undergraduate degree in Statistics at Princeton, Dr. Matchar earned his MD from the University of Maryland. His research is focused on evidence synthesis to support informed clinical and policy decisions, and on the implementation and evaluation of innovative strategies to promote practice change. He is principal investigator of VA Cooperative Study #481, the Home INR Study (THINRS), a 28-city study of home monitoring of anticoagulation, a 10-city project to improve care provided to individuals with advanced chronic kidney disease, and is the chair of the Executive Committee of the Stroke QUERI, a system-wide initiative in the Department of Veterans Affairs to optimize care of individuals at risk of stroke or who have experienced a stroke. Dr. Matchar is the director of the Duke Evidence-based Practice Center, which includes a contract to provide technical support to CMS, related to national coverage decision-making and the DEcIDE Network Team, in support of research to optimize benefits to beneficiaries of Medicare, Medicaid, and SCHIP.
2:30-3:00 p.m. Influencing Policy and Decision-Makers (cont.)

Discussant: Kristen Lich (PhD), Assistant Professor of Health Policy and Administration, School of Public Health, University of North Carolina at Chapel Hill

Kristen Hassmiller Lich is an Assistant Professor in the Department of Health Policy and Administration in the School of Public Health at UNC-Chapel Hill. She received her BS in Psychology and Gerontology from the University of Akron, an MHSA from the School of Public Health at the University of Michigan, and a PhD in Health Services Organization and Policy, also from Michigan. Her teaching and research interests involve applying operations research and complex systems tools to solve problems in health and healthcare. She has studied tobacco policy (both domestic and international) and tuberculosis control. Her current research focuses on improving the mental healthcare system in North Carolina.

Monday, April 7, 2008, Afternoon II Session: Efficiency of Healthcare Delivery

3:30-4:00 p.m. Effectiveness and Efficiency in Healthcare

Speaker: Julie S. Ivy (PhD), Assistant Professor of Industrial and Systems Engineering, North Carolina State University

Dr. Julie Simmons Ivy is an Assistant Professor at NC State in the Edward P. Fitts Department of Industrial and Systems Engineering and Fitts Fellow in Health Systems Engineering. Previously, she has been a Senior Associate Consultant at the Mayo Clinic in the College of Medicine, and a Senior Engineer at IBM. His primary research interests are in optimization under uncertainty as it relates to industry applications in healthcare delivery, medical decision-making, supply chain planning, and factory scheduling. He has won the INFORMS Daniel H. Wagner Prize (2005), the Institute of Industrial Engineers Outstanding Publication Award (2005), and the Canadian Operations Research Society Best Paper Award (2000). He has co-authored more than a dozen journal articles, working papers, and conference proceedings, and holds nine patents with the U.S. Patent and Trademark Office. He completed his PhD in Management Science, his MSc in Physics, and his BSc in Chemistry and Physics at McMaster University in Hamilton, Ontario, Canada.

Moderator: Brian Denton (PhD), Assistant Professor of Industrial and Systems Engineering, North Carolina State University

Dr. Brian Denton is an Assistant Professor at NC State in the Edward P. Fitts Department of Industrial and Systems Engineering and Fitts Fellow in Health Systems Engineering. Previously, he has been a Senior Associate Consultant at the Mayo Clinic in the College of Medicine, and a Senior Engineer at IBM. His primary research interests are in optimization under uncertainty as it relates to industry applications in healthcare delivery, medical decision-making, supply chain planning, and factory scheduling. He has won the INFORMS Daniel H. Wagner Prize (2005), the Institute of Industrial Engineers Outstanding Publication Award (2005), and the Canadian Operations Research Society Best Paper Award (2000). He has co-authored more than a dozen journal articles, working papers, and conference proceedings, and holds nine patents with the U.S. Patent and Trademark Office. He completed his PhD in Management Science, his MSc in Physics, and his BSc in Chemistry and Physics at McMaster University in Hamilton, Ontario, Canada.
### Effectiveness and Efficiency in Healthcare (cont.)

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<tr>
<th>Discussant: Jennifer Wu (MD, MPH), Assistant Professor of Obstetrics and Gynecology, Duke University</th>
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<tr>
<td>Jennifer M. Wu, MD, is an Assistant Professor of Obstetrics and Gynecology in the Division of Urogynecology and Pelvic Reconstructive Surgery at Duke University. She is a practicing urogynecologist who cares for women with pelvic floor disorders, which include urinary and fecal incontinence and pelvic organ prolapse. Her research focuses on the epidemiology of pelvic floor disorders, the relationship between childbirth injury and pelvic floor dysfunction and the impact of these conditions on quality of life. She is also interested in cost-effectiveness analyses and applying decision analysis to the study of urogynecologic disorders.</td>
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<th>4:00-4:30 p.m.</th>
<th>Disease Management through Modeling</th>
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<td><strong>Speaker:</strong> José L. Zayas-Castro (PhD), Professor and Chair of Industrial and Management Systems Engineering, University of South Florida</td>
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<td>Dr. José L. Zayas-Castro is Professor and Chairperson of the Department of Industrial and Management Systems Engineering at USF. Previous to his current appointment, he worked at the University of Missouri-Columbia and the University of Puerto Rico-Mayagüez. Dr. Zayas-Castro is actively working in healthcare engineering in collaboration with USF’s Health Sciences, H. Lee Moffitt Cancer Center, the James A. Haley Veterans Affairs Hospital in Tampa, and Tampa General Hospital. In addition, he works in aspects related with graduate medical education, and innovation and entrepreneurship in the intersection of engineering, health sciences, and the medical device sector.</td>
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<th>Discussant: Marie Davidian (PhD), William Neal Reynolds Professor of Statistics, Director of the Center for Quantitative Sciences in Biomedicine, North Carolina State University</th>
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<td>Marie Davidian is the William Neal Reynolds Professor of Statistics and Director of the Center for Quantitative Sciences in Biomedicine at NC State, and Adjunct Professor of Biostatistics and Bioinformatics at Duke University. Her interests include statistical methods for analysis of clinical trials and longitudinal studies, design and evaluation of treatment strategies, and mathematical-statistical modeling of disease mechanisms. She has served as Coordinating and Executive Editor of the journal <em>Biometrics</em>, as Chair of the NIH Biostatistical Methods and Research Design study section, and as President of the Eastern North American Region (ENAR) of the International Biometric Society. She is a Fellow of the American Statistical Association, the Institute of Mathematical Statistics, and the American Association for the Advancement of Science.</td>
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4:30-5:00 p.m.  Making Treatment Decisions

**Speaker:** Michael Pignone (MD), Associate Professor of Medicine; Director of Medical Practice and Prevention at the Sheps Center for Health Services Research, University of North Carolina at Chapel Hill

Dr. Michael Pignone is an Associate Professor of Medicine in the Division of General Internal Medicine at UNC-Chapel Hill, Chief of the Division of General Internal Medicine, and Director of the UNC Center for Excellence in Chronic Illness Care and the Program on Medical Practice and Prevention Research at the UNC Sheps Center for Health Services Research. He received his MD and residency training from the University of California-San Francisco. He then completed fellowship training in clinical epidemiology and health services research through the Robert Wood Johnson Clinical Scholars Program at UNC from 1996-98, during which time he also received a master’s degree in epidemiology from the UNC School of Public Health. Dr. Pignone has served on the faculty of the UNC School of Medicine from 1998 to the present. He also serves as an Associate Editor for the journals *Medical Decision Making* and *Clinical Diabetes* and on the editorial board for *Archives of Internal Medicine*. Dr. Pignone’s research is focused on medical decision-making and he helped found the UNC Decision Support Laboratory.

**Discussant:** Hari Balasubramanian (PhD), Research Associate for Healthcare Policy and Research, Mayo Clinic

Hari Balasubramanian is a Post-Doctoral Research Associate working at the Department of Health Sciences Research (HSR) at the Mayo Clinic in Rochester, Minnesota. He works on research and education initiatives pertaining to operations research in healthcare. His current projects include quantitative and optimization approaches in patient access management, surgery delivery and medical decision-making. He also co-teaches the course Introduction to Health Systems Engineering, offered annually at the Mayo Graduate School. He obtained his doctoral degree in Industrial Engineering from Arizona State University in August 2006, where he worked on developing computationally efficient scheduling approaches for complex manufacturing systems.
6:30-8:30 p.m.  Dinner – Challenges: What Needs to be Done?

**Introduction of Speaker: Paul Cohen (PhD), Head and Edgar S. Woolard Distinguished Professor of the Edward P. Fitts Department of Industrial and Systems Engineering, North Carolina State University**

NC State ISE Department Head Paul Cohen received his BS degree in Industrial Engineering from the University of Rhode Island and MS and PhD degrees in Industrial and Systems Engineering from Ohio State University. He has also worked industrially at Battelle Memorial Institute and the Wanskuck Co. performing metalworking research. His work has focused on the modeling of plastic deformation processes, development of new tooling materials and tribology. His more recent research has examined properties and processes at the nano-scale. He has served in leadership roles in industry-based university research centers, published over 100 papers and served in editorial positions for leading journals. He has won numerous awards from the Institute of Industrial Engineers, Society of Manufacturing Engineers, American Society for Engineering Education and National Science Foundation. He is the Chair-elect of the Council of Fellows of the Institute of Industrial Engineers.

**Speaker: Vinod K. Sahney (PhD), Senior Vice President and Chief Strategy Officer, Blue Cross and Blue Shield of Massachusetts; Adjunct Professor of Health Policy and Management, Harvard University**

Vinod K. Sahney is Senior Vice President and Chief Strategy Officer for Blue Cross Blue Shield of Massachusetts. Before joining Blue Cross he served as Senior Vice President at Henry Ford Health System-Detroit for 25 years. He was responsible for strategy, marketing, government relations, management services, public relations, health services research, health promotion and disease prevention. He has been elected to both The Institute of Medicine and National Academy of Engineering. He is a Fellow of both IIE and HIMSS. He is a founding member of Institute of Healthcare Improvement (IHI) and has served on its Board of Directors and as Chair of the Board for six years. He is a founding member and Past President of Society for Health Systems. He has served as a Baldrige Judge and on the Defense Healthcare Advisory Board.
### Morning: Tuesday, April 8, 2008 – Morning I Session: Promoting Access

#### Moderator: Julie S. Ivy (PhD), Assistant Professor of Industrial and Systems Engineering, North Carolina State University

(see page 12 for bio)

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<td>8:00-9:00 a.m.</td>
<td><strong>Panel on Access and Disparities</strong></td>
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**Panel Leader:** Paul Stanfield (PhD), Chairperson and Associate Professor of Industrial and Systems Engineering, North Carolina A&T State University

Dr. Paul Stanfield is Associate Professor and Chair of the ISE Department at North Carolina A&T State University. Additionally, Dr. Stanfield serves as advisor, instructor and research director for the Institute for Defense and Business and the Center for Excellence in Logistics and Technology (LOGTECH). He is the former President of ABCO Automation, an 80-employee engineering consulting firm, is a registered professional engineer and has consulted extensively for over 30 private companies and all military branches. His research interests include supply chain system modeling, enterprise information systems, life cycle management through application of automated identification technologies, and stochastic scheduling. He is a former Institute of Industrial Engineers (IIE) Region 3 Vice President and past winner of the Outstanding Young Industrial Engineer in Education, Pritsker Doctoral Dissertation, and IIE Graduate Research Awards. Dr. Stanfield received his BS in Electrical Engineering, MS in Industrial Engineering/Operations Research, and PhD in Industrial Engineering from NC State and his MBA from UNC-Greensboro.

**Discussants:**

- **Dorothy Browne (DrPH), Director of the Institute for Public Health; Professor of Social Work, North Carolina A&T State University**
  
  In addition to her current positions, Dr. Dorothy C. Browne was an Adjunct Professor of Maternal and Child Health at the UNC School of Public Health-Chapel Hill. Her areas of expertise include health disparities, especially those associated with drug use (e.g., HIV/AIDS) and high-risk behaviors of adolescents and young adults. Current research focuses on factors related to the health disparities of obesity and diabetes, and CVD. Prior to arriving at North Carolina A&T State University in July 2007, Dr. Browne was a Professor of Public Health at Morgan State University; Interim Associate Dean of Research at Morgan State School of Public Health and Policy and the Co-director of the Morgan-Hopkins Center for Health Disparities Solutions at Morgan. She was also the Director of the Morgan State site and Senior Scientist/Co-director of the Morgan Drug Abuse Research Program. Browne received her undergraduate degree from Bennett College for Women, an MSW from the University of Pittsburgh School of Social Work and an MPH and DrPH from Harvard University School of Public Health.

- **Robert Millikan (PhD, DVM), Associate Professor of Epidemiology, School of Public Health, University of North Carolina at Chapel Hill**
  
  Robert Millikan, DVM, PhD, is a Professor in the Department of Epidemiology, School of Public Health and Lineberger Comprehensive Cancer Center, UNC School of Medicine at Chapel Hill. His current research projects include Carolina Breast Cancer Study and the Genes Environment and Melanoma Study (North Carolina Melanoma Study). He teaches in Cancer Epidemiology Methods, Genetic Epidemiology, Molecular Epidemiology, and co-teaches Advanced Methods for Epidemiologic Data Analysis at the University of North Carolina. He recently completed a Fulbright Fellowship at University College Dublin, Ireland.
### Panel on Access and Disparities (cont.)

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<tr>
<td>Peggye Dilworth-Anderson (PhD), Professor of Health Policy and Administration, School of Public Health; Director of the Center for Aging and Diversity, Institute on Aging (IOA), University of North Carolina at Chapel Hill</td>
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<tr>
<td>Alvin E. Headen, Jr. (PhD), Associate Professor of Economics, College of Management, North Carolina State University</td>
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Peggye Dilworth-Anderson co-directs the National Institute on Aging-funded training program at the IOA in healthcare and aging research. Her areas of expertise include minority aging and health, family caregiving, health disparities, and long-term care. Her current research focuses on health disparities pertaining to Alzheimer’s disease and related dementias. Dr. Dilworth-Anderson currently serves on the 2005 White House Conference on Aging Advisory Committee and past elected positions include serving as Chair of the Behavioral and Social Science Section of the Gerontological Society of America (2002-03), and Chair of the Ethnic Minority Section of the National Council on Family Relations (1985-87). Dr. Dilworth-Anderson completed her undergraduate training in Sociology from Tuskegee Institute in 1970, and received her master’s and doctorate degrees in sociology from Northwestern University in 1972 and 1975, respectively. She is a Fellow of the Gerontological Society and the National Council of Family Relations.

Alvin E. Headen, Jr. was recently appointed to the National Advisory Council on Minority Health and Health Disparities (NACMHD), a part of the National Institutes of Health (NIH). Prior to joining NC State’s College of Management, Dr. Headen held economist positions with Blue Cross/Blue Shield and the American Medical Association. His career has centered on the economics of healthcare and particularly healthcare for minorities. Dr. Headen’s research for more than two decades has explored the factors that contribute to racial and ethnic disparities in healthcare that have persisted in the United States in the face of economic growth.
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<th>9:00-9:30 a.m.</th>
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<td><strong>Speaker:</strong> Jeffrey S. Spade, (MHA), Executive Director, North Carolina Rural Health Center, North Carolina Hospital Association</td>
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<td>Jeffrey S. Spade, MHA, FACHE, is the Executive Director of the NC Rural Health Center, a resource center supported by the North Carolina Hospital Association (NCHA), and Vice President of NCHA. His activities and accomplishments include 23 rural NC hospitals designated as Critical Access Hospitals; 46 Disproportionate Share Hospitals participating in the 340B drug purchasing program; directing the 100K Lives Campaign for North Carolina, saving an estimated 2,724 lives; organizing a statewide collaborative to implement and sustain rapid response teams at 56 NC hospitals, saving over 300 lives annually; providing leadership for the Rural Affinity Group of the 5 Million Lives Campaign; and leading the Governor’s Task Force for Healthy Carolinians. Mr. Spade is an active board member of the NC Association of Free Clinics, a fully participating member of the North Carolina Institute of Medicine, a Fellow in the American College of Healthcare Executives and has a faculty appointment with the Institute for Healthcare Improvement, Boston, MA. He is a graduate of the Duke University, Fuqua School of Business (MHA) and the University of Wisconsin (BS Molecular Biology).</td>
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<td><strong>Discussant:</strong> Fay Cobb Payton (PhD), Associate Professor of Information Technology, College of Management, North Carolina State University</td>
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<tr>
<td>Dr. Fay Cobb Payton is an Associate Professor of IT at NC State. She earned a PhD in Information and Decision Systems (with a specialty in Healthcare Management) from Case Western Reserve University. Her research interests include healthcare disparities (HIV/AIDS) among African American and sub-Saharan African populations, health informatics, data management and social exclusion (including the digital divide/equity and STEM). She currently serves as the Vice Chair of the Associate of Information Systems SIG-International Health and the Section Editor for the <em>African Journal of Information Systems</em>. She is also a member of the IEEE Medical Policy Working Group. Dr. Cobb has worked with The PhD Project since 1996.</td>
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<th><strong>Patient Scheduling</strong></th>
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<td><strong>Speaker:</strong> Mark Lawley (PhD), Associate Professor of Biomedical Engineering, Purdue University</td>
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<td>Before joining Biomedical Engineering in 2007, Dr. Lawley served nine years as Assistant and Associate Professor of IE, also at Purdue, two years as Assistant Professor of IE at the University of Alabama, and held engineering positions with Westinghouse Electric Corporation, Emerson Electric Company, and the Bevill Center for Advanced Manufacturing Technology. He has authored over 80 technical papers and has won three best paper awards for his work in systems optimization and control. In January 2005, he was appointed Regenstrief Faculty Scholar in support of Purdue’s Regenstrief Center for Healthcare Engineering. Dr. Lawley is particularly interested in developing optimal decision policies for system configuration and resource allocation in large healthcare systems. As a Regenstrief Scholar, he has focused on research initiatives with Wishard Hospital, the Regenstrief Institute of Indianapolis, the Richard L. Roudebush Veterans Administration Medical Center, Ascension Health, St. Vincent Hospitals, and the American College of Physicians. He received his PhD in Mechanical Engineering from the University of Illinois at Urbana Champaign in 1995 and is a registered Professional Engineer in the State of Alabama.</td>
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Patient Scheduling (cont.)

Discussant: Xiuli (Shelly) Qu (PhD), Assistant Professor of Industrial and Systems Engineering, North Carolina A&T University

Dr. Xiuli (Shelly) Qu received her MS and PhD in Industrial Engineering from Purdue University. Before that, she received a BSEE and a MSEE from the University of Science and Technology Beijing. Her research and teaching interests focus on healthcare delivery, healthcare information system, and stochastic modeling and optimization. In her previous work, she has developed mathematical models and quantitative procedures for decision-making in open access scheduling. Using these procedures, she investigated the impacts of clinic environmental characteristics, and then summarized the general guidelines for determining a best scheduling policy in open access scheduling systems.

Tuesday, April 8, 2008, Morning II Session: Improving Operations

Moderator: Reha Uzsoy (PhD), Clifton A. Anderson Distinguished Professor of Industrial and Systems Engineering, North Carolina State University (see page 11 for bio)

10:30-11:00 a.m Methods and Models for Operations Improvement

Speaker: Heather Woodward-Hagg (PhD), Research Scientist, VA HSR&D Center of Excellence on Implementing Evidence-based Practice, IU Center for Health Services and Outcomes Research, Regenstrief Center for Healthcare Engineering, Purdue University

Dr. Heather Woodward-Hagg is a Certified Quality Engineer (CQE), Certified Six Sigma Black Belt (CSSBB), was an Assistant Professor of Industrial Technology at the College of Technology at Purdue University and is now an investigator/researcher for the VA HSR&D Center of Excellence on Implementing Evidence-based Practice and the Indiana University Center for Health Services and Outcomes Research at Regenstrief Institute, Inc. Professor Woodward-Hagg spent nine years at Intel as a Process and Quality Engineer within semiconductor manufacturing. The focus of her research has been to translate systems engineering methodologies, such as Lean and Six Sigma, into relevant and accessible tools that can be readily applied by healthcare professionals to create sustained improvement in the quality of healthcare delivery across Indiana.

Discussant: William Burton (MS), Director of Performance Services, Duke University Hospital

As the Director of Performance Services, William C. Burton directs the Management Engineering, Balanced Scorecard and Six Sigma programs for the Duke University Health System. Bill came to Duke University in 1993. Prior to joining Duke, he worked with SunHealth Enterprises (now Premier Inc.) for over 10 years as a Management Consultant. He received his BS and MS from North Carolina State University in Industrial Engineering and is a Certified Six Sigma Black Belt.
11:00-11:30 a.m. Logistics and Supply Chain

Speaker: Ronald Rardin (PhD), John and Mary Lib White Systems Integration Chair, Director of Center on Innovation in Healthcare Logistics, Distinguished Professor and Interim Department Head of Industrial Engineering, University of Arkansas-Fayetteville.

Ronald (Ron) L. Rardin heads the University’s new Center on Innovation in Healthcare Logistics targeting innovations in supply chain and material flow aspects of healthcare operations in collaboration with Wal-Mart, Blue Cross Blue Shield, VHA, and other partners. His current teaching and research interests center on large-scale optimization modeling and algorithms, especially their applications in healthcare delivery and energy planning.

Discussant: Lauren Davis (PhD), Assistant Professor of Industrial and Systems Engineering, North Carolina A&T State University

Lauren Berrings Davis is an Assistant Professor in ISE at North Carolina A&T State University. She received her BS in Computational Mathematics from Rochester Institute of Technology in 1991, her MS in Industrial and Management Engineering from Rensselaer Polytechnic Institute in 1992, and her PhD in Industrial Engineering from North Carolina State University in 2005. Her research interests are in stochastic modeling of supply chain systems, with a focus on models for quantifying the value of information.

11:30-noon Design and Operation of Surgical Suites

Speaker: Brian Denton (PhD), Assistant Professor of Industrial and Systems Engineering, North Carolina State University (see page 12 for bio)

Discussant: Sarah Root (PhD), Assistant Professor of Industrial Engineering, University of Arkansas

Sarah Root’s research interests are in applied large-scale optimization, with emphasis on problems arising in transportation, logistics, and healthcare. She is particularly interested in problems that arise in the intersection of logistics and healthcare. She joined the University of Arkansas faculty in 2007 after completing her PhD at the University of Michigan.
Noon-12:30 p.m.: Wrap-Up – Understanding Each Other

<table>
<thead>
<tr>
<th>Speaker: Steve Witz (PhD), Director of Regenstrief Center for Healthcare Engineering, Purdue University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steven Witz is the Director of the Regenstrief Center for Healthcare Engineering at Purdue University and holds the St. Vincent Health Chair for Healthcare Engineering. He joined the Regenstrief Center in 2006 after a 26-year career as a healthcare administrator in both community hospital systems and academic medical centers. In conjunction with administrative responsibilities, Steve has held academic positions at the University of Minnesota, University of Utah, Brigham Young University and Purdue University where he is a Clinical Professor in Health Sciences.</td>
</tr>
</tbody>
</table>
The Healthcare Engineering Alliance (HEA)
First Annual Healthcare Engineering Symposium
on the Interface of Health Services Research and Healthcare Engineering

Organized locally by:

North Carolina State University Edward P. Fitts Department of Industrial and Systems Engineering
North Carolina A&T State University Department of Industrial and Systems Engineering
University of North Carolina at Chapel Hill Cecil G. Sheps Center for Health Services Research

Sponsored by:
Appendix B:
Symposium Speaker Slides
Welcome to
The Healthcare Engineering Alliance (HEA)
First Annual Healthcare Engineering Symposium
The Interface of Health Services Research and Healthcare Engineering
April 6-8, 2008
Radisson Hotel Research Triangle Park, Research Triangle Park, NC

Local Organizers
- North Carolina State University: Edward P. Fitts Department of Industrial and Systems Engineering
- North Carolina A&T State University: Department of Industrial and Systems Engineering
- University of North Carolina at Chapel Hill: Cecil G. Sheps Center for Health Services Research

The Healthcare Engineering Alliance
- North Carolina A & T State University
- North Carolina State University
- Purdue University
- University of Arkansas
- University of South Florida

Sponsors
- National Science Foundation
- North Carolina State University, Edward P. Fitts Department of Industrial and Systems Engineering
- The University of North Carolina at Chapel Hill, Cecil G. Sheps Center for Health Services Research
- North Carolina State University, College of Engineering

ISE Health Systems Engineering
- Brian Denton
- Julie Ivy
- Steve Roberts
- Reha Uzsoy
- Jim Wilson

Special Appreciation to
- Elaine Erwin
- Debbie Allgood-Staton
- Burak Eryigit
- Hakan Sungur
- Bill Irwin
Program Notes
- Poster Sessions at Break (Rooms D, E)
- Lunch, Dinner (Room H: 3rd floor)
- Expertise-based Program
  - Presentations
  - Discussants
  - Questions and comments from audience
- Sessions
  - Monday AM1, AM2, Lunch, PM1, PM2, Dinner
  - Tuesday AM1, AM2

The Interface: Health Services
Research and Healthcare Engineering
- What do we have in common?
- What is our common agenda?
- How can we best collaborate?
  - In research
- In academic programs
- In institutionalized delivery
- Most importantly, how do we impact health care?
- What are the “action items” we will take from this symposium?
Healthcare Engineering Symposium
NCSU
April 7, 2008
W. Dale Compton
Purdue University

National Academy of Engineering

<table>
<thead>
<tr>
<th>Membership</th>
<th>NAE</th>
<th>Members</th>
<th>2,225</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Foreign Associates</td>
<td>193</td>
</tr>
<tr>
<td></td>
<td>NAS</td>
<td>Members</td>
<td>2,071</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foreign Associates</td>
<td>382</td>
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<tr>
<td></td>
<td>IOM</td>
<td>Members</td>
<td>1,605</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foreign Associates</td>
<td>84</td>
</tr>
</tbody>
</table>

NRC Volunteers* | 5908
NRC Committees* | 574
Staff (December 2007) | 1,116
Total Budget (CY 2007) | $247.9M
Regular Program (CY 2007) | $164.3M
Reports | 199
*includes FGA's Associateship and Fellowship Panels, and TRB technical committees

1999—The Institute of Medicine Published
*Err is Human
44,000 to 98,000 die annually
and over one million are injured
from medical errors

2000—Patient safety had become
a national concern

2002—Joint Commission for the
Accreditation of Healthcare
Organizations (JCAHO)
Required all hospitals to
implement 11 new safe practices

2001—The Institute of Medicine Published
*Crossing the Quality Chasm
Health Care System Should be

• Safe
• Effective
• Patient-Centered
• Timely
• Efficient
• Equitable

How well does our health care system
meet those six Objectives?

Unfortunately, the answer is
--less than is desirable.
State of the System
Safety failures—1 million injuries annually
Knowledge—Practice Gap
Waste, Inefficiency, Spiraling Costs—“30 to 40 cents of every health care dollar covers costs of system failures, poor communications and inefficiency” = $480 billion/yr
Health care costs rising at double digit rates
Growing uninsured population ~ 45 million in 2006
Revenue squeeze on care providers

Some Contributing Reasons:
- Rapid Advances in Medical Science and Technology
- Increased Complexity of Health Care Delivery
- Cottage-Industry Structure
  - Large Fraction of Physicians are in IPAs
- Acute-vs. Chronic-Care Orientation
  - Aging Population
- Lack of Understanding of Quality and Productivity
  - Few Examples of Success
- Persistent Underinvestment in Infom./Comm. Tech.
  - Difficulty in IT Beyond EMR and CPOE Systems

Many Engineering Contributions to Medical Technology Through Bioengineering, Materials, etc.

There has been no Concerted Effort to Exploit Engineering Tools to Improve Quality and Productivity and Enhance Use of Information/Communication Technology

There is Engineering Content in Each of These
- Safe
- Effective
- Patient-Centered
- Timely
- Efficient
- Equitable

How do we go about Encouraging Engineers and Health Care Professionals to Look Seriously at the Possibilities for Utilizing Engineering Tools?

A Small Workshop Recommended That a Full Scale Study be Undertaken to Answer that Question.

This led the NAE and IOM to Undertake an Effort that Culminated in the Report

“Building A Better Health Delivery System
A New Engineering/Health Care Partnership”

The Committee—Equal Health Care Professionals and Engineers

Three workshops—Presentations by Experts in Health Care and Relevant Engineering Activities

Findings—Engineers have the Capability to Make a Significant Contribution
  - Few Providers of Health Care are Aware of Relevant Engineering Tools
  - Few Engineers Understand the Issues that Health Care Confronts

Report has Sought to Provide some Insight to the above and to Recommend How to Improve the Situation
The overwhelming conclusion was

Ways must be found to effectively apply system engineering tools to dramatically improve the efficiency of the health care delivery system. Productivity and the efficiency of the system must be enhanced.

Why engineering?

Engineering has a long history of dealing with large, complex, distributed systems.

Central focus for the study became the SYSTEM

Presented a Special Challenge

The “healthcare delivery system” was not designed as a system and does not operate as a system—with few exceptions it is a collection of discrete entities that tend to operate largely independent of each other—the “silos.” Thus the term “Cottage Industry.”

A Patient-Centered Model of the Health Care System

Workshop Presentations

• Framing the Health Care Challenge
• Equipping the Patient and the Care Team
• Engineering Tools and Procedures
• Information Technology for Clinical Applications and Microsystems
• Barriers and Incentives to Change

Examples of the application of system engineering tools to health care delivery issues

Scheduling of personnel & capital equipment
Flow of patients through a facility
Simulation of an operating room
Supply-chain management of resources
Statistical process control of operations
Knowledge discovery in large data bases
Financial engineering tools for risk management
Measuring and monitoring productivity—Metrics
Value of quality
Pharmacological Genomics

Three Families of Systems Tools for Use at Different Levels of the HC System:

• Systems Design
• Systems Analysis
• Systems Control
System Design Tools

<table>
<thead>
<tr>
<th>Patient</th>
<th>Team</th>
<th>Org.</th>
<th>Envir.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concurrent Engr. and QFD</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Human Factors</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Failure Mode Analysis</td>
<td>x</td>
<td>x</td>
<td></td>
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</tbody>
</table>

System Analysis Tools

<table>
<thead>
<tr>
<th>Patient</th>
<th>Team</th>
<th>Org.</th>
<th>Envir.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeling and Simulation</td>
<td></td>
<td></td>
<td>(x)</td>
</tr>
<tr>
<td>Enterprise Management</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Financial Engr. and Risk Analysis</td>
<td>(x)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Knowledge Discovery in Data Bases</td>
<td>(x)</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

System Control Tools

<table>
<thead>
<tr>
<th>Patient</th>
<th>Team</th>
<th>Org.</th>
<th>Envir.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical Process Control</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Scheduling</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Barriers to Implementation

- Inadequate Information and Information Tech.
- Policy and Market
- Organization and Managerial
- Educational

Crying NEED for Good DATA!

Information and Communication Systems

From Electronic Medical Records (EMR) and Computerized Physician Order Entry System (CPOE) to National Health Information Infrastructure (NHII)

Elements of a NHII

- Health Care Data Standards & Infrastructure
  - Data Interchange Formats
  - Terminologies
  - Knowledge Representation
- EHRs
- CPOEs
- Digital Source of Evidence and Knowledge to the Care Provider
- Decision Support Tools
- Human-Computer Interfaces
Microelectronic Systems and Emerging Modes of Communication

- Making Every Room an Intensive Care Unit
- Wireless Integrated Microsystems for Health Care
- Advancing Patient Self-Care
- Therapeutic Uses

What will be the Long-term Role of the Internet in Health Care?

Major Caveat

No intention of making engineers clinicians nor of making clinicians system engineers

What is Needed

Engineers who understand the constraints of the health care system
Clinicians who know what questions to ask and what to do with the answers

How do we Accelerate Change?

Recognize Barriers—Education of both the Health Care Professionals and Engineers Need to Change
Platforms Must be Provided for Interdisciplinary Research, Education and Outreach
Aggressively Attack Short-term Opportunities

Systems Engineering Agenda—Recommendations

Actions to promote development, adaptation, and use of systems engineering tools
3rd party payers to incentivise tool use
Expand/coordinate outreach & support
New educational materials
Increase public/private support for R,D&D

Increase public/private support for R,D&D

Establish multidisciplinary centers at institutions of higher learning capable of bringing together researchers, practitioners, educators, and students from relevant fields to
- Conduct basic and applied research on the system challenges to health care
- Demonstrate and diffuse the use of these tools, technologies and knowledge
- Educate and train a large cadre of current and future health care and engineering professionals

30 – 50 Multidisciplinary Centers
Geographically Distributed
$3.25 M Annual Ave. Core Support for each Center
Annual Total Core Funding between $100M and $160M
Support for 240–400 Faculty and 700–1200 Engineering & Medical Graduate Students Annually
Design and build NHII for the future and insure an evolving network capable of incorporating WIMS and other next-generation functionality/tech. Advance standards, interoperability, and reduce barriers to implementation.

Research, development & demonstration

Human-information/communications technology system interfaces
Improve interoperability and connectivity of syst.
Software dependability
Secure, dispersed, multi-agent databases

Study Committee

- W. Dale Compton, PhD, Cochair, Purdue Univ.
- Jerome Grossman, MD, Cochair, Harvard
- Rebecca Bergman, Medtronic
- John Birge, PhD, Univ. of Chicago
- Denis Cortese, MD, Mayo Clinic
- Robert Dittus, PhD, Vanderbilt Univ.
- G. Scott Gazelle, MD, MGH
- Carol Haraden, PhD, IHI
- Richard Migliori, MD, United Resource Networks
- Woodrow Myers, MD, WallPoint
- William Pierskalla, PhD, UCLA
- Stephen Shortell, PhD, UC Berkeley
- Kensall Wise, PhD, Univ. Michigan
- David Woods, PhD, Ohio State Univ.

Sponsors for the NAE/IOM Study

National Science Foundation
National Institutes Health
Robert Wood Johnson Foundation

H. R. 1467—National Science Foundation
Finding—no systematic plan exists for designing and implementing system and information tools and for ensuring that the healthcare workforce can make the transition to the information age.

“Information” means healthcare information
(a) Grants—$3.5M in fiscal 2008
(b) Informatics Multidisciplinary Research Centers $4.5M in fiscal 2008
(c) Capacity building grants for students in undergraduate and masters program—$9.0 in 2008

H.R. 2406—National Institute of Standards & Technology
Develop standards . . . necessary to increase efficiency, quality of care and lower costs in the healthcare industry.
Ensure that all components of healthcare infrastructure can be a part of an electronic information infrastructure.
Establish healthcare information enterprise integration
Establish healthcare information enterprise integration research centers at institutions of higher learning.
Other Initiatives

New PhD program in Health Informatics—UVA
Subsidization Private Health IT by State of New Mexico
Treatment of Traumatic Brain Injuries—NAE/IOM Army Medical Research & Material Command
Regenstrief Center for Healthcare Engineering—Purdue
IOM Roundtable—Engineering a Learning Health Care System

The NAE Purpose
To promote the technological welfare of the nation by marshaling the knowledge and insights of eminent members of the engineering profession.

The IOM Mission
The Institute of Medicine serves as adviser to the nation to improve health.

* * * *

As independent, scientific advisers, the Academies strive to provide advice that is unbiased, based on evidence, and grounded in science.v

All Academy reports can be found at www.nap.edu
The Interface of Health Services Research and Healthcare Engineering: What is Health Services Research?

Eugene Oddone, MD, MHSc
Center for Health Services Research in Primary Care, Durham VA Medical Center and Duke University Medical Center
April 6, 2007

Outline
- Context
- HSR-Defined
- Focused Examples
- Recommendations/Discussion

Mortality in the 20th Century

Fundamental Concepts in HSR
- Where does healthcare occur?
- How is healthcare delivered?
- How much does it cost?
- How can we make care better?

Ecology of Medical Care: Prevalence of Illness and Health System Contacts

Ecology Revisited: Prevalence of Illness Health System Contacts
But our health care system provides great care, right?

### Quality of Healthcare in the U.S.

**Table 1: Adherence to Quality Indicators, Overall and According to Type of Care and Function.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Indicators</th>
<th>No. of Participants eligible</th>
<th>Total No. of Times Indicator Eligible with MI</th>
<th>Percentage of Recommended Care Received (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall care</td>
<td>469</td>
<td>671,264</td>
<td>98,404</td>
<td>84.9 (84.8-85.0)</td>
</tr>
<tr>
<td>Type of care</td>
<td>58</td>
<td>671,264</td>
<td>59,268</td>
<td>54.9 (54.8-55.0)</td>
</tr>
<tr>
<td>Acute</td>
<td>58</td>
<td>671,264</td>
<td>59,268</td>
<td>54.9 (54.8-55.0)</td>
</tr>
<tr>
<td>Chronic</td>
<td>290</td>
<td>671,264</td>
<td>21,564</td>
<td>16.1 (15.9-16.3)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>43</td>
<td>671,264</td>
<td>39,488</td>
<td>53.2 (53.1-53.2)</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>178</td>
<td>671,264</td>
<td>29,679</td>
<td>55.7 (55.6-55.8)</td>
</tr>
<tr>
<td>Treatment</td>
<td>178</td>
<td>671,264</td>
<td>29,679</td>
<td>55.7 (55.6-55.8)</td>
</tr>
</tbody>
</table>

* CI denotes confidence interval.

### Cardiac Catheterization among Medicare Patients with Myocardial Infarction

![Graph showing Cardiac Catheterization among Medicare Patients with Myocardial Infarction](image)

### Variability in Performance of Quality Indicators for Patients with MI

![Maps showing Variability in Performance of Quality Indicators for Patients with MI](image)

### Rates of Knee Arthroplasty among Medicare Eligible Patients

![Graph showing Rates of Knee Arthroplasty among Medicare Eligible Patients](image)

### In-Hospital or 30-Day Mortality among Medicare Patients according to Quintile of Total Hospital Volume

![Graph showing In-Hospital or 30-Day Mortality among Medicare Patients according to Quintile of Total Hospital Volume](image)
Institute of Medicine Reports

We get what we pay for, right?

Medicare Growth 2002–2030

- Medicare enrollment
  - 2002: 40 million
  - 2030: 77 million

- Worker : beneficiary ratio
  - 2002: 4.0 : 1
  - 2030: 2.3 : 1
  - 2070: 2.0 : 1

www.whitehouse.gov

Life Expectancy vs. Spending

The Cost of a Long Life
Health Services Research

Health services research (HSR) is a multidisciplinary field of basic and applied inquiry that examines access, use, costs, quality, delivery, organization, financing, and outcomes of health care services.

Health Services Researchers Address Issues Such as:
- Evidence based care
- Clinical practice performance
- Access to care
- Delivery of care
- Outcomes of care
- Patient preferences
- Resource allocation and health policy
- Organization re-engineering
- Technology assessment

Health Services Research Involves Collaboration Among:
- Clinical epidemiologists
- Clinical researchers
- Organization researchers
- Implementation experts
- Health Systems Engineers
- Informatists
- Statisticians
- Psychologists
- Sociologists
- Economists
- Public health experts
- Clinical ethicists
- Providers

Health Services Research Studies

- Utilize a wide variety of research methods
  - Randomized, controlled trials
  - Large secondary database analyses
  - Qualitative methods
  - Advanced statistical techniques
  - Psychometrics
  - Econometrics
- Emphasis on translation to practice
Tension between Discovery Science and Health Services Research

Discovery to Implementation

Models in Health Services Research

Levels of Models

Wagner Chronic Care Model
Changing Systems

- Evidence-Based Guidelines
  - e.g. VHA Practice Guidelines
- System Change Strategy
  - e.g. Chronic Care Model
- Change Model
  - e.g. Plan-Do-Study-Act Cycles
- Learning Model
  - e.g. Learning Collaboratives

Improved Processes
Improved Outcomes
Improved Satisfaction
More Appropriate Costs

Adapted from material presented by Edward H. Wagner, MD, MPH

Improving Blood Pressure Control in Primary Care: Translating Evidence to Practice

- Veterans Study to Improve The Control of Hypertension (V-STITCH)
- Hypertension Intervention Telemedicine Study (HINTS)

Health Decision Model

- Patient Characteristics
  - Perceived Risks
  - Cognition
  - Coping & Stresses
  - Closeness
  - Mental Health
- Provider Characteristics
  - Communication Style
  - Medication Regimen
  - Intensity of Therapy
  - Treatment Adherence
    - Beliefs about Therapy
- Social Environment
- Medical Environment
- TREATMENT ADHERENCE
- BLOOD PRESSURE CONTROL

The V-STITCH Study Design

- Providers Randomly Assigned (clusters)
  - Provider Intervention
  - Patient Intervention N = 150
  - Patient Usual Care N = 151
- Provider Reminder
  - Patient Intervention N = 144
  - Patient Usual Care N = 143

Point of Care Decision Support

- Translating evidence reduce risk of death, cardiovascular events, and coronary events with clinical trials, hypertension.
- HTEC trial showed 25 mg declined risk to 36% control the blood pressure and lower risk to hypertension.
- In a state, all patients, included patients, hypertension and well patients, patients in state personal communication site, patients in state personal with or without drug treatment, and others. Translated reduced for risk by 1.3% for all coronary events, 25% for stroke events, and 30% for non-fatal myocardial infarction.
- There is little to information about most divided but best strategies of lower blood pressure and lower risk.

Blood Pressure Control Rates Primary Analysis

- Behavioral
  - N=144
- Reminder
  - N=143
- Decision Support
  - N=151

Time Effect: P<.01
Group*Time Effect: P=.11

Time in Months
**Nurse Behavioral Intervention vs. None Secondary Analysis**

<table>
<thead>
<tr>
<th>BP Control</th>
<th>Time in Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40</td>
<td>0</td>
</tr>
<tr>
<td>0.45</td>
<td>6</td>
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<tr>
<td>0.50</td>
<td>12</td>
</tr>
<tr>
<td>0.55</td>
<td>18</td>
</tr>
<tr>
<td>0.60</td>
<td>24</td>
</tr>
</tbody>
</table>

**RN Behavioral**

- N=294
- P=0.03

**No RN**

- N=294

**Conclusions**

- A brief telephone intervention improved BP control by 21% at 24 months; a 12.6% improvement compared to the non-nurse group.
- Computer Decision Support did not improve BP control rates at 24 months.
- No increase in clinic utilization.

**HINTS Study: Design**

- Usual Care: PCP drives management, no special program.
- Tailored Behavioral Phone Intervention:
  - Home BP monitoring evaluated by nurse.
  - Tailored behavioral modules.
- Medication Management (ATHENA) Phone Intervention:
  - Home BP monitoring evaluated by nurse.
  - Medication management implemented by study MD/RN.
- Combined Intervention:
  - Home BP monitoring evaluated by nurse.
  - Medication management/tailored behavioral modules.

**Facilitating Complex Studies…**

**Home Readings: Console View**

**RN:MD Dialogue for Medication Change**
Where is the space that we can engage?

- We are not delivering optimal quality care
- Our health care is inefficient and expensive
- Reductions in inappropriate care and more attention to evidence based guidelines may save lives and lower cost
- Similarities with Japanese Industry post-WWII, pre-Deming?

“Knowing is not enough; we must apply. Willing is not enough; we must do.”
--Goethe
Why Does VA Health Services Research Care About Healthcare Systems Engineering?

Seth Eisen, MD, MSc
Director, VA Health Services Research & Development
April 7, 2008

Diabetes Quality of Care Indicators in VA & Managed Care Systems

<table>
<thead>
<tr>
<th>Indicator</th>
<th>VA (%)</th>
<th>CMC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ann Eye Exam</td>
<td>91</td>
<td>75</td>
</tr>
<tr>
<td>Ann HbA1C</td>
<td>93</td>
<td>83</td>
</tr>
<tr>
<td>Ann Lipid Scng</td>
<td>79</td>
<td>63</td>
</tr>
<tr>
<td>Ann Foot Exam</td>
<td>98</td>
<td>84</td>
</tr>
<tr>
<td>Ann Proteinuria Scng</td>
<td>92</td>
<td>81</td>
</tr>
<tr>
<td>Influenza Vaccination</td>
<td>72</td>
<td>64</td>
</tr>
<tr>
<td>BP &lt; 140/90</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>BP &lt; 130/85</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>HbA1C &lt; 8.5</td>
<td>83</td>
<td>65</td>
</tr>
<tr>
<td>LDL &lt; 100 mg/dL</td>
<td>52</td>
<td>36</td>
</tr>
</tbody>
</table>

CMC = Commercial Managed Care
* = statistically significant

American Consumer Satisfaction Index (ACSI)

- Produced by Nat’l Quality Research Center, U of Michigan,
- Telephone interviews of ~ 80k Americans annually,
- Measures satisfaction for > 200 companies in 43 industries,
- Score (range = 0 to 100) - “Average American Consumer Satisfaction”.

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>VA</th>
<th>Non-VA Hosp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatients</td>
<td>83</td>
<td>77</td>
</tr>
<tr>
<td>Outpatients</td>
<td>83</td>
<td>83</td>
</tr>
</tbody>
</table>

* Overall score
VHA Characteristics

- Serve ~ 5.3 million vets annually, (↑ from 3M in 1995)
- 153 Hospitals, 900 Free Standing Clinics, 135 Nursing Homes,
- 210 Readjustment Counseling Centers,
- Trained ~ 1/3 of all practicing MD’s,
- ~ $36 Billion budget.

200,000 Employees

- Nurses 55,000
- Physicians 15,000
- Pharmacists 4,500
- Dentists 1,000

No. of Hospitalizations FY '97 - '07

No. of Outpatient Encounters FY '97 – '07

Four research branches within VA Office of Research & Development (ORD):

- Biomedical Laboratory R&D Service (BLR&D)
- Clinical Science R&D Service (CSR&D)
- Rehabilitation R&D Service (RR&D)
- Health Services R&D Service (HSR&D)
VA is an Intramural Research Program

- Unlike NIH & DoD, VA has no statutory authority to make research grants to non-VA entities,
- PI’s must be employed by VA,
- Co-investigators may be non-VA,
- Research objectives are “veteran centric”
  - Post deployment health
  - Complex common diseases
  - Women’s health
  - Access to care

VA Research Budget

<table>
<thead>
<tr>
<th>VA</th>
<th>NIH Equiv</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORD¹</td>
<td>~$500m²</td>
</tr>
<tr>
<td>HSR&amp;D</td>
<td>~$90m²</td>
</tr>
</tbody>
</table>

¹ Office of Research & Development
² excludes overhead & MD salaries

The VA is for Researchers Who Love Data

Data Added to VHA Computer Database

<table>
<thead>
<tr>
<th>Information Characteristic</th>
<th>Added per Workday</th>
<th>Added in 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progress Notes</td>
<td>+638k</td>
<td>874 M</td>
</tr>
<tr>
<td>Discharge Summaries</td>
<td>+955k</td>
<td>1.65 B</td>
</tr>
<tr>
<td>Orders</td>
<td>+884k</td>
<td>590 M</td>
</tr>
<tr>
<td>Images</td>
<td>+729k</td>
<td>1.06 B</td>
</tr>
<tr>
<td>Vital Signs</td>
<td>+607k</td>
<td>850 M</td>
</tr>
</tbody>
</table>

Statistics through December 2006
Summary of VA Strengths

- Tradition of quality improvement,
- National health care system,
- Electronic medical record with extensive data,
- Strong research tradition, outstanding researchers, research funding,
- Integrated organizational structure that facilitates implementation.

Healthcare Systems Engineering Relevant Research Initiatives

- Center for Scientific Computing (CSC),
- Consortium for Health Informatics Research (CHIR),
- Provider education to improve patient outcomes.

Center for Scientific Computing (CSC)

- Relevant data commonly in > 1 location,
- Multiple permissions required for access,
- Restricted use of EHR for research analyses,
- Data security & privacy risks.

Barriers to Researcher Data Access

- Relevant data commonly in > 1 location,
- Multiple permissions required for access,
- Restricted use of EHR for research analyses,
- Data security & privacy risks.

Advantages of CSC Concept

- More data available than ever before,
- Data security & privacy will be enhanced because of remote access structure,
- Real time mirror with clinical data will permit real time clinical application & decision support research,
- Availability of text data will greatly broaden research potential,
- Computing power will permit complex modeling,
- Technical computer advances will be rapidly available for use,
- Rapid sharing & dissemination of informatics products will facilitate research progress.
Consortium for Healthcare Informatics Research (CHIR)

Barriers to Informatics Research
- No prior research emphasis on informatics,
- Informatics expertise dispersed across VA research sites,
- Substantial health information in text data format:
  - physician, nursing, pharmacist progress notes,
  - radiology, pathology, cardiology reports,
  - bacteriology antibiotic sensitivity data,
  - hospital discharge summaries,
  - adverse event descriptions.

Medical Informatics Research Initiative
- Create a virtual informatics research consortium,
- Extract, cleanse, reformat, de-identify text,
- Prepare text for data mining (e.g., map text to standardized terminology, identify temporal relationships, create security & application standards)
- Apply text processing to clinical issues,
- Encourage non-consortium investigators to develop informatics research projects that include text data.

Provider Education to Improve Patient Outcome

Barriers to Education Research
- Inadequate theory, no systematic approach,
- Inadequate measures,
- Inadequately tailored to teacher & learner,
- Disease focused,
- Emphasizes knowledge acquisition,
- Minimal link to health outcomes,
- No continuous feedback loop of educational reinforcement,
- Not embedded into daily practice of providers.

“Consortium of VA Education Expertise”
- CSC - health data & computing power,
- CHIR - text processing,
- Participation by Office of Academic Affiliations (OAA), and Employee Education System (EES),
- HSE - systems concepts, human / computer interface, & feedback.
VA Offers Healthcare Systems Engineers:

Examples of Opportunities:
- Simulation & computer modeling using the VA’s massive databases,
- Develop new, data driven outcome measures,
- Develop automated, real-time, surveillance & decision support,
- Perform human factors engineering,
- Evaluate human-computer interactions & interfaces,
- Facilitate large scale intervention research projects,
- Education research for performance improvement,
- Imbed education feedback into ubiquitous computers.

Developers of Concepts

Washington Staff
- HSR&D – Merry Ward, Kate Bent
- OAA – Malcolm Cox
- EES – Melissa Scherwinski
- Primary Care – Michael Mayo-Smith
- System Redesign – Michael Davies
- OI&T – Jack Bates

Researchers
- Nashville – Ted Speroff, Steve Brown
- Indianapolis – Brad Doebbeling
- Salt Lake City – Johnathan Nebeker, Matt Samore
Health Care and Engineering

P. Jon White, MD
Health IT Director
March 7th, 2008

Introduction and Overview

- AHRQ and Health Services Research
- Herodotus, History and Hubris
- The Big Questions
- The Journey of 1000 Miles

The Mission

Improve the quality, safety, efficiency and effectiveness of health care for all Americans

Core Business

- Create Knowledge
- Synthesize and Disseminate
- Implementation
- Organizational Excellence
The Health IT Portfolio

- Support the Agency’s Mission

Three Broad Goals:
- Provide Engineered Clinical Knowledge
- Improve Medication Management
- Deliver Patient-Centered Care

Health Services Research

- Multidisciplinary
- Quality and Cost of Healthcare
- Quality and Quantity of life

Clinical Engineers

- "A Clinical Engineer is a professional who supports and advances patient care by applying engineering and managerial skills to healthcare technology." - ACCE Definition, 1992

- Improve healthcare delivery by promoting the development and application of safe and effective healthcare technologies through public awareness and global advancement of clinical engineering research, education, practice and related activities.

Hubris
The Big Questions
- Healthcare Fundamentals
- Process vs Systems
- The Five Whys
- Links in the Chain
- Great Examples
  - VA, Kaiser
  - Replicability and Extensibility

What's it all about?

What's It All About?
Begin The Journey

- Ask the right questions
- Use your tools wisely
- Say "interdisciplinary" like you mean it

In Summary

- AHRQ and Health Services Research
- Herodotus, History and Hubris
- The Big Questions
- The Journey of 1000 Miles
Manufacturing Enterprise Systems
Service Enterprise Engineering

Cerry M. Klein
Program Director
cklein@nsf.gov

• The National Science Foundation (NSF) is an independent federal agency created by Congress in 1950
• The Charge was and is “to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...”
• Has an annual budget of approximately $6 billion
• NSF is the funding source for approximately 20 percent of all federally supported basic research conducted by America’s colleges and universities
• In many fields such as mathematics, computer science and the social sciences, NSF is the major source of federal backing
Directorate for Engineering

Trends

- Engineering discovery and innovation are crucial for addressing increasingly complex challenges touching every sector of society.
  - Health
  - Quality of life
  - Sustainability
  - Energy
  - Security
- Engineering makes important contributions to almost all disciplines
- NSF Engineering discovery, innovation and education are critical elements of the national agenda (e.g., America COMPETES Act and the American Competitiveness Initiative).

Transformative Research

- Research driven by ideas that have the potential to radically change our understanding of an important existing scientific or engineering concept or leading to the creation of a new paradigm or field of science or engineering. Such research also is characterized by its challenge to current understanding or its pathway to new frontiers.

Source: Commonwealth Fund National Scorecard on U.S. Health System Performance, 2006


Health Care Costs

- In 2007, health care spending in the United States reached $2.3 trillion, and was projected to reach $3 trillion in 2011 and $4.2 trillion by 2016
- Health care spending is 4.3 times the amount spent on national defense
- In 2005, the United States spent 16 percent of its gross domestic product (GDP) on health care. It is projected that the percentage will reach 20 percent by 2016
- Nearly 47 million Americans are uninsured and the United States spends more on health care than other industrialized nations who provide health insurance to all their citizens
- The United States spends six times more per capita on the administration of the health care system than its peer Western European nations

International Comparison of Spending on Health, 1980–2004

- Average spending on health per capita (SUS PPP)
- Total expenditures on health as percent of GDP

Source: Commonwealth Fund National Scorecard on U.S. Health System Performance, 2006

Percentage of Gross Domestic Product Spent on Health Care in 2004

- 10.0%
- 10.5%
- 9.3%
- 9.2%
- 8.7%
- 8.4%
- 8.3%
- 8.0%

Source: Commonwealth Fund National Scorecard on U.S. Health System Performance, 2006

Note: Data is from the Commonwealth Fund's Multinational Comparisons of Health Systems Data, 2006 (New York: The Commonwealth Fund, Apr. 2007).

**Health Care Spending per Capita in 2004 Adjusted for Differences in Cost of Living**

- **United States:** $3,041
- **Canada:** $3,198
- **France:** $3,189
- **Netherlands:** $3,061
- **Germany:** $3,195
- **Australia:** $3,057
- **OECD Median:** $2,971
- **United Kingdom:** $2,998
- **Japan:** $2,239
- **New Zealand:** $2,083

**Health Care Expenditure per Capita by Source of Funding in 2004 Adjusted for Differences in Cost of Living**

- **Private Spending:**
  - **United States:** $6,102
  - **Canada:** $5,163
  - **France:** $4,311
  - **Netherlands:** $3,162
  - **Germany:** $3,672
  - **Australia:** $3,005
  - **OECD Median:** $2,976
  - **United Kingdom:** $3,158
  - **Japan:** $2,083
  - **New Zealand:** $2,077

- **Out-of-Pocket Spending:**
- **Public Spending:**

**National Health Expenditures, 2006**

- **Hospital Care:** 30%
- **Physicians’ services:** 21%
- **Physician-office services:** 10%
- **Other professional services:** 12%
- **Rental - Other products:** 2%
- **Retail - Rx drugs:** 10%
- **Home health care:** 2%
- **Nursing home care:** 2%
- **Cost, public health activities:** 2%
- **Program administration:** 1%

**Source:** Centers for Medicare and Medicaid Services, Office of the Actuary, National Health Statistics Group

**Economic Impact**

- More expensive for firms to add new workers slowing job growth.
- For existing workers, health care costs suppress wage increases by driving up total compensation costs.
- As the number of uninsured increases, so does the cost-shift for uncompensated care built into the insurance premiums of those who purchase coverage.
- A third of the medical costs for the uninsured are uncompensated; in 2004, uncompensated care was estimated to be $40.7 billion which is primarily funded (85% of total bill) by government dollars.
- The high incidence of uninsured generates losses throughout the economy, due mainly to the lower productivity of the uninsured (and generally, less health and functional) workers. The Institute of Medicine has estimated that total economic losses attributable to the uninsured amounts to between $65 billion and $130 billion per year with the annual cost of reduced productivity alone at between $87 billion and $126 billion.

**Health Care Costs**

- Premiums for employer-based health insurance rose by 6.1 percent in 2007. Small employers saw their premiums, on average, increase 5.5 percent. Firms with less than 24 workers, experienced an increase of 6.8 percent.
- The annual premium that a health insurer charges an employer for a health plan covering a family of four averaged $12,100 in 2007. Workers contributed nearly $3,300, or 10 percent more than they did in 2006.
- Since 2000, employment-based health insurance premiums have increased 100 percent, compared to cumulative inflation of 24 percent and cumulative wage growth of 21 percent during the same period.
- According to the Kaiser Family Foundation and the Health Research and Educational Trust, premiums for employer-sponsored health insurance in the United States have been rising four times faster on average than workers’ earnings since 2000.
- The average employee contribution to company-provided health insurance has increased more than 143 percent since 2000.
- Average out-of-pocket costs for deductibles, co-payments for medications, and co-insurance for physician and hospital visits rose 115 percent during the same period.

**It is Not Just Cost**

- Despite having the most costly health system in the world, the United States consistently underperforms on most dimensions of performance, relative to other countries.
- Compared with five other nations—Australia, Canada, Germany, New Zealand, the United Kingdom—the U.S. health care system ranks last or next-to-last on five dimensions of a high performance health system:
  - Quality,
  - Access,
  - Efficiency,
  - Equity,
  - Healthy lives.
Health care reform must be systemic

Some History at NSF (compiled by Ron Rardin)

- In 1999 the Institute of Medicine (IOM) study To Err is Human: Building a Safer Health System
- In May 2001, the National Academy of Engineering (NAE) assembled a variety of interested experts for a workshop on engineering and healthcare delivery systems
- In 2001, NSF’s DMI division reorganized to create a new program in "Service Engineering Enterprises (SEE)". Healthcare became a major focus of SEE.
- Based on NSF commitments, the NAE and IOM partnered and solicited additional funding from the Robert Wood Johnson Foundation and the nascent NIBIB at NIH to launch a study in 2002 that led to Building a Better Delivery System: A New Engineering/Health Care Partnership

SEE at NSF

- Base budget of ~$4M/year (flat this year)
- 100+ proposals per year, plus dozens more from special solicitations; ~10% funded
- Steady state, with average grants of $320K, this is about 10 grants per year
- Regular due dates February 15 and October 1
- CAREER - July

A Six Country Ranking of Healthcare Quality, Access, Efficiency, Equity and Mortality

<table>
<thead>
<tr>
<th>Country</th>
<th>Australia</th>
<th>Canada</th>
<th>Germany</th>
<th>New Zealand</th>
<th>UK</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OVERALL RANKING (2007)</strong></td>
<td>3.5</td>
<td>5</td>
<td>2</td>
<td>3.5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Quality Care</td>
<td>4</td>
<td>6</td>
<td>2.5</td>
<td>2.5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Right Care</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Safe Care</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Coordinated Care</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Patient-Centered Care</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Access</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Efficiency</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Equity</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Long, Healthy, and Productive Lives</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4.5</td>
<td>4.5</td>
<td>6</td>
</tr>
<tr>
<td>Health Expenditures per Capita, 2004</td>
<td>$2,876*</td>
<td>$3,165</td>
<td>$3,005*</td>
<td>$2,083</td>
<td>$2,546</td>
<td>$6,102</td>
</tr>
</tbody>
</table>

Source: Calculated by Commonwealth Fund based on the Commonwealth Fund 2004 International Health Policy Survey, the Commonwealth Fund 2005 International Health Policy Survey of Sicker Adults, the 2006 Commonwealth Fund International Health Policy Survey of Primary Care Physicians, and the Commonwealth Fund Commission on a High Performance Health System National Scorecard.
Program Objectives

- Foster research on modeling and analysis issues arising in service systems
- Build collaborations within NSF and in other agencies to incorporate realistic models of human behaviors and their impact on a system
- Lead engineering academia to focus on unfamiliar sectors related to services such as health care, public policy, energy, logistics, security
- Promote research in networks of hybrid systems involving service and other systems such as manufacturing, transportation, energy, and public works systems

Some Currently Funded Projects

- Optimization of Intensity Modulated Radiation Therapy with Time Varying Delivery Plans and Fraction Constraints
- Optimal Management of Expedited Placement Livers
- GOALI: Patient Scheduling for Primary Care Clinics: Theory and Implementation
- Optimization of the Design and Operation of Surgery Delivery Systems
- Optimal Design of the Liver Allocation System Considering Patient Preferences
- Adaptive Appointment Systems with Patient Preferences
- Pediatric Vaccine Formulary Optimization and Analysis

My Initial Leanings

Levels of Abstraction

- Environment (regulatory, policy, insurance, consumers)
- Network (healthcare providers and payers)
- Organization (PHDs, hospitals, clinics, etc)
- Team (frontline care groups)
- Population (interventions for patient groups)
- Patient (evidence-based care)

Final Report from the workshop Research Agenda for Healthcare Systems Engineering

In Health Care Looking For

- Impact across different environments
- Systems wide integration and application
- Projects that integrate and/or consider
  - Equity
  - Quality
  - Cost effectiveness
  - Service sustainability
- Interdisciplinary projects that include health care providers

In Health Care Looking For

- Considerations of the Human Factor in the modeling and analysis
- Public Policy Implications (both directions)
- Can it be implemented? Will it have broad impact, not just localized application?
  - A study conducted for the Midwest Business Group on Health by two research organizations, the Juran Institute and the Severyn Group, concluded that “30 percent of all direct health care outlays today are the result of poor-quality care, consisting primarily of overuse, underuse, and waste.”

For NSF

- Do not want to repeat 1970’s research
  - “Most of the O.R. work I see going on in health and medical care tends to be very micro”
- Want research
  - That is above the “treatment optimization” level
  - That is not just applied OR (algorithm driven)
  - That integrates the health provider and consumer
  - That is realistic, when possible
- As you know, health care is a complex and difficult problem with conflicting objectives – but that is what makes it interesting and compelling
What Can You Do?

• Help Me
  • Would like to have a discussion with the research community
  • Would like your input on setting direction and content
  • Would like to leverage NSF money to help facilitate interaction between the different research communities and constituents

Thank You!!

Cerry Klein
cklein@nsf.gov
703-292-5365

http://www.nsf.gov
Methods of Cost-Effectiveness

Anita Brogan, PhD
Healthcare Engineering Symposium
April 7, 2008

Economic Evaluation and Health Care

- What is economic evaluation?
  - Economic evaluation can be used to estimate the VALUE of a new (or existing) intervention

- How do we define VALUE?
  - By considering the overall cost impact of the new intervention (including cost offsets) against the level of achievable additional health benefits

Interdisciplinary Research

- The art of economic evaluation is informed by several disciplines

  - Public Health/Health Services Research/Medicine
  - Economics
  - Operations Research/Industrial Engineering

Why Do Economic Evaluation?

- Health care budgets are limited
- Decision makers cannot invest in all opportunities
- Knowing the value of competing interventions helps decision makers make informed judgements

  - Examples:
    - The CDC plans to award grants for HIV infection prevention. Which interventions should they fund?
    - How will a managed care organization determine the formulary status of a new drug?

  - More than 25 countries have requirements or formal guidelines for economic evaluation of health care technologies

Types of Health Economic Analyses

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Cost</th>
<th>Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-minimization</td>
<td>Dollars</td>
<td>Assumed equal for all treatments</td>
</tr>
<tr>
<td>Cost-consequence</td>
<td>Dollars</td>
<td>Lists various outcomes</td>
</tr>
<tr>
<td>Cost-effectiveness</td>
<td>Dollars</td>
<td>Single outcome (life-years, symptom-free days)</td>
</tr>
<tr>
<td>Cost-utility</td>
<td>Dollars</td>
<td>Well-being and mortality combined (QALYs)</td>
</tr>
<tr>
<td>Cost-benefit</td>
<td>Dollars</td>
<td>Dollars</td>
</tr>
<tr>
<td>Budget-impact</td>
<td>Dollars (Total, PMPM, PTMPM)</td>
<td>Lists various outcomes</td>
</tr>
</tbody>
</table>

The Cost-Effectiveness Ratio

- Incremental Cost-Effectiveness Ratio (ICER)
  - Additional overall cost associated with new intervention divided by additional overall benefit
  - Typically compared to current standard of care
  - Equation: \[ \frac{\text{Cost(new)} - \text{Cost(current)}}{\text{Effectiveness(new)} - \text{Effectiveness(current)}} \]
  - Provides a measure of value: How much does one additional unit of benefit cost?
  - Can be compared to willingness-to-pay: How much are we willing to pay for one additional unit of benefit?
Measuring Effectiveness

- The denominator of the ICER can be derived from the clinical efficacy of the new intervention

Clinical Efficacy
- Change in disease symptoms
- Change in life expectancy
- Change in overall well-being
- Combination measure

Health Outcomes
- Symptom-free days gained
- Life-years gained
- Utility gains (between 0 and 1)
- QALYs gained

Example QALY Calculation
- Suppose individuals with Disease A receiving standard-of-care treatment (Intervention A) are expected to live for 10 years with a utility value of 0.5
  - 10 years x 0.5 = 5 QALYs
- Suppose Intervention B
  - Extends life expectancy to 12 years
  - Improves utility to 0.7 for a period of 5 years, after which utility returns to 0.5
  - QALYs gained
    - 5 years (0.7 – 0.5) + 2 years (0.5) = 2 QALYs

Capturing Total Costs (Numerator of ICER)

- Intervention Costs
  - Drug, device, or other intervention cost
- Administration Costs
  - Fixed costs to administer the intervention
- Other Direct Medical Care Costs
  - Costs for the care of individuals affected by the intervention
    - Examples: inpatient, outpatient, lab test, and other drug costs for care related to the condition or adverse events
- Indirect Costs
  - Costs for lost productivity due to morbidity or mortality

Example of Total Costs for a New Drug

Cost-Effectiveness Models

- Modeling is often necessary when direct observation is insufficient for estimating effectiveness
- Models can
  - Extend beyond clinical trial period
  - Include standard-of-care comparator if not in trial
  - Account for differences between trial and clinical practice
  - Allow derivation of health outcomes from clinical endpoints
  - Gather data from a range of sources into a single framework
- Models may include decision analysis, regression, Bayesian analysis, and/or life-table analysis
Reference Case

- Panel on Cost-Effectiveness in Health and Medicine
  - Convened in 1993 by the US Public Health Service
  - Developed recommendations to improve the comparability and quality of CE studies across a broad range of conditions and interventions
- Recommendations for the Reference Case
  - Societal perspective, including costs to all entities
  - Health effects measured by QALYs
  - Future costs and outcomes discounted (3% per year)
- Recommendations for Presentation of Results
  - List costs, health outcomes, and ICERs
  - Provide base-case results with sensitivity analysis

Cost-Effectiveness Example

- Cost-effectiveness of darunavir, a new protease inhibitor (PI) for HIV treatment
- Markov model with 5-year time horizon and 3-month cycle length
- Transition probabilities calculated from clinical trial data
- Sample transitions shown for CD4 cell-count health state 201-350

Cost-Effectiveness Example: 5-Year Results

<table>
<thead>
<tr>
<th>Health Outcomes (Discounted at 3%) per year</th>
<th>Darunavir</th>
<th>Available PIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life-years</td>
<td>4.095</td>
<td>3.901</td>
</tr>
<tr>
<td>QALYs</td>
<td>3.693</td>
<td>3.301</td>
</tr>
<tr>
<td>Cost Outcomes (Discounted at 3%) per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antiretroviral drug costs</td>
<td>$124,476</td>
<td>$103,386</td>
</tr>
<tr>
<td>Other medical/medication costs</td>
<td>$82,945</td>
<td>$102,108</td>
</tr>
<tr>
<td>Total costs</td>
<td>$207,422</td>
<td>$205,495</td>
</tr>
<tr>
<td>Incremental Cost-Effectiveness Ratios (Darunavir vs. Available PIs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incremental cost per life-year gained</td>
<td>$6,211</td>
<td></td>
</tr>
<tr>
<td>Incremental cost per QALY gained</td>
<td>$4,647</td>
<td></td>
</tr>
</tbody>
</table>

- $4,647 per QALY is much less than the typical US cost-effectiveness threshold of $50,000 per QALY
- Conclusion: Darunavir is cost-effective compared to available PIs

Wrap-Up

- Cost-effectiveness analysis can provide a measure of VALUE for a new intervention
  - Imperfect but useful tool decision makers can use, along with other evidence, to make informed judgments when facing limited budgets
  - Incremental cost-effectiveness ratios (ICERs) are calculated by dividing the change in total costs by the change in a particular health outcome
- New interventions are typically considered cost-effective in the US if the ICER is less than $50,000 per QALY gained

Suggested Reading

- Books
- Articles
  - Three articles in JAMA from the Panel on Cost-Effectiveness in Health and Medicine: One article in each of issues 14, 15, and 16 (Volume 276, 1996).
Cost-Effectiveness Analysis
Putting it in context

Peter J. Fabri MD, PhD
Professor of Surgery and Professor of Industrial Engineering
University of South Florida

2001 Institute of Medicine Report
Across the Quality Chasm

◆ Health Care Should Be:
  – Safe (sometimes)
  – Effective (sometimes)
  – Patient-centered (rarely)
  – Timely (sometimes)
  – Efficient (rarely)
  – Equitable (hardly)

Quality and Safety

◆ What would you think if I told you
  – More people die per year in the US from medical error than on the highway
  • Safety
  – Healthcare costs (the largest expense in the US at $2 trillion) could be reduced by as much as 50% if we could improve how health care is delivered (safety, error, efficiency, duplication, waste)
  • Cost-effectiveness

Cost-Effectiveness

◆ “The quality and cost of health care have suffered mightily from the lack of meaningful results information”
◆ “It is striking that in a field so preoccupied with cost, the understanding of cost is often so primitive”
◆ “Data on results are rarely available…. There is essentially no information at all on diagnostic effectiveness or its cost….

The Many Faces of Quality

How an engineer looks at quality.

The Blind Men and the Elephant

How a physician looks at quality.

Porter ME, Teisberg EO. “Redefining Health Care” 2006
Problems with Scope of Analysis

1. Cycle of Care
   - "Disease" Onset
   - "Disease" Resolution

2. Episode of Care 1
   - Episode of Care 2
   - Episode of Care 3

3. Intervention 1
   - Intervention 2
   - Intervention 3

4. Problems with Cost Estimates
   - Usually “episode” limited
   - Usually “specialty-focused” not global
   - Cost versus charge inconsistency
   - Direct costs versus indirect costs
   - Current costs versus delayed costs
   - Cost of intervention versus cost of complication

Problems with Effectiveness Estimation

- Limited follow-up
- Incomplete documentation
- Conflict of interest
- Observer bias
- Poor definition of desired outcome
- Focus on surrogate outcomes
- Qualitative versus Quantitative perspective
- Lack of agreement on goal of treatment
- Lack of patient-centered assessment
- Turf

New Math

- Divide one uncertain number by another uncertain number and the total uncertainty could become infinite.
- Until we have better ways to measure costs and effectiveness over the cycle of care, we may only be measuring trade-offs and cost-shifts, and then playing with numbers.

Example

- Traditionally, patients were kept in the hospital until care requirements ended
  - Often full episode and perhaps even full cycle of care
  - Aggregate hospital costs included high-cost days and low-cost days
- Early discharge with home care resulted in higher average acuity (greater revenue) and shorter stay (lower cost)
  - Families had to stay home from work (lost wages)
  - Visiting nurses had to travel long distances (cost shifting)
  - Complications were not documented in the medical record (concealed costs/decreased effectiveness)
  - Readmission isn’t counted in the apparent cost (incomplete data)
- Is this actually cost-effective? Maybe yes, maybe no.

The Solution

- Healthcare engineers should:
  - develop standardized definitions of costs
  - develop methods to capture costs across the care cycle
  - distinguish between cost saving, cost shifting, and cost trade-off
  - develop acceptable methods of outcome assessment and reporting
  - define reliable measures of effectiveness
The Future

- Reliable data will result in reliable models
- Reliable models will result in rigorous analysis
- Rigorous analysis will result in quality improvement
- Quality improvement will result in lower cost

Thank you.
Transforming Clinical Practice
Brad Doebbeling MD, MSc
VA HSRD Center of Excellence
Regenstrief Institute, Inc.
IU School of Medicine & Purdue University
Indianapolis, IN

Goals for Today
• Need for Better Healthcare Systems
• Conceptual Frameworks
• Examples of Recently Funded Research Projects

Need for Better Healthcare Systems:
“We are carrying the 19th century clinical office into the 21st century world. It’s time to retire it.”
Donald Berwick, MD
Institute for Healthcare Improvement

Organizational Transformation

Lean Implementation
• Lean—a generic process management philosophy directed at smoothing flow and eliminating waste
• Incorporating implementation science as framework to design, measure, change culture, spread and sustain
• Positive deviance from complexity science to discover known solutions from participants and their solutions to spread
• Bottom up, inside out, asset based
• “DO WHAT you CAN, WITH WHAT you HAVE, WHERE you ARE.”
Peter Woodbridge, MD, MBA

Indy Balanced Scorecard Performance

Peter Woodbridge, MD, MBA
Implementation & System Redesign

Improving Patient Handoffs in VA Medicine and Nursing Services

- **Aim 1**: Identify barriers and facilitators to effective handoffs in the social, linguistic and technological contexts in which they take place.
- **Aim 2**: Determine how variations in handoff processes lead to “near misses” and adverse outcomes.
- **Aim 3**: Foster adoption of safe and effective practices based upon the findings among participating units.

Indy MRSA Implementation Collaborative—AHRQ Funding

Current State Process Map and Action Plan Developed for the Contact Isolation Processes in Hospital C.

Future State Process Map and Action Plan Developed for the Contact Isolation Processes in Hospital C.

An Operational Citywide Electronic Infection Control Network: Results from the First Year

- We currently track almost 17,000 patients with a history of MRSA infection or colonization across the Indianapolis region.
- Since May 2007, delivered 2698 admission alerts on patients with a history of MRSA, of which 19% percent were based on data from another institution.
- Our system delivers alerts to 20 infection control providers (ICPs) spanning 16 hospital across Indianapolis.
**Initial Outcomes**

- Marked improvement in reliable use of key processes of care
- Reduction in MRSA cases
- 60% reduction in study units
- 20-25% reduction hospital wide

**Epidemiology of MRSA Risk & System Redesign Spread to Prevent MRSA in a Community Network**

- Extension of Indianapolis MRSA implementation collaborative to foster further implementation and spread of the system redesign initiatives
- Investigate Healthcare Associated, Community-Acquired MRSA
- Further develop the informatics and data sharing efforts with CDC’s National Healthcare Surveillance Network and Regenstrief Institute’s informatics biosurveillance initiative.

**Informatics Tool Development for MRSA Data Mining and Surveillance**

Specific Aim 1. Identify informatics use cases for electronic clinical and microbiologic data to support VHA’s MRSA initiative.

Specific Aim 2. Develop and evaluate a surveillance reporting system using text mining for the capture of critical information on VA patients’ MRSA history.

Specific Aim 3. Deliver data on MRSA status from our electronic database via secure e-mail to participating institution’s key staff using electronic “triggers” to rapidly inform decisions on need for isolation.

Specific Aim 4. Assess the usability and effectiveness of this informatics tool to support the VHA MRSA initiative.

Merchant, Friedlin, Brandt, French, Samore, Doebbeling for VA Healthcare Informatics Research Colab.

**Applying informatics to improve practice**

**Mechanisms of CDS Development in VA**

- Clinical experts
- Pilot test CRs
- Provider, Satisf., Usability
- Assess, Evidence review

Saleem, Flanagan, Doebbeling, Yano

**Stroke Quality Improvement Decision Support System (SQUIDDS)**

- Enhancements and implementation of new practice interventions
- Embedding evidence-based interventions in electronic health record
- Updated protocols in relationship to evidence
- Feedback on practice through benchmarking of performance
- Focused specific decision support in IPES for data and indicators

Houston, Williams, Damuah, Allen, VA HSR&D IR
Implementing and Improving the Integration of Decision Support into Outpatient Clinical Workflow

- Identify key approaches for effective clinical decision support integration into clinical workflow
- Colorectal cancer screening reminders
- 2 VA sites (West Haven & Salt Lake City)
- 2 nationally recognized health information technology sites (Regenstrief Institute & Partners Healthcare in Boston)
- Multimethod implementation research
  - direct observation, key informant interviews, simulation modeling in human-computer interaction lab, local implementation of improved prototype

Project status: funded by AHRQ ($400,000), underway, completed first site visits

VA-INPC Data Link

“a full view” of colorectal cancer care received by Indianapolis veterans

INPC (Indianapolis Network for Patient Care)
- citywide clinical informatics network organized by patient
- clinical data about 1 patient from almost all institutions in greater Indianapolis can be viewed in a single virtual medical record:
  - Regenstrief Medical Record System (Wishard public hospital)
  - Clarian (Indiana University Hospital and Methodist Hospital)
  - Community, St. Vincent, and St. Francis health systems

1. Determine the impact on VA performance of CRC screening and surveillance when VA and INPC data are linked.
2. Estimate to what extent unnecessary testing for CRC surveillance occurs when VA and INPC data are linked.

Support:
- Haggstrom – VA Young Investigator Award from Indy VA R&D
- DoD Warfighter grant to expand to other cancers, processes of care

AHRQ CDS Consortium Proposal research objectives

- Knowledge management lifecycle
- Knowledge specification
- Knowledge Portal and Repository
- CDS Knowledge Content and Public Web Services
- Evaluation
- Dissemination

1. Knowledge Management Life Cycle
2. Knowledge Specification
3. Knowledge Portal and Repository
4. CDS Public Services and Content
5. Evaluation Process for each CDS Assessment and Research Area

Simulation-based Planning Model for Mental Health Care Services

- construction of client flow simulation models, and using these models to facilitate collaborative planning
- construct models representing transitions from inpatient to outpatient services and from day treatment to other less intensive community-based programs
- two components of client flows incorporated: 1) actual client movements, and 2) client functioning level transition patterns

Recently Funded VA HSR&D IIR: Doebbeling, Hagg, Salyers, Lawley

Modeling and Visualization

Haggstrom, Jones, Rosenman, Doebbeling
Readiness for Innovation and Potential Benefits of the Planning Approach

Conditions Facilitating Innovation Implementation (Greenhalgh, et al. 2004)

- **Strategic Change:** The staff and administrators recognize that the current situation is intolerable.
- **Innovation System Fit:** Fits with the organization’s existing values, norms, strategies, goals, skill mix, and supporting technologies and ways of working.
- **Assessment of Implications:** Implications of the innovation including its subsequent effects are fully assessed and anticipated.
- **Support and Advocacy:** Supporters of the innovation outnumber and are more strategically placed than its opponents.
- **Dedicated Time and Resources:** The innovation starts out with a budget and the allocation of resources is both adequate and continuing.
- **Capacity to Evaluate the Innovation:** The organization has tight systems and appropriate skills in place to monitor and evaluate the impact of innovation (both anticipated and unanticipated).

Contribution of Planning Approach

- **Tension for Change:** The staff and administrators perceive that the current situation is intolerable.
- **Clear Display of the Extent of Veterans Staying in More Intensive Care Settings Than Necessary:** By simulation demonstration, solutions to the problem will be generated through consensus building, ensuring fit between system and proposed solutions.
- **Consensus Building Among Staff Representatives:** Will be beneficial to gain support from front-line workers.
- **Planning Process Will Include Estimating Costs and Resources Required to Implement Potential Solutions:** Planning process will include estimating costs and resources required to implement potential solutions.
- **Updating Simulation Input Parameters and Simulation Output Analyses Are Easily Done for System Performance Monitoring:** Updating simulation input parameters and simulation output analyses are easily done for system performance monitoring, since under assumptions procedure are implemented.

Steps of Collaborative Planning Approach

1. Conceptual Model Development
2. Deriving Input Parameters – actual client movements, LOF transition
3. Simulation Specification
4. Simulation Output Analyses
5. Model Validation: Comparison of model’s outputs and observed data
6. Sensitivity Analysis
7. Simulation Experimentation
8. Estimate resources and costs required to implement solution

Evaluation and Planning for the Next Step

1. Semi-structured interviews with managers and clinicians
2. Context of use assessment with mental health chiefs in VISN 11
3. Advisory panel meeting for development of multi-site implementation studies

CCE-5: The Cancer Care Situation Room

- Prototype of an interactive, integrated visual and statistical analysis capability for the Indiana cancer care system
- Increases ability to detect patterns, clusters, and trends
- Massively raw datasets -> data integration -> data extraction -> data visualization -> information for evidence-based decisions
- **Outcomes:**
  - Initial phase to visualize CRC screening and f/u data from single VAMC
  - Use electronic CPRS data to visualize screening and scheduling data from perspective of clinic manager
  - Set of prototype visualization tools to help understand current and future state of CRC care in Indiana
  - Increase information communication, reasoning, and decision making based upon huge, disparate datasets and datatypes
  - Planning information for development of a total cancer care situation room

Personal Health Record

- Technology platform: **My HealtheVet**
  - Web-based personal health record that promotes patient-provider communication
- **Clinical content:**
  - Surveillance guidelines (American Society of Clinical Oncology)
  - Treatment received
  - Potential treatment toxicities
  - Self-reported narratives (free text entry)
- **Proposed pilot studies:**
  - Qualitative study of patient & provider needs
  - Usability testing of Web interface and content

Project support:

- D. Haggstrom, VA Career Development Award

Colorectal cancer surveillance care and personal health records

- **Technology platform:** **My HealtheVet**
  - A Web-based personal health record that promotes patient-provider communication
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  - Surveillance guidelines (American Society of Clinical Oncology)
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- **Proposed pilot studies:**
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Usability Evaluation of MyHealtheVet

- New VA HSR&D Rapid Response Project funded 3/08
- Assess usability of MyHealtheVet Personal Health Record from patient’s perspective
- Focus groups, observed usability studies
- Recommendations to improve usability

Project support:

- D. Chumbler, S. Saleem, B. Doebbeling
Healthcare “System” Chasm
“Between the healthcare we have and the care we could have lies not just a gap but a chasm”.

Toward Evidence-Based Quality Improvement: Systematic Review
- Most comparisons reporting dichotomous process data (87%) observed improvements in care, thus dissemination and implementation of guidelines may promote compliance.
- Reminders potentially effective intervention, likely to result in moderate improvements in processes.
- Educational materials and audit and feedback result in modest effects.
- Multifaceted interventions did not appear to be more effective than single interventions.

New System

• Clinical Reminder Definition
  – Four specific reminders for four unique patient cohorts
  – Provides directional interface

• Reminder Dialog
  – Standard VISN dialog
  – Captures data to assist in identifying patient cohorts
  – Directional interface with drop down menus

• Reminder Reports
  – Standardized VISN reports
  – Fall-safe to identify patients to ensure follow-up recommendations

• Consult Templates
  – Standardized VISN GI consult completion template
  – Captures data for follow-up
  – Consult Completion Note/Patient Letter for reporting biopsy results

Interdisciplinary approach

• A wide range of research perspectives not directly related to healthcare can be used in system transformation
  – Complex systems theory, organizational change theory, knowledge utilization, knowledge management, systems engineering and implementation research

• Interdisciplinary research teams can begin to bring these various perspectives together, creating synergy and applying a diverse range of perspectives and tools to healthcare systems.

Outpatient methods to promote adherence

Clinical Practice Organizational Survey, Yano, Flanagan & Doebbeling

Performance Improvement Data Working Group (PIDaWG)

Measure performance against national and regional centers
• Display performance criteria
• Display national data with comparison
• Display local measurements
• Display data from VistA
• Manual data collection tool
• Display process metrics in conjunction with R/PIM projects
• Continue improvement system
Central concepts to System Transformation

• Integration
  - routinize new behaviors
  - may require training, aligning reinforcements with new behaviors, or assigning responsibilities

• Sustainability
  - maintain gains in patient safety and quality as well as maintain support for change

• Spread
  - changes throughout the organization
  - requires a supportive infrastructure for sharing successful redesign experiences
  - incentives are aligned with spreading innovations through a system

Wang et al., 2006

Facilitating System Transformation

• Involve top- and middle-level leaders
• Align and integrate improvement efforts with organizational goals
• Establish and maintain infrastructure, processes, and performance feedback that supports continuous improvement
• Involve champions, teams, and staff in redesign efforts.

Wang et al., 2006
Influencing policy and decision makers

David Matchar, MD
Professor and Director,
Duke Center for Clinical Health Policy
Research and Evidence-based Practice Center

Overview

- The problem: creating technical analysis that is actually used in decision making
- Illustration: Medicare coverage decision making for use of PET scanning in suspected Alzheimer’s disease
- Lessons

The problem

- Health policy decision-makers have to make difficult choices in a rapidly changing and highly complex environment, which often includes vast quantities of contradictory information.

Medicare coverage decision making

- No specific coverage list in the original Social Security Amendments
- Congress delegated the coverage decision to HEW (now HHS)
  - “May not reimburse for items and services which are not reasonable and necessary…”

The tension: stewardship and innovation

- Medicare is the steward of the Trust Fund on behalf of beneficiaries
  - Relevance and defensibility are key
- Industry is the vehicle for bringing innovative interventions to patients
  - Clarity and low market barriers are key

Medicare Coverage Advisory Committee

- Medicare Coverage Advisory Committee (MCAC) “shall review and evaluate medical literature ... to assist HCFA in determining reasonable and necessary applications of medical services and technology.”
Illustration: PET in Alzheimer’s disease

“Does having a PET scan significantly improve the likelihood of better cognitive function? Because if it does -- as one who values my cognitive function -- I want one. And health insurance should pay for it.”

Prevalence of AD in the general population

![Graph showing the prevalence of AD in the general population from Boston, Baltimore, Framingham and Rochester studies](Image)


Illustration: Neuroimaging (NI) in cognitive impairment

Value of knowing

Test

Delayed progression

Decreased mortality

Indirect inference: causal pathway

True +

Test

True +

Treat

Delayed progression

False -

False +

Adverse Event

Decreased mortality

Integrative Model

Data inputs

Asymptomatic

MCI

Dead

Mild Dementia

Moderate Dementia

Severe Dementia

Epidemiological studies

Test performance studies

Drug trials

QOL/preference studies
Results: integrative model

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NI and AD diagnosis: mild dementia

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<th>False – (%)</th>
<th>True – (%)</th>
<th>Correct (%)</th>
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<tr>
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<td>0</td>
<td>0</td>
<td>56</td>
<td>44</td>
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</tbody>
</table>

Many fewer false positives and a few more false negatives

Primary conclusion

- NI could improve the overall accuracy compared to clinical exam.
  However,
- Treatment based on an exam leads to better health outcomes than treatment based on NI results.

How can this make sense?

- Recall, net accuracy with NI is better because there are many fewer false positives and a few more false negatives.
- However, false positives ≠ false negatives:
  - Incorrectly treating (false positive) is not as bad as incorrectly not treating (false negative).
  - Incorrectly treating: Rx is relatively benign and may be beneficial even if patient doesn’t have AD.
  - Incorrectly not treating: patient loses benefit of Rx.

When testing is preferred

1. If a new treatment becomes available that is not only more effective than current therapies but is also associated with a risk of severe adverse effects.
   Increases the benefit of avoiding false positives.

When testing is preferred

2. If the results have demonstrable benefits beyond informing choice of therapies - the “value of knowing.”

  Improves ability to adjust and to plan.
When testing is preferred

3. If testing could be demonstrated to be a better reference standard than clinical examination.

**Predicting response to therapy:** compared to a standard examination, testing better distinguishes patients who respond to therapy or who will have adverse effects.

Epilogue

- Based on analysis, CMS made a national non-coverage decision
- Pressure led to conditional coverage
- Meeting convened with CMS, NIA, FDA, ADA, and other stakeholders
- Commissioned design of a PCT

Lessons

- A successful health technical analysis is one that is used to make clinical or policy decisions
- Analysis must be excellent and relevant
  - Excellence: adherence to principles that give validity to the results.
  - Relevance: responding to a practical question in a compelling way
- Excellence tends to be emphasized by scientists, while relevance tends to be emphasized by decision makers.

Two communities

- The “two communities thesis” postulates the existence of two camps (researchers/analysts and policymakers) that do not naturally tend to account for the values and perspectives of the other. However, the different value that both communities confer to excellence and relevance has little to do with the personalities of the individuals involved. The roots of the conflict lie in the different logic and demands that characterize the respective spheres of research and decision making.

The key determinant of success

- Understanding the needs
- Developing specifications of the task, usually manifested in the “statement of work.”
- Establishing a shared conceptual framework in a process in which all stakeholders actively take part.

Requisite analysis

```
+-------------------+         +-------------------+
|  Stupid Model     |         |  Perfect Model    |
|                   |         |                   |
| +-------------------+         +-------------------+ |
|  Requisite Model  |         |                   |
|                   |         |                   |
```

4
Measures of Effectiveness: How Should We Quantify “Good” Decisions

Julie Simmons Ivy
Edward P. Fitts Department of Industrial & Systems Engineering
North Carolina State University

“An Ounce of Prevention is Worth a Pound of Cure”

• “Health maintenance” refers to personal activities intended to enhance health or prevent disease and disability. These include screening procedures, risk assessment, early intervention, and prevention (Arcury et al., 2001).

Prevention

• Primary Prevention:
  – Pelvic Floor Dysfunction
    • Impact of Birth Delivery Mode

• Secondary Prevention:
  – Breast Cancer Screening
    • Dynamic Screening Intervals for Pre- and Post-menopausal

• Tertiary Prevention:
  – Breast Cancer Screening/Treatment
    • Improving Quality/Accuracy of Treatment given Uncertain Information

Decision Making Under Conditions of Uncertainty

• Applying and Enhancing Modeling Tools of Probability and Operations Research
  • Stochastic Modeling
  • Markov Decision Processes
  • Partially Observable (Hidden) MDP
  • Optimization

• Implicit Requirement for utilizing these modeling tools is Metric for Measuring a “Good” Decision

Defining “Good” Decisions

• Who is the decision maker?
  – Patient, Physician, Payer
  – All

• What is the Decision Maker’s Objective?
  – Payer: Minimize Cost
  – Patient: Maximize Effectiveness ⇒ Utility

• Possible Metric: Mortality Risk

Exploring Trade-offs

• Applications:
  – Mammography Screening: Breast Cancer Prevention
    • Exploring Relationship between Mortality Risk and Screening “Effort”
  – Elective C-Section: Pelvic Floor Dysfunction Prevention
    • Exploring Trade-off between Cost and Utility
Dynamic Breast Cancer Screening Decisions

- NSF Sponsored Collaborative Research Grants (DMI-423090 and DMI-0423410) with
  - Lisa M. Maillart
    - University of Pittsburgh | Department of Industrial Engineering
  - Kathleen Diehl and Scott Ransom
    - University of Michigan | School of Medicine

General Breast Cancer Facts

- Risk
  - 1 in 3
    - female cancer diagnoses is breast cancer (excluding skin)
  - 1 in 8
    - lifetime risk of developing breast cancer
  - 1 in 28
    - lifetime risk of dying from breast cancer

- Survival
  - lifetime survival rate
    - localized, 80%
    - regional, 55%
    - distant metastatic, 20%

General Breast Cancer Facts: Screening

- The earlier breast cancer is detected and followed by appropriate treatment, the greater the chance of survival
- Mammography is the "single most effective method of early detection"
  - 80% sensitivity
  - 95% specificity
- Current screening policy recommendation (static)
  - annual mammograms (and CBE) starting at age 40
    - adherence: 30% of women over 50 do not have a yearly mammogram

Age Effects

- Incidence
  - increases with age
- Aggression
  - decreases with age
- Mammogram accuracy
  - increases with age
    - due to lower tissue density
- Survival
  - increases with age
    - due to more responsive tumors

Research Question

- Given these opposing dynamics...
  - over time
    - incidence
    - aggression
    - accuracy
    - treatment responsiveness
- ...is there value in considering dynamic screening policies?
  - policies with screening intervals that change over time

Approach

- Divide life after age 20 into 13 intervals
  - 20-24, 25-29, ... 85-100
- Restrict attention to "two-phase” policies
  - one, fixed “pre-menopausal” interval
  - one, fixed “post-menopausal” interval
**Approach**

- Define “value” in terms of lifetime mortality risk
- Define “effort” in terms of expected number of mammograms
- Formulate a partially observed Markov chain model
- Analyze a broad set of policies and construct insightful tradeoff curves

**Natural History**

- **State 0**: Cancer free
  - Stage 0: Cancer cells present
  - Stage I: 2 cm or less
- **State 1**: Stage II: 2-5 cm
- **State 2**: Stage III: 5 cm+
- **State 3**: Stage IV: metastatic cancer
- **State 4**: Non-breast cancer death

**Markov Chain Model for Each Decade**

- Transitions occur every 6 months

**Conclusions**

- A patient can achieve a mortality risk “in between” that of two routine policies by using a two-phase policy
- The current recommendation is “epsilon-efficient”
- To maintain moderate risk, do not significantly delay screening start age or advance screening stop age
- Both ramping up and tapering down policies can be efficient
Limitations and Future Work

• Limitations
  – Calculate Worst Case Scenario for Lifetime Mortality Risk: Assume patients enter treatment only through screening
  – Parameter Estimation – Data Limitations

• Future Work:
  – Explore implications of race, comorbidity, age
  – Incorporate alternative screening modalities

• Opportunity:
  – Carolina Mammography Registry

Decision Evaluation Metrics

• Is Mortality the best metric?
• What role does Quality of Life play?
  – Quality of Life:
    • patient's ability to enjoy normal life activities
    • degree of well-being felt by an individual or group of people
    • a patient's general well-being, including mental status, stress level, sexual function, and self-perceived health status.

Decision Evaluation Metrics

• Utility:
  • a measure of the relative satisfaction from or desirability of consumption of goods.
  • In the analysis of health outcomes, utility is a number between 0 and 1 that is assigned to a state of health or an outcome. Perfect health has a value of 1. Death has a value of 0.

Decision Evaluation Metrics

• When Death is NOT the major threat:
  – Morbidity:
    • State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.
    • undesired result or complication
  – Utility – Quality Adjusted Life Years

Decision Evaluation Metrics

Childbirth and Pelvic Floor Dysfunction: An Integrated Decision Analysis

• Collaborators:
  • Xiao Xu, PhD
  • Divya A. Patel, PhD
  • Scott Ransom, DO, MBA, MPH
  • John O.L. DeLancey, MD
  • Dee Fenner, MD
  • Sejal Patel, undergrad. research assistant

Background

• In the United States, cesarean section (CS) rates have now reached their highest levels:
  • 30.3% in 2005
  • 20.7% in 1996
Background

In the absence of medical or obstetrical indications at the onset of childbirth, women may face two alternatives for their delivery:
- Trial of labor: labored deliveries
- Elective cesarean section: unlabored deliveries

Some speculate that the increase in the cesarean section rate may be due in part to an increase in the elective CS.

Most previous studies have focused on immediate outcomes (e.g., infection, hemorrhage, and lacerations).

Little information is available regarding the long term outcomes of different modes of delivery (e.g., sexual dysfunction).

We extended previous work by incorporating both short and long term outcomes associated with mode of delivery.

Childbirth and Pelvic Floor Dysfunction

Elective CS is frequently cited as a means to prevent pelvic floor dysfunction (PFD), including:
- Urinary incontinence (UI): prevalence as high as 55%
- Fecal incontinence (FI): prevalence is 11% - 15%
- Pelvic organ prolapse (POP): 200,000 surgeries per year in US

Unique to PFD is that the conditions are typically symptomatic 20 years after childbirth.

PFD is not a fatal disease, but has significant impact on:
- Quality of life
- Cost from society’s perspective

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PFD is not a fatal disease, but has significant impact on:
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Objectives

To study the cost-effectiveness of 2 delivery management strategies at a woman’s first childbirth (without any medical or obstetric indications):
- Trial of labor
- Elective CS

To identify important knowledge gaps in the pathway from first childbirth to PFD

To inform future discussion on elective CS

Methods

Constructed a decision tree to compare the two delivery management strategies:
- Women at their first childbirth without medical indications
- Consider one childbirth
- Modeled the path and relevant clinical outcomes associated with each management strategy, including:
  - resulting actual mode of delivery
  - short- and long-term maternal outcomes
  - perinatal outcomes

Short Term Birth-Associated Outcomes

Maternal Outcomes
- Maternal death
- Maternal Morbidity:
  - Blood transfusion
  - Wound infection
  - Hysterectomy
  - Surgical injury (uterine, bladder or bowel)

Infant Outcomes
- Neonatal death
- Neonatal Morbidity:
  - Respiratory (Respiratory Distress Syndrome and Transient Tachypnoea)

Assumed that maternal and neonatal outcomes are independent of each other
Decision Tree: Mode of Delivery

1st childbirth without medical/obstetric indication

Trial of labor
Vaginal delivery
Spontaneous vaginal delivery
Instrumental vaginal delivery

Elective cesarean section
Emergency cesarean section

Short Term Maternal/Neonatal Outcomes

Delivery
Maternal death
Neonatal death
Newborn alive
Neonatal morbidity
Healthy newborn

Mother alive
Maternal morbidity
Healthy mother

Long Term Maternal Outcomes

Surgical treatment
No surgical treatment
Stress urinary incontinence

Surgical treatment
Cured
Not cured

No stress urinary incontinence
Fecal incontinence

No fecal incontinence

Pelvic organ prolapse

Cured
Not cured

Preliminary Results

Cost Minimizing Decision:
Trial of labor has a lower expected lifetime cost than Elective CS

Utility Maximizing Decision:
Elective CS has higher expected lifetime utility than Trial of labor

Expected Lifetime Cost

<table>
<thead>
<tr>
<th></th>
<th>Trial of Labor</th>
<th>Elective C-Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Lifetime Cost</td>
<td>$11,684</td>
<td>$11,871</td>
</tr>
<tr>
<td>Expected Lifetime QALYs</td>
<td>57.6</td>
<td>58.4</td>
</tr>
<tr>
<td>Cost-Effectiveness Ratio</td>
<td>$202.8/QALY</td>
<td>$203.3/QALY</td>
</tr>
</tbody>
</table>

Conclusion: No dominate alternative

Next Steps

Conducting one-way sensitivity analysis on utility data
Few data on maternal utility associated with childbirth experience (by mode of delivery, parity and outcomes)
No established method for handling concurrent and subsequent health states
Probabilistic Sensitivity Analysis on Critical Parameters to Estimate Variance
Discussion

- We identified several knowledge gaps, particularly
  - Limited data on maternal and infant outcomes by mode of delivery and parity
  - The link between POP and mode of delivery/parity has not been well characterized
- Continued work in this area should help women, physicians, and policy makers make informed decisions regarding the optimal delivery management strategy.
Measures of Effectiveness:
How Should We Quantify “Good” Decisions

Discussion

Jennifer M. Wu, MD, MPH
Assistant Professor, Dept. of Obstetrics and Gynecology
Division of Urogynecology and Reconstructive Pelvic Surgery
Duke University

Cesarean Deliveries

- Cesarean section is the most common surgery performed on women in the United States.
- ~ 1.25 million cesareans every year.
- Cesarean rate is increasing.

Cesarean Deliveries

- The increasing cesarean rate is concerning.
  - Cesarean section = major abdominal surgery
  - Vaginal delivery = more “natural,” avoids surgery, surgical complications, faster recovery
  - Future repeat cesareans are more challenging because of adhesions/scarring.


Elective Cesareans

- Rate of elective cesareans is rising. Why?
  - Unknown.
  - Prevention of pelvic floor trauma and future pelvic floor disorders
  - Convenience for a woman or her physician to set the time and date of surgery.

Pelvic Floor Disorders

- Pelvic floor disorders:
  1. Fecal incontinence = involuntary loss of solid or liquid stool
  2. Urinary incontinence = involuntary loss of urine
  3. Pelvic organ prolapse = descent (or prolapse) of the vaginal walls.
- Urogynecology = study of pelvic floor disorders.
Childbirth & Pelvic Floor Disorders

- Fecal incontinence: Childbirth may cause vaginal tear that extends into the anal sphincter. A weakened sphincter unable to prevent leakage of stool.
- Prolapse: Childbirth can weaken pelvic floor muscles and tissue leading to descent of the pelvic organs.
- These are long-term outcomes of childbirth.
- Significant impact on quality of life.

Route of Delivery

<table>
<thead>
<tr>
<th>Choice about Route of Delivery</th>
<th>Actual Route of Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned Vaginal Delivery</td>
<td>Vaginal Delivery</td>
</tr>
<tr>
<td>Or</td>
<td>Forceps or Vacuum</td>
</tr>
<tr>
<td>Planned Cesarean Delivery</td>
<td>Cesarean Delivery</td>
</tr>
<tr>
<td>(Elective)</td>
<td></td>
</tr>
</tbody>
</table>

Decision Making

- For an individual
  - Maternal and neonatal outcomes
  - Short-term and long-term outcomes
  - Birth process – attempting a vaginal delivery
  - Subsequent deliveries
- For society
  - Cost; Cost per quality adjusted life year

Maternal Outcomes

<table>
<thead>
<tr>
<th>Short-term Complications</th>
<th>Long-term Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>Subsequent uterine rupture</td>
</tr>
<tr>
<td>Intraoperative or intrapartum complications (i.e., injury to bladder/bowel, sphincter lacerations, perineal hematomas)</td>
<td>Subsequent placental abnormalities</td>
</tr>
<tr>
<td>Anesthetic complications</td>
<td>Urinary incontinence</td>
</tr>
<tr>
<td>Hemorrhage with transfusion or hysterectomy</td>
<td>Fecal incontinence</td>
</tr>
<tr>
<td>Postoperative or postpartum pain</td>
<td>Pelvic organ prolapse</td>
</tr>
<tr>
<td>Wound complications</td>
<td></td>
</tr>
<tr>
<td>Infectious complications</td>
<td></td>
</tr>
<tr>
<td>Thromboembolic complications</td>
<td></td>
</tr>
</tbody>
</table>

Infant Outcomes

<table>
<thead>
<tr>
<th>Short-term Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
</tr>
<tr>
<td>Birth injuries (i.e., brachial plexus injury, fractures, cerebral hemorrhages)</td>
</tr>
<tr>
<td>Respiratory complications (i.e., transient tachypnea, respiratory distress syndrome, persistent pulmonary hypertension, requiring ventilation)</td>
</tr>
<tr>
<td>Neurologic complications (i.e., seizures, encephalopathy)</td>
</tr>
<tr>
<td>Infectious complications</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Long-term Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
</tr>
</tbody>
</table>
**Decision Model**

- Decision model and route of delivery:
  - Consider numerous outcomes simultaneously using best available evidence.
  - Incorporate quality of life (utilities)
  - Incorporate cost
  - Ability to perform sensitivity analyses

**Decision Model**

- Challenges:
  - Limited high-quality data comparing trial of labor and elective cesarean; no RCTs.
  - Outcomes may not be independent.
  - Limited utility data for birth outcomes

**Measures of Effectiveness:**

*How Should We Quantify “Good” Decisions*

**Discussion**

Jennifer M. Wu, MD, MPH
Assistant Professor, Dept. of Obstetrics and Gynecology
Division of Urogynecology and Reconstructive Pelvic Surgery
Duke University
Disease Management through Modeling

HEA Symposium, NC State
April 7 2008

José Zayas-Castro Ph.D.
Department of Industrial and Management Systems Engineering
University of South Florida

Outline

- Disease Management (DM)
- Background
- DM Components
- DM modeling gaps
- DM modeling challenges
- Performance Measures
- Alternatives in DM Modeling
- Examples

Disease Management (DM)

- Reduce healthcare costs
- Improve quality of life
- Develop integrative care
- Minimize disease’s effects

DM Background

- Primary assumption:
  When the right tools, expertise, and equipment are applied to a population, costs decrease, resources are utilized more productively and quality improves.
- Health insurance plans and employers nationally in 2005 spent about $1.2 billion on disease management programs [1]
- Some current approaches
  - Web-based assessment tools,
  - Clinical guidelines,
  - Call-center-based triage
  - Best practices

DM Components

- Identification of the population
- Care guidelines and performance standards
- Management of identified people
- Tracking and monitoring systems

DM modeling gaps

- Are physicians trained to develop analytical models to assess patient’s condition?
- Do diagnostic procedures consider comprehensive patients’ profiles?
- Which information is considered to diagnose patients’ diseases or to prescribe treatments?
- Are diagnostics based on a single data point from the most recent test?
Expected Outcomes

• Anticipate adverse events
• Estimate treatments’ effectiveness over time
• Explain influence of different variables in patient condition
• Improve patient satisfaction.
• Enhance quality of health care delivery.

Performance Measures

• Patients’ general health status
  - Genetic measures – e.g., identification of patient’s disease. Osteoporosis, diabetes, hypertension, heart failure, obesity, asthma, cancer, arthritis, clinical depression, sleep apnea…
• Patients’ disease - specific health status
  - Specific measures – e.g. For osteoporosis calcium levels, or for diabetes blood sugar levels.
• Facilities utilization
• Service utilization
• Cost

Alternatives in DM Modeling

• Care Episodes
  - Diagnosis and treatment planning
  - Care Guidelines
  - Resource Utilization

• Care Cycle
  - Modeling disease etiology
  - Effectiveness through stochastic analyses & optimization
  - Patient centered care
  - Assess care cycle

• Care Support
  - Optimization (e.g. quality of service, cost minimization, facilities sizing, location and management,)

Change Detection of Synchrony in Oscillatory Neurophysiologic Signals for Patient Condition Monitoring

• Sleep apnea: periods of pauses in breathing during sleep.
  - Hypertension and related heart attacks & stroke
  - Students’ disruptive behavior and poor academic performance

Reliability of Gene Expression Values from Microarrays

• Use of gene expression values as a basis for:
  - Disease Diagnosis
  - Individualized Treatment Planning
  - Drug Discovery
  - Noise in the signal prevents accurate estimation of gene expression values
  - Developing a denoising methodology that adopts 2-D multiresolution denoising of image

Error Minimization in Health Care Settings through the Dynamic Analysis of Near-Misses

Improve the quality of care in outpatient settings by dynamically detecting and analyzing near-misses to assess and reduce the likelihood of occurrence of adverse events.
Survival Prediction for Pancreatic Cancer

- 37,170 new cases are expected to in the US in 2008
- 33,370 people will die of pancreatic cancer this year

Define the states of the model using these markers
Utilize Maximum Likelihood estimation to carry out estimation of parameters.
Validation and prediction by means of a “time to death” function.

A Simulation Based Optimization Approach for Strategic Allocation Of Resources During a Pandemic Outbreak

- Define a random process $X = \{X_t : t \in \mathbb{R}^+\}$ as the pandemic spread process
- Define system state at time $t$, in terms of number of infected, deaths, remaining stockpile of vaccine and remaining stockpile of antiviral drugs.

OBJECTIVE: To find actual allocation to current outbreak and virtual allocation to future outbreaks to minimize total cost.

Assessment of Dynamic changes in Blood Calcium levels, Platelets and Mean Platelet Volume

- Low levels of platelets predisposes to bleeding, while high levels may increase the risk of thrombosis.
- Platelet counts are modeled as the dynamic consequence of platelet production and platelet elimination.

In Synopsis

Multidisciplinary Research & Education
Modeling

Problem identification
Improved disease management

Conclusions

Engineering tools
Disease Management
Better diagnosis process
Right treatment for right patient
Comprehensive Patient health's monitoring
Improved quality of care
Medical support systems

Thanks …
Discussion: Disease Management Through Modeling
Dr. Zayas-Castro

Marie Davidian
Department of Statistics
and Center for Quantitative Sciences in Biomedicine
North Carolina State University

http://www.stat.ncsu.edu/~davidian
http://www.ncsu.edu/~cqsb

Discussion: Disease Management Through Modeling
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Key points

- Improving the management of human disease can benefit from the use of quantitative modeling
- Modeling at the population, system, individual levels
- Challenges: Need for data for model development/validation, quality of the data, high dimensional data, appropriate outcome measures
- Like any good discussant, I will complement the talk by telling you about my experiences...

Dynamic treatment regimes

Clinical practice: Treatment of a chronic disease/disorder is an ongoing, dynamic process

- Adjust, change, add, or discontinue treatment based on progress, side effects, patient burden, compliance, etc.
- Sequential decision-making based on accruing observations on the patient

Dynamic treatment regime: aka Adaptive treatment strategy

- A set of sequential decision rules dictating actions at key decision points, each outputting the next step of treatment based on input of information to that point
- Define an algorithm that attempts to operationalize clinical practice

Dynamic treatment regimes

Challenges:

- How to design studies to evaluate and compare fixed dynamic treatment regimes
- How to develop dynamic treatment regimes — high-dimensional information, many decision points, observational data ⇒ time-dependent confounding ...
- Estimating the optimal dynamic treatment regime
- Will give the best outcome for the population and for individual patients given the information available
- Statistical/probabilistic modeling

Mechanistic modeling

How best to use potent ARV therapies to treat acute and chronic HIV infection?

- Continual treatment impossible: Side effects, burden, cost, drug resistance, ...
- Structured Treatment Interruption — cycles of therapy followed by interruption
- Dynamic treatment regimes
- When to interrupt? When to re-initiate? On what basis?

HIV dynamic models: Interplay between virus and immune system

- Nonlinear dynamical system
Mechanistic modeling

Nonlinear dynamical system: Ordinary differential equations, $\frac{dU}{dt}$

$\dot{T}_1 = \lambda_1 - d_1 T_1 - (1 - \epsilon_1 u(t))k_1 V_2 T_1$

$\dot{T}_2 = \lambda_2 - d_2 T_2 - (1 - \epsilon_2 u(t))k_2 V_1 T_2$

$\dot{T}_3 = (1 - \epsilon_1 u(t))k_1 V_2 T_1 - \delta T_3^* - m_2 E T_3^*$

$\dot{T}_4 = (1 - \epsilon_2 u(t))k_2 V_1 T_2 - \delta T_4^* - m_2 E T_4^*$

$\dot{V}_1 = (1 - \epsilon_1 u(t))(T_1^* + T_4^*) - cV_2 - (1 - \epsilon_1 u(t))\rho_1 10^3 k_1 V_1 - (1 - \epsilon_2 u(t))\rho_2 10^3 k_2 T_2 V_1$

$\dot{V}_{NI} = (1 - \epsilon_2 u(t))(T_1^* + T_4^*) - cV_2$

$E = \lambda E + \beta E (\frac{T_1^* + T_4^*}{(T_1^* + T_2^*) + \Delta}) - \delta E E - \frac{d_E (T_1^* + T_2^*)}{(T_1^* + T_2^*) + \Delta} E - \delta E E$

Initial conditions $\{T_1(0), T_2(0), T_4^*(0), T_5^*(0), V_1(0), V_{NI}(0)\}$

Treatment input: $u(t) = 1$ if therapy given at time $t$, $= 0$ if not

$\Rightarrow CD4 count = T_1 + T_1^*$, viral load $= V_1 + V_{NI}$

Mechanistic modeling

Collaborative project: H.T. Banks (applied mathematician at NCSU), Eric Rosenberg (immunologist/infectious disease physician at Mass General Hospital), and me

- **Embed** the mechanistic model in a statistical framework to describe inter- and intra-patient heterogeneity
- **Model-based simulation** and control theory to develop practically feasible dynamic treatment regimes
- Run a clinical trial

Some references


Shameless promotion

- Recently established: the NCSU Center for Quantitative Sciences in Biomedicine (CQSB) http://www.ncsu.edu/cqsb/
- **CQSB Mission**: Bring together scientists in the quantitative and biological/biomedical disciplines to spearhead and collaborate on research projects in the health sciences
- Atlantic Coast Symposium on the Mathematical Sciences in Biology and Biomedicine, April 24–26, 2008, Brownstone Hotel, Raleigh http://www.ncsu.edu/cqsb/acs08.html

Some references


Robins JM. – Visit http://www.hsph.harvard.edu/robsina/


Collaborative modeling to inform decision making about colorectal cancer screening

Michael Pignone, MD, MPH
University of North Carolina- Chapel Hill
Department of Medicine
Sheps Center for Health Services Research

Background

- Colorectal cancer is an important cause of morbidity and mortality
  - 150,000 new cases per year
  - 50,000 deaths
- Screening can reduce incidence and mortality, but is underutilized
- Several different screening tests are available, with different features and costs

AHRQ Systematic Review

- All models found all CRC screening strategies were cost-effective compared with no screening
  - C/E ratios usually under $30,000 / life-yr saved
- Models reached different results as to the most effective and cost-effective strategy
- Variation likely due to differences (and uncertainties) in input parameters- no easy way to sort out these factors in the review


Aims

- To bring together modelers to compare different analyses of colorectal cancer screening in a collaborative exercise
  - Compare different screening strategies
  - Gain insight into reasons for different results
  - Determine areas for future research focus
- To use insights to better inform future modeling and CRC screening research

Collaborative modeling exercise and workshop - 2004

- Convened by NCI and NAS
- Facilitators: Pignone, Wagner, Russell
- 5 modeling groups
- Pre-conference modeling exercise
- Conference to examine and discuss results
- Report with recommendations issues
- Journal publication

Strategies examined

• No screening
• FOBT annually
• FOBT annually + SIG every 5 years
• SIG every 5 years
• Radiological Test every 5 years
• COL every 10 years

Methods

• Standardized inputs for:
  – Test and treatment costs
  – Test Performance
  – Adherence
  – Surveillance strategies
• Each modeler was asked to make 10 “runs” of their models with different combinations of the parameters standardized

Basic Assumptions

• Start screening at age 50, end at age 80
• Cohort of 100,000 average-risk adults
• Use 2003 dollars
• Discount Rate = 3%
• No quality adjustment
• Report life-years and costs to age 85

Assumptions for Standardization

• 100% adherence
• Surveillance every 5 years

Assumptions for standardization: Costs

• FOBT: $10
• Sigmoidoscopy: $200 ($375)
• Radiology test: $200
• Colonoscopy: $625 ($900)
• Costs of treating cancer
  – Local: $24,000
  – Regional: $31,000
  – Distant: $40,000

Assumptions for standardization: Test performance

• FOBT
  – Sensitivity Cancer: 40%
  – Sensitivity Polyps: 10%
• Sigmoidoscopy (reach = 50% of colon)
  – Sensitivity Cancer: 95%
  – Sensitivity Polyps: 85%
• Colonoscopy
  – Sensitivity Cancer: 95%
  – Sensitivity Polyps: 85%
  – Specificity: 100%
• Radiology test
  – Sensitivity cancer: 80%
  – Sensitivity polyps: 70%
  – Specificity: 90%
Costs—Original Assumptions

Life-years—Original Assumptions

Cost-effectiveness compared with no screening—original assumptions

Standardized Results

Costs—Standardized

Life-years—Standardized
Life years compared with no screening: standardized

Costs compared with no screening: standardized

Cost-effectiveness compared with no screening- standardized

Incremental Cost-Effectiveness Ratios and Preferred Strategies

ICERs: Original Assumptions

ICERs: All Standardized
Preferred strategies at different thresholds - Original

<table>
<thead>
<tr>
<th>$20,000</th>
<th>$40,000</th>
<th>$60,000</th>
<th>$80,000</th>
<th>$100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvard</td>
<td>FORT</td>
<td>FORT</td>
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<tr>
<td>Lanka</td>
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<td>RAD</td>
<td>RAD</td>
<td>RAD</td>
</tr>
<tr>
<td>MISCAN</td>
<td>FORT/FS</td>
<td>FORT/FS</td>
<td>FORT/FS</td>
<td>FORT/FS</td>
</tr>
<tr>
<td>Vijan</td>
<td>RAD</td>
<td>COL</td>
<td>COL</td>
<td>COL</td>
</tr>
<tr>
<td>Vandy</td>
<td>FORT</td>
<td>FORT</td>
<td>RAD</td>
<td>RAD</td>
</tr>
</tbody>
</table>

Preferred strategies at different thresholds - standardized

<table>
<thead>
<tr>
<th>$20,000</th>
<th>$40,000</th>
<th>$60,000</th>
<th>$80,000</th>
<th>$100,000</th>
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</tr>
<tr>
<td>Vandy</td>
<td>FORT</td>
<td>FORT</td>
<td>FORT</td>
<td>FORT</td>
</tr>
</tbody>
</table>

Limitations

• Limited set of parameters used - did not adjust natural history (e.g. % cancers arising from polyps, dwell time)
• Only examined one set of values for standard parameters - different values may have produced different results (adherence)
• Did not account for uncertainty in estimates (i.e. no probabilistic sensitivity analyses)

Conclusions

• All models found all strategies to be cost-effective compared with no screening
• Original model results showed substantial variation in costs and effectiveness
• Preferred strategies varied at different thresholds
• Adjustment for differences in costs, test performance, surveillance, and compliance mitigated many, but not all, of the observed differences
  – Cost adjustment was the single strongest factor

Implications for Modeling

• Need to establish standard cost inputs
• Additional work on modeling adherence and costs associated with improving it
• Examine effect of different model structures

Implications for Medical Decision Making

• Colon cancer screening appears effective and cost-effective compared with no screening and should be strongly endorsed and promoted
• Current data are insufficient to strongly recommend one method over another under assumption of cost-free full adherence
Recommendations: USPSTF 2002

"The U.S. Preventive Services Task Force (USPSTF) strongly recommends that clinicians screen all men and women 50 years of age or older for colorectal cancer. (A recommendation)"

"The USPSTF found fair to good evidence that several screening methods are effective in reducing mortality from colorectal cancer. The USPSTF concluded that the benefits from screening substantially outweigh potential harms, but the quality of evidence, magnitude of benefit, and potential harms vary with each method."

"There are insufficient data to determine which screening strategy is best in terms of the balance of benefits and potential harms or cost-effectiveness. Studies reviewed by the USPSTF indicate that colorectal cancer screening is likely to be cost-effective (<$30,000 per additional year of life gained) regardless of the strategy chosen."

USPSTF Ann Intern Med. 2002; 137:129-31

What has actually happened?

• Screening has increased considerably
• Most recent screening has been colonoscopy among insured patients
• Reasons:
  – Decision making from provider viewpoint
    • Availability
    • Enthusiasm
    • Single-test decision making
  – Lack of systems to support FOBT screening

Future modeling-driven studies

• Modeling decision making in the elderly
• Incorporating new technologies
• Eliciting and incorporating informed patient preferences in decision making process
• Planning screening programs to reduce disparities in health care and outcomes
Closing the Knowing – Doing Gap: A Partnership between Health Services Researchers and Management Engineers

Vinod K. Sahney, PhD
Senior Vice President and Chief Strategy Officer
Blue Cross Blue Shield of Massachusetts
Vinod.Sahney@bcbsma.com
617-248-3313

Presented at: The Interface of Health Services Research and Healthcare Engineering
Raleigh, NC
April 7, 2008

Outline

I. Introduction
II. Tsunami of Health Care
III. Changing Paradigm
IV. Institute for Healthcare Improvement (IHI)
V. Partnership between Health Services Researchers and Management Engineers
VI. Discussion

Introduction

Science • Knowledge covering general truths
• General laws obtained and tested through the scientific method
• System of acquiring knowledge using observations and experimentation to describe and explain natural phenomena

Health Services Research
• To examine:
  • Health care quality
  • Effectiveness
  • Patient outcomes
  • Access to care
  • Costs and financing
  • Primary and managed care
  • New technologies
• To inform policy makers:
  • How to improve clinical practices
  • Shape health care delivery systems
  • To create knowledge for improvement

Industrial Engineering
• Concerned with the development, improvement, implementation and evaluation of integrated systems such as people, money, knowledge, information, energy, materials and process
• Systematic methods for diagnosing and correcting problems with service delivery
• Improving productivity, quality and safety
• Management engineering – health care

How Many More Studies Will It Take:
A Collection of Evidence that Our Health Care System Can Do Better

NEHI
New England Healthcare Institute, 2008
1998 - 2006
Hospital Acquired Infection

- Two million patients harmed each year
- 30,000 deaths per year
- Each infection represents an additional $15,000 in health care costs
- Current status – Reliability – 13%

<table>
<thead>
<tr>
<th>Infection Type</th>
<th>Hospitals with Full Compliance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspiration and ventilator associated pneumonia</td>
<td>38.5%</td>
</tr>
<tr>
<td>Central venous catheter related bloodstream infection</td>
<td>35.4%</td>
</tr>
<tr>
<td>Surgical site infection</td>
<td>32.3%</td>
</tr>
<tr>
<td>Influenza</td>
<td>30.7%</td>
</tr>
<tr>
<td>Hand Hygiene</td>
<td>35.6%</td>
</tr>
</tbody>
</table>

* Leapfrog Group/National Quality Forum List of Safety Practices

And the Latest Large American Study…


- 403 indicators of clinical quality of care
- 30 acute and chronic conditions, plus prevention
- Medical records for 6,712 patients
- Participants had received 94.8% of scientifically indicated care

Conclusion: “The Defect Rate” in the technical quality of American health care is approximately 45%.

National Scorecard on U.S. Health System Performance

<table>
<thead>
<tr>
<th>Indicator</th>
<th>U.S. National Rate</th>
<th>Benchmark Measure</th>
<th>Benchmark Rate</th>
<th>Score: Rate of U.S. to Benchmark (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality (100)</td>
<td>115</td>
<td>Top 3 Countries</td>
<td>86.0</td>
<td>90</td>
</tr>
<tr>
<td>Annual Inpatient Utilization (100)</td>
<td>7</td>
<td>Top 3 Countries</td>
<td>2.1</td>
<td>29</td>
</tr>
<tr>
<td>Healthy Days (100)</td>
<td>16.6</td>
<td>Top 3 Countries</td>
<td>19.0</td>
<td>87</td>
</tr>
<tr>
<td>Children tested 11 or more school days</td>
<td>8.2</td>
<td>Top 10% states</td>
<td>3.6</td>
<td>14</td>
</tr>
<tr>
<td>Adults received screenings and preventive care (%)</td>
<td>40.3</td>
<td>Target</td>
<td>88.0</td>
<td>81</td>
</tr>
</tbody>
</table>

Commonwealth Fund, September 2006

National Scorecard on U.S. Health System Performance

<table>
<thead>
<tr>
<th>Indicator</th>
<th>U.S. National Rate</th>
<th>Benchmark Measure</th>
<th>Benchmark Rate</th>
<th>Score: Rate of U.S. to Benchmark (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality (100)</td>
<td>115</td>
<td>Top 3 Countries</td>
<td>86.0</td>
<td>90</td>
</tr>
<tr>
<td>Annual Inpatient Utilization (100)</td>
<td>7</td>
<td>Top 3 Countries</td>
<td>2.1</td>
<td>29</td>
</tr>
<tr>
<td>Healthy Days (100)</td>
<td>16.6</td>
<td>Top 3 Countries</td>
<td>19.0</td>
<td>87</td>
</tr>
<tr>
<td>Children tested 11 or more school days</td>
<td>8.2</td>
<td>Top 10% states</td>
<td>3.6</td>
<td>14</td>
</tr>
<tr>
<td>Adults received screenings and preventive care (%)</td>
<td>40.3</td>
<td>Target</td>
<td>88.0</td>
<td>81</td>
</tr>
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</table>

Commonwealth Fund, September 2006

National Scorecard on U.S. Health System Performance

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</tr>
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<tbody>
<tr>
<td>Chronic Disease under control (%)</td>
<td>52.0</td>
<td>Medicare Private Plans</td>
<td>90.0</td>
<td>81</td>
</tr>
<tr>
<td>Seniors/ Home residents with pressure sores (%)</td>
<td>10.0</td>
<td>Top 10% states</td>
<td>11.0</td>
<td>97</td>
</tr>
<tr>
<td>Adults to see doctor on same day or next day within 15 days (%)</td>
<td>47.4</td>
<td>Top 6 Countries</td>
<td>81.0</td>
<td>54</td>
</tr>
<tr>
<td>Adults in need of care after hours without going to ER (%)</td>
<td>38.0</td>
<td>Top 6 Countries</td>
<td>79.0</td>
<td>51</td>
</tr>
<tr>
<td>Adults with no access problems due to cost (%)</td>
<td>60.0</td>
<td>Top 5 countries</td>
<td>91.0</td>
<td>66</td>
</tr>
</tbody>
</table>

Commonwealth Fund, September 2006

Tsunami of Health Care
### Per Capita Health Spending in the U.S. in Constant 2000 Dollars

\[ y = 1025.3e^{0.0449x} \]

\[ R^2 = 0.9936 \]

### Cost Increases

Between 2000 and 2006 estimated per capita expenditures rose 47%

National Health Expenditures per Capita, 1990-2006

Health care’s share of the GDP is projected to reach 20% by 2015

Source: Centers for Medicare and Medicaid Services, Office of the Actuary, National Health Statistics Group

Source: “National Health Spending In 2006: A Year Of Change For Prescription Drugs,” February 2008


### Medical Trend Outpacing Inflation

BCBSMA’s medical cost trend is growing four times faster than workers’ earnings, and nearly five times the rate of inflation.

### III. Changing Paradigm

**High Cost Low Quality**

To

**High Quality Low Cost**

### High Cost – Low Quality

- $2.7 trillion
- 16.7% GDP
- 460 peer reviewed studies from 1998 – 2006
- 30% waste - $700B
- Misuse, overuse, under use

### High Cost – Low Quality (cont’d)

**Misuse**

- Causes harm, preventable complications
- Adverse treatment events
- Harvard study – 5% of expenditures
- Hospital acquired infections
  - 5% to 10% of all patients
  - 90,000 avoidable deaths
  - $5B expense
High Cost – Low Quality (cont’d)

Overuse
- Potential of harm exceeds benefits
- Variation between high and low utilization regions
  - 30%
  - $70B
- Antibiotic prescription
  - 55% unnecessary

Under Use
- Lack of insurance
  - Lack of access
    - Increased mortality rates
    - 5% to 15%
  - Increased adverse impact on productivity
- Performance Pays: Higher Quality, Lower Costs
  - Premier Quality Demonstration Project

Improving Value in Health Care

<table>
<thead>
<tr>
<th></th>
<th>Cost Savings</th>
<th>Political Viability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Global Payment/Fixed Budget</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>2. Cost Effectiveness of New Technologies Fee For Service/Episodes</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>3. Electronic Medical Records Transparency of Cost/Quality Data Consumer Directed Health Plans (CDHPs) End of Life Care</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>4. Encourage Prevention Malpractice Reform</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>5. Systems Approach to Quality/Cost Improvement</td>
<td>M</td>
<td>H</td>
</tr>
</tbody>
</table>

IV. Institute for Healthcare Improvement

The Institute for Healthcare Improvement is a not-for-profit organization driving the improvement of health by advancing the quality and value of health care.
IHI Vision

The Institute for Healthcare Improvement is a premier integrative force, an agent for profound change, dedicated to improving health care for all. Our measures of success include improved safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity.

IHI Initiatives

- National Forum
  - 7,000 participants
  - 20,000 live by satellite
- Breakthrough Series
  - Emergency Rooms
  - ICU
  - Surgical Infection
  - Ventilator Associated Pneumonia
- Pursuing Perfection – 13 Hospitals
- Impact Network – 210 Hospitals
- Care at the Bedside
- Patient Safety Officer Training
- Executive Quality Academy
- Global Initiatives
- Health Care Professional Education

IHI Breakthrough Series (6 to 13 months time frame)

Select Topic
(develop mission)

Expert Meeting

Develop Framework & Changes

Planning Group

Participants (10-100 teams)

Prework

Congress, Guides, Publications etc.

Supports

Email

Visits

Phone

Assessments

Monthly Team Reports

IHI – 100,000 Lives Saved Campaign

- Campaign: December 2004 - June 2006
- Save 100,000 lives by improving reliability of healthcare within U.S. hospitals
- Target 2,300 hospitals
- Six proven initiatives

Six Initiatives

- Deploy “Rapid Response Teams” at the first sign of patient decline
- Deliver reliably, evidence-based care for acute myocardial infarction
- Prevent adverse drug events by implementing medication reconciliation
- Prevent central line infections – Implement bundles
- Prevent surgical site infections – Implement bundles
- Prevent ventilator associated pneumonia – Implement bundles

Accomplishments

Co-Sponsors:

- Agency for Healthcare Research and Quality
- American Medical Association
- Association of American Medical Colleges
- Center for Medicare and Medicaid
- Joint Commission on Accreditation of Healthcare Organizations
- National Patient Safety Foundation
- University Health System Consortium
- American College of Cardiology
Accomplishments (cont’d)

Co-Sponsors (continued):
- Centers for Disease Control and Prevention
- Society for Healthcare Epidemiology of America
- American Nurses Association
- Leapfrog
- The National Business Group on Health
- 20 State Hospital Associations

3,300 Hospitals Voluntarily Signed Up
$15M Private Contributions
122,000 Lives Saved

V. Partnership between Health Services Researchers & Management Engineers

Management Engineers
- Turn knowledge into practice
- Implementation of best practices
  - VAP bundle
  - Forming micro-system teams
  - Project management
  - Performance monitoring
  - Introduction of technology
  - Creating a culture of learning and improvement

Systems Approach to Improvement in Quality/Cost

Lessons from Other Industries
1. Standardize work
2. Reliability theory – human factors
3. Quality improvement – error reduction
4. Process improvement
5. Use of information technology
6. Supply chain management
7. Outsourcing/Offshoring

“No Toyota in Health Care”

VI. Discussion

- Health Services Research
  - Creating knowledge for improvement
- Management Engineering
  - Execution
  - Continuous Improvement
  - Engagement of front line

The Goal is Closing the “Knowing Doing Gap” and “Turning Knowledge into Practice”

Appendix
Standardize Work

- Riskiest places where errors happen
  - Hand-offs between providers
  - From nurse to nurse at shift change
  - From physician to nurse in operating room
  - From surgery to intensive care unit

- Critical information not passed on to receiving area

Examples
- 25% of missed diagnoses in emergency rooms
  - Failure of positive lab test back to ordering physician
- Children's Hospital of Boston

Standardize Work – Management Engineering

Change Hand-Offs to Hand-Overs

- Clarity of sequencing of steps
- Designated person in charge of monitoring transfer
- Developing protocols for each member of the team
- Shift change knowledge exchange
  - Bedside round
  - Patient goal boards
  - Medication review
- Human factors – reliability improvement
  - Face to face interaction
  - Verbal communication/dialog
  - Checklists
  - Standardized work allows lower wage workers to do the task

Reliability Theory – Human Factors

Health Services Research

Reliability = error free operations over time

Current evidence
- Four defects for every ten opportunities to deliver evidence-based care in physician’s office practice
- One to two defects for every ten opportunities to deliver evidence-based care in hospital practice

Reliability Theory - Human Factors

Why Is Health Care So Unreliable?

- We tend to rely on vigilance and hard work
- We focus on outcomes rather than process
- We fail to design and implement standard work
- We do not learn from human factors science and reliability
- We value individual freedom over reliable design

Reliability Theory – Human Factors

Teamwork – Communications Training

Management Engineers
- Common equipment
- Standard order sheets
- Check lists
- Awareness education
- Decision aids/reminders
- Default – evidence-based action
- Process standardization

Team training for teams working in critical areas
- OR
  - Birthing units
- Teams communication simulation
  - Harvard simulation laboratory
  - Objective
    - Improved communications
    - Improved hand-offs
    - Culture
- Top Gun crew training – Life Wing Partners
  - Obstetrics department procedures and staff communications
  - Fairview Hospital, MN
  - Provena Hospital, IL
Quality Improvement – Error Reduction

- Implementing best practices
- Concept of bundles
  - Surgical bundle
  - VAP bundle
- Elements of a bundle
  - Five steps must be done correctly
  - Each step done accurately 90% of the time
  - Overall reliability (.90)^5 = 59%

Hospital Acquired Infection

Health Services Research vs. Management Engineering
Surgical Bundle: Reducing Post Surgical Infections

1. Antibiotic use consistent with guidelines
2. Antibiotic initiated within one hour prior to surgical incision
3. Antibiotic discontinued within 24 hours of surgery
4. Patient hair clipped – NOT shaved
5. Keep patient warm

Process Improvement – Management Engineering

- LEAN
- Six Sigma
- Patient flow in hospital

Process Improvement - Patient Flow

- Patients waiting in emergency room for beds
- Patients waiting in ICU/Recovery for beds
- Lack of systems approach to understand patient flow, causes of bottle-necks, priority of moving patients through the system
- Special problems for high occupancy hospitals

- Examples
  - Lucille Packard Children’s Hospital, California
    - 3100 more patient days
    - 7.5% increase in patient days
    - Hospital occupancy > 90%
  - St. Luke’s Episcopal Hospital, Houston
    - 5.1% added patient days
    - Improved bed turnaround time by 76%

Process Improvement – Patient Flow

Impact of Poor Patient Flow Management

- Emergency room overflow
- Work overloads on nursing staff
- Longer length of stay
- Stress and errors
- Patients on wrong floors

Key Strategies for Improvement

- Understanding variability
  - Random
  - Schedule caused variability
- Smoothing elective schedules
- Designated OR’s for unscheduled cases
- Assigning discharge dates upon admission and revising as necessary
- Centralized bed management technology
- Bed tracking systems
- Nurse expeditors
- Services available 24/7
- Standard order sets and care pathways for top 20 DRGs
- Bed turnaround time
### Use of Information Technology Management Engineering

- e-Ticket – Customers doing the work
- e-Appointments
- e-Patient self history
- e-Visits with physicians
- e-Prescribing
- Automated prescription refill
- CPOE

### Supply Chain Management and Engineering

**EHCR: Efficient Health Care Response**
- Processing costs: $23B
- Savings potential: $11B

**High Variability**
- Supply expenses: 14-20% of expenses

**IHI Supply Chain Breakthrough Project**
- 75 best practices

### Outsourcing/Offshoring

- Utilizing expertise of another company
- Scale advantage

**Examples**
- UPS managing supply chain for other companies
- Marriott managing cafeterias
- Bio-medical equipment maintenance
- Labor cost advantage
- Examples
  - IT centers
  - Call centers
  - Dictation
  - Accounts management
Access to Care for Alzheimer's Disease in Diverse Cultures

Peggye Dilworth-Anderson, Ph.D.
Professor, Health Policy & Administration
Director, Center for Aging and Diversity/Institute on Aging
University of North Carolina at Chapel Hill

Alzheimer's Disease: The Silent Epidemic
- Alzheimer's disease (AD) is the most common form of dementia; it accounts for 60-80% of all cases
- Symptoms include remembering names and events, impaired judgment, disorientation, confusion, behavior changes, and trouble speaking, swallowing, and walking
- Hallmark abnormalities are plagues and tangles in the brain

Alzheimer's Disease: The Silent Epidemic
- As many as 5.2 million people in the United States are living with Alzheimer's
- Every 71 seconds, someone develops Alzheimer's
- Alzheimer's is the seventh-leading cause of death
- The direct and indirect costs of Alzheimer's and other dementias to Medicare, Medicaid and businesses amount to more than $148 billion each year

Risk Factors for AD and Health Disparities
- The greatest risk factor for AD is AGE
- African Americans are at greater risk for AD than Whites
- Lower levels of education, quality of education and income are factors put Africans at greater risk for AD

Life Course Risk Factors for AD
- High cholesterol
- Type 2 diabetes
- High blood pressure
- Obesity

Risk Factors, Access to Care and Health Disparities
- African Americans have more risk factors for AD than Whites
- African Americans are more likely to receive a later diagnosis of AD than Whites
- African Americans are more likely to receive medications in later stages of AD
Addressing Risk and Access to Care: Empowering the Community

- Provide training in dementia care to community-based individuals in key counties in North Carolina
- Provide an informational intervention to caregivers of poor, rural and medically underserved elders
- Create a model for how to best design and provide educational information to elders and caregivers about AD

Addressing Access
Train the Trainer: A Dementia Care Program

- Five year project 2004-2008
- 13 counties in North Carolina
- Diverse populations: African-American, American Indian, Caucasian

Intervention Pathway:
Train the Trainer: A Dementia Care Program

Step 1:
Building an Intervention
- Modified-Community-based Participatory Research model
- Determining the appropriate time to intervene
- Community Collaboration & Partnerships

Step 1a:
Providing Resources to Trainers
- Five Interactive half-day Training Sessions
- Training Topics:
  - Symptoms and Progression of Dementia
  - Skills in Providing Care
  - Creating Meaningful Days
  - Problem-solving Difficult Behaviors
  - Accessing Care
Step 3b: Providing Resources to Caregivers through Trainers

- Three 2-hour training sessions
- Topics:
  - Normal Aging Process
  - Caregiving Skills
  - Family Dynamics
  - Dementia Care and Caregiving
  - Managing Problem Behaviors
  - Developing help-seeking strategies
  - Symptoms, Diagnosis & Treatment of Dementia

Step 4: Results

Caregiver Demographics

- Average age: 56.6
- Age range: 18 - 89
- 86.5% Female
- 56.3% Married
- 42.1% are primary caregivers

Race/Ethnicity

- Black 12%
- White 54%
- American Indian 34%

Education Level

- < HS: 34%
- HS: 27%
- Some College: 20%
- College or higher: 19%

Employment

- Full Time: 43%
- Part Time: 29%
- Retired: 15%
- Disabled: 9%
- Unemployed: 7%

Usefulness of the Training Sessions (Follow-up Test)

- 94.1% of caregivers are currently using the skills and knowledge gained from the training
- Many caregivers expressed enthusiasm about sharing the information they learned
- 71.5% said the training impacted their jobs
- 28.6% used the training to position themselves in a better job

Usefulness of the Training Sessions (Follow-Up Test)

- 30.8% of caregivers reported the trainings improved their understanding of dementia
- 48.9% reported an increased knowledge of memory loss in general
- Some felt the information helped improve communication with the care recipient’s medical provider

Impact of Trainings on Caregiving (Follow-up Test)

- 83.3% found the information on managing problem behavior beneficial
- The information also helped them develop emotion management and coping strategies for themselves and family members
- Most said the information improved their caregiving skills
Summary

- Involving the community in study implementation and dissemination of results is important.

- AD risk are linked to life course lack of access to care and a life-time of health inequalities and disparities.

- Interventions are needed to help reduce AD risk factors early in life that affect AD risk in later life.

Acknowledgements

Funding provided by GlaxoSmithKline Community Partnership Program

Other Support Provided by:
- Eastern NC Chapter Alzheimer’s Association
- North Carolina Commission of Indian Affairs
- Numerous individuals, colleagues and graduate students

Question & Answer Session
Two concepts:
Access to health care services
Disparities in health status and health outcomes

Two Dimensions of Access
Financial Access: --Out of Pocket
--Third party payor
->Private Health Insurance
->Government Programs
Medicare
Medicaid
-> Provider/ charity/free care

Geographic Access: neighborhoods

Their suggestions for modeling:

> More attention needs to be devoted to eliminating disparities in quality across hospitals rather than within hospitals.

> When it comes to addressing within-hospital disparities in health outcomes, interventions should be targeted toward those hospitals that are lower-performing as opposed to hospitals nationwide.

> …Targeted interventions could be designed to address disparities in outcomes for specific conditions.
Modeling Change: Recent Findings for Long Term Care

>Change: From community-based to institution based;

Data from the National Center for Health Statistics reveal that:

“In 1985, elderly blacks were underrepresented in nursing homes compared to elderly whites (35 compared to 48 per 1,000). By 1995, this disparity had disappeared and by 1997, the residency rate among elderly blacks was significantly higher than for elderly whites (49 compared with 43 per 1000 elderly whites). This trend continued through 1999.” (Centers for Disease Control and Prevention 2004, P. 2).”

My analysis [manuscript] of data on hours of care received by ADL limited elders, in the 1989 and 1999 waves of the National Long Term Care Survey:

>Change: Disparities within the configurations of source of community based care for more severely disabled (ADL limited) elders

1) average hours of care provided by caregivers from all sources to ADL limited— the more severely disabled—elders increased;

2) Primary Informal Caregiver (PIC ) hours to those elders declined;

and

3) the rate of decline in hours of care provided by PIC to ADL limited elders was larger for blacks than whites.

Whether this result from substituting paid for unpaid care has not been studied.
Improving Access: Community Collaborations to Expand Care for NC’s Uninsured

HEA Symposium April 2008

Jeff Spade, FACHE
jspade@ncha.org

Improving Access Agenda

- The Burden of the Uninsured
  
  "Of all the forms of inequality, injustice in healthcare is the most shocking and inhumane."  
  Martin Luther King Jr.

- Policy Solutions Posed for North Carolina
- Community Based Care Networks Serving the Uninsured
- Concepts to Consider for Health Services Research and Healthcare Engineering

US Estimates of the Uninsured

January 2007 through September 2007

- 43.7 million people or 14.7% of the population uninsured.
- Not a significant change from the 2006 estimate of 43.6 million.
- The number of uninsured children under age 18 remained the same, at 6.8 million for 2006 and for most of 2007.

1997-2007 CDC National Health Interview Survey

US Estimates of the Uninsured

Growth of NC Uninsured

- More than 1.5 million non-elderly people in North Carolina who were uninsured (2006)
  - More than three-fifths of the uninsured have low incomes (<200% of the federal poverty guidelines).
  - Between 2000-2006, North Carolina experienced a larger increase in the numbers of uninsured, and larger decrease in employer based coverage than most of the country.
  - Uninsured adults are not unemployed, with most working full time (52.2%).
The Unraveling Social Contract?
In 2005-2006...
• There were 626,000 NC uninsured who worked full time.
• 52.2 percent of the adult uninsured worked full time.
• 18.1 percent of the adults working full time were uninsured.
From 2001-2002 to 2005-2006...
• There were 150,000 more NC uninsured who worked full time.
• The percent of uninsured adults who worked full time increased by 6.5 percent
• The percent of adults working full time who were uninsured increased by 2.5 percent.

Number Non-elderly Uninsured 2005

Percent Non-elderly Uninsured 2005

Time Since Last Pap Smear, Female Workers Ages 39-64, by Insurance Status, 2004

Time Since Last Preventive Specific Antigens (PSA) Test, Male Workers Ages 39-64, by Insurance Status, 2004
NC IOM 2006 Recommendations

1. Additional state funding to support and expand the healthcare safety net, to provide healthcare services to the uninsured.
2. Promotion of personal responsibility for leading a healthy lifestyle and the inclusion of healthy lifestyle promotion in state policies.
3. Development of a limited-benefit Medicaid expansion for low-income parents (78K uninsured covered).
4. Creation of a subsidized health insurance product targeted to small employers with 25 or fewer employees, low-income sole proprietors, and low-income individuals who had not previously offered health insurance coverage (33.5K uninsured covered).
5. Creation of a high-risk pool for individuals with pre-existing health conditions (18K uninsured covered).

Core Safety Net Healthcare Providers and Funding Sources

- Federally Qualified Health Centers
- Free Clinics
- State Funded Rural Health Clinics
- Public Health Departments
- Community Practitioner Program & Private Physicians
- Emergency Departments
- Other Safety Net Resources
- Medication Assistance Programs
- Dental Safety Net Programs
- Behavioral Health Programs
- Funding for Safety Net Infrastructure

Primary Care Safety Net Not Sufficient to Meet All Needs

- In many NC communities, uninsured populations lack access to:
  - Specialty services
  - Medications
  - Behavioral health
  - Dental care
- Existing safety net resources not well integrated.
- Only 25% of NC uninsured received primary care services through safety net organizations in 2003.
- Nationally, less than half of the uninsured are aware of a safety net provider in their community.

Community Based Care Networks Serving the Uninsured

- Care+ShareNC Project
  To facilitate community based care systems to improve the health of North Carolina’s low income and uninsured residents.
- Values and Guiding Principles
- Essential Elements
Values and Guiding Principles

- Community collaborations will be:
  - Collaborative (integrated)
  - Sustainable
  - Patient-centered (patient focused)
  - Built on best practices and evidence-based care
  - Accountable
  - Cost effective

Community Based Care Networks

1. Community projects should be collaborative
   - Governance structure should include: representatives from hospital, primary care providers, safety net providers, local health department, DSS, specialists, dentists, pharmacies, LME.
   - Governance structure encouraged to include: schools, religious groups, community organizations, Area Health Education Centers Programs (AHEC), Healthy Carolinians, uninsured, and others.

2. Maintenance of effort (for ongoing efforts)
   - Existing collaborations should maintain current level of funding, or show why existing funding is no longer available.
   - New funding can be used to expand existing efforts.

3. Outreach, eligibility and enrollment
   - Uninsured should be screened for eligibility for public programs (Medicaid, SCHIP) or for available private insurance (employer-based coverage).

4. Medical home. Project should strive to ensure that uninsured have access to a medical home with a primary care provider who will:
   - Provide medical care, including prevention, early detection, acute care, chronic disease management and referral to other providers (when necessary).

5. Project should arrange for and help link patients to needed specialty care, ancillary services (x-ray, labs), hospital and pharmaceutical care.
   - Services should be available for free or for a nominal price.
   - Plans to expand access to other services (dental, behavioral health).

6. Disease/care management
   - Projects should include disease & care management to help patients with chronic illnesses manage their health.

7. Patient centered. The project should be patient and family centered. Key concepts include:
   - Dignity and respect: Health care providers listen to and honor patient perspective and choices.
   - Information sharing: Patients and their families receive information that is timely, accurate and understandable so that they can participate in decision making.
   - Participation: Patients and their families are encouraged and supported to participate in their care and decision making at the level they choose.
   - Collaboration: Patients are included in program and policy development.

Community Based Care Networks

8. Quality improvement
   - The project engages in quality improvement and service improvement efforts using evidence-based care.
   - Can be in conjunction with CCNC disease management initiatives or other evidence-based models.

9. Reporting requirements, similar to a balanced scorecard, may include:
   - Information on safety net activities to the NC IOM Safety Net website.
   - Metrics on patients served, services provided, outcomes, quality and patient satisfaction.

10. Sustainable
    - Project should develop an ongoing business plan to identify sources of funding or support that can help sustain the community based collaborative over long term.

Essential Network Elements

- Patients can access the full continuum of care.
- Providers participate in creating and maintaining the community based system.
- Patients flow seamlessly between all providers in the network.
- Members enrolled in the system or collaborative one time.
- Information flows between all providers.
- Shared IT system tracks utilization and measures outcomes.
- Services are utilized appropriately, not duplicated, and follow best practices.

Technical Assistance Center

- Resource Development
- Grant Administration and Management
- Community Outreach and Development
- Technical Assistance/Operational Support
- Central Support Services
- Research & Evaluation
- Project Communication and Educational Services
- Administration & Advisory Board Support

Research and Engineering Concepts

- Improve system operation, effectiveness & efficiency.
- Organize process and outcome measures.
- Develop significant system capacities, such as HIT, eligibility & enrollment, coordination of care, chronic disease management, evidence based practice.
- Patient engagement models.
- Create business case for system investments.
- Incorporate quality, reliability, safety and performance improvement.
Access to Care and Health Disparity
NC State Engineering Health Care Symposium
April 2008

Fay Cobb Payton, Ph.D.
Associate Professor of IS/IT
NC State University
fay_payton@ncsu.edu

Definition

- Access to Care
  Indicators of access to care include the extent to which persons have a place they usually go for medical care, and whether persons receive their care in the right setting.

- Health Disparity
  The health resources and Services Administration defines health disparity as “population-specific differences in the presence of disease, health outcomes, or access to health care.”[2]

Disparity in Health Care

- The percentage of persons with a usual place to go for medical care was 77.0% for Hispanic persons, 88.6% for non-Hispanic white persons, and 86.4% for non-Hispanic black persons.

- Of the three race/ethnicity groups, Hispanic persons were least likely to have a usual place to go for medical care.

- 6.5% of Hispanic persons, 5.5% of non-Hispanic white persons, and 6.4% of non-Hispanic black persons were unable to obtain needed medical care due to cost at some time during the year preceding the interview.

- Hispanic persons and non-Hispanic black persons were more likely than non-Hispanic white persons to have lacked access to medical care due to cost.

- Hispanic children are nearly three times as likely as non-Hispanic white children to have no usual source of health care.

- African Americans and Hispanic Americans are far more likely to rely on hospitals or clinics for their usual source of care than are white Americans (16 and 13 percent, respectively, v. 8 percent).

- African-American diabetics are 7 times more likely to have amputations and develop kidney failure than white diabetics.

- When compared to whites, the minority groups such as African Americans, Native Americans, Asian Americans, and Latinos have higher incidence of chronic diseases, higher mortality, and poorer health outcomes. Minorities also have higher rates of HIV/AIDS and infant mortality than whites.

- Former U.S. Surgeon General David Satcher, MD, estimated that nearly 84,000 deaths could be prevented each year if U.S. eliminated the gap in mortality between black and white Americans.

- Blacks, Hispanics and other groups less likely to get strong pain medications in hospital emergency.
Causes of Health Disparity

- There are many factors that can cause health disparities between ethnic and racial groups.
  - The personal, socioeconomic, and environmental characteristics of different ethnic and racial groups.
  - The barriers certain racial and ethnic groups encounter in trying to enter the health care system.
  - The quality of care different ethnic and racial groups receive.

Disparities in access to health care

Reasons for disparities in access to health care can include the following:

- Lack of insurance coverage
- Lack of a regular source of care
- Lack of financial resources
- Legal barriers
- The health care financing system
- Linguistic barriers
- Structural barriers
- Health literacy

Future Directions

To eliminate disparities, the efforts should be made on:

- Understanding the reasons that disparities in health care exist by continuing to incorporate research.
- Identifying and implementing effective strategies to eliminate disparities.
- Continuing to boost data collection.
- Working closely with communities to make sure the research is relevant to them.
- Evaluating the importance of cultural competence to health disparities.
- Building capacity for health services research among minority institutions and minority investigators.

References

Outpatient Clinical Scheduling

Research Team
Mark Lawley, Principal Investigator
Kumar Muthuraman, University of Texas
Laura Sands, Purdue School of Nursing
DeDe Willis, MD, Indiana University School of Medicine
Ayten Turkcan, Research Scientist, Purdue
Poo-Ching DeLaurentis, Research Assistant, Purdue
Rebecca Sandbro, Research Assistant, Purdue
Ji Lin, Research Assistant, Purdue
Santanu Chakraborty, Research Assistant, Purdue
Joanne Daggy, Research Assistant, Purdue
Bo Zeng, Post-doc, Purdue

Funding: National Science Foundation, $460K, Regenstrief Foundation $395K

Partnering Clinics
Wishard Health Services
– Cottage Corner Health Center (low income)
– North Arlington Health Center (low income)

Community Physicians of Indiana
– Giest Family Medicine and Pediatrics (mod. class)

Clinical Scheduling
• In the US, almost 90% of patient care provided in the approx. 200,000 non-psychiatric outpatient clinics
• Pressures for improving clinic operations
  – Aging population
  – Increased chronic disease
  – Hospitals to reduce LOS
  – Improved patient service
    • Access
    • Outcomes
    • Satisfaction
  – Revenue / Reimbursement

• Why is patient scheduling complex?
  – High patient no-show, cancellation, walk-in
  – Tardy arrivals (patients and physicians)
  – Stochastic, patient dependent service times
  – Sequential schedule construction
  – On-call physicians
  – Physician constraints
  – Many others ...

• Project thrust
  – Study and improve internal clinic operations
  – Develop new scheduling theory that accounts for environmental complexities
    • Sequential scheduling
    • Patient no-show
    • General service time distributions
  – Implement in real systems and validate impact

• Patient no-show
  – Ubiquitous problem in clinical operations
  – Can be 40-50% for some types of clinics
  – Approx. 20% for our partners
  – Can be modeled and used in scheduling
  – No show prob. can be estimated using
    • patient history, diagnosis, demographics, medications
    • lead time to appointment,
    • exogenous factors such as weather, public transp.
Sequential Scheduling Process

- Patient calls clinic for appointment with physician
- Scheduler looks at the current schedule, negotiates with patient, adds the patient to a “slot” (we would add estimate no-show prob.)
- Couple of days in advance, clinic might call to remind the patient
- Patient is expected to, but might not, arrive at appointed time.
- Note that schedules are built incrementally, patient by patient.
- Information used is current schedule (plus no-show prob)
- No opportunity to “optimally” schedule final set of patients.
- How can we create good sequential schedule that takes patient no-show into account?

Slot Model

- I slots in a consultation day
- J patient types, p_j probability of patient no-show
- X_i denotes the number of patients arriving at beginning of slot i
- Y_i number of patients overflowing out of slot i
- L_i number of patients served in slot i, initially assumed Poisson
- Q(S_n) overflow probability matrix
- R(S_n) arrival probability matrix

Slot Model

Objective: \( \max E\left[ r \sum_i X_i - c \sum_i Y_i - C Y_I \right] \)

Myopic scheduling algorithm

1. Set \( S_0 = 0 \) for all \( i = 1, \ldots, J \) and \( j = 1, \ldots, J \)
2. Wait for \( n_i^0 \) call
3. \( n_i^0 \) call arrives and is of type \( j \)
4. For each \( j \) in \( Q \)
   (a) Set \( Q' = Q^{-1} \) and \( R' \)
   (b) Compute \( Q' \) and \( R' \) from \( Q^{-1} \) and \( R^{-1} \)
   (c) Compute \( f' = f(Q', R') \)
5. If \( f' \geq f_i \)
   (a) Then \( i' = \arg \max_i f' \), \( f_i = f'_i \) and \( R_i = R_i' \), set \( n = n + 1 \)
6. Else stop

Unimodal Profit Function

**Theorem 1** If \( n \) is such that \( f(Q^n, R^n) < f(Q^{n-1}, R^{n-1}) \) then for all \( m \geq n \), \( f(Q^m, R^m) < f(Q^{m-1}, R^{m-1}) \).

**Proposition 3** A sufficient condition for \( f(Q^n, R^n) > f(Q^{n-1}, R^{n-1}) \) is given by: \( r > \sum_{i=1}^{J} \frac{c - q_i}{(r - q_i)^{n-1}} \) for all \( i \).

**Proposition 4** A sufficient condition for \( f(Q^n, R^n) < f(Q^{n-1}, R^{n-1}) \) is given by: \( r > \min_i \sum_{j=1}^{J} \frac{c - q_j}{(r - q_j)^{n-1}} \).
General Service Times

- Overflow implies patient in service overflowing from one slot to next.
- Must include time in service in previous slot
- Distribution of \( L_i \) takes more general form that requires numerical integration

\[
L_i = \int Pr(L_i = \omega) f_{L_i}(\omega) d\omega
\]

Unimodularity continues to hold

Non-myopic approaches for sequential scheduling

- Optimal Sequential Schedule: Dynamic Programming

\[
V^\beta(s_n,t) = \begin{cases} 
 pV^\beta(s_{n-1},t+1) + (1-p)V^\beta(s_{n-1},t+1) & \text{accept} \\
 V^\beta(s_{n-1},t+1) & \text{reject} 
\end{cases}
\]

- Add simple forecasting to the previous assignment algorithm

Next Steps

- Continue clinic process mapping, operational data collection, simulation – seeking opportunities to improve
- Make suggestions to improve clinic operational efficiency, help implement
- Continue no-show modeling efforts
- Continue developing sequential patient scheduling theory and algorithms
- Begin working with scheduling software vendors

Publications

- Muthuraman, K., Lawley, M. A stochastic overbooking model for outpatient clinical scheduling with no-shows. To appear in IIE Transactions Special Issue on Healthcare

Submitted and Working papers

- Chakraborty, S., Muthuraman, K., Lawley, M. Sequential clinical scheduling with general service times and no-show patients, Operations Research.
What are the short-comings?
Creating Sustained Quality Improvement in Healthcare Organizations

Heather Woodward-Hagg

Purdue Statewide Regional Campus Collaborative
- Interdisciplinary collaborative of Engineering, Technology and Clinical Faculty from Purdue Statewide Campuses
- Focus on partnership with hospitals and healthcare providers to provide facilitation in application of systems engineering methods to enable sustainable change
  - Over 40 projects completed, 5 on-going, 23 hospitals, 9 hospital systems
  - 83% implementation rate
  - 81% of implemented projects sustained at 9-12 months
  - 65% of implemented projects showed good spread

Purdue Statewide/Regional Campus Model

VA COE on Implementing Evidence-based Practices (CIEBP)
- Mission: To advance the science of transforming the health care system, both within and outside the VA health care system.
- Vision: Become the leading national research center for learning about health system transformation
- Strategy: Partner with managers, clinicians and other researchers in interdisciplinary teams to improve healthcare practice

Research Working Groups & Strategic Initiatives
- Patient Safety
- Cancer Care Engineering & Improvement
- Stroke QUERI
- Symptom Epidemiology & Care
- Assertive Community Treatment (SMI)
- Transformational Change
- Health Information Technology
- Systems Redesign

http://www.ciebp.research.va.gov
http://www.indyhealthservicesresearch.org/

Translating Research into Practice - TRIP
- “The translation of research findings into sustainable improvements in clinical practice and patient outcomes remains a substantial obstacle to improving the quality of health care.” - ARHQ
Rubenstein, Pugh Model for TRIP

Three concepts central to system transformation:
- **Integration**: training, aligning reinforcements with new behaviors, or assigning responsibilities
- **Sustainability**: maintaining gains in safety and quality as well as maintaining support for change
- **Spread**: requires supportive infrastructure for sharing successful redesign experiences

Medication Delivery
- Estimated 30% of all medical errors occur during medication delivery processes
- Average litigation expense = $680,000
- Technology available to prevent errors:
  - BCMA – Bar Code Medication Administration
  - Pyxis – Automated Medication Delivery
  - Infusion (Alaris) pumps – regulates IV flow

BCMA Background
- BCMA introduced to reduce medication errors in 1999
- Bypassing / workarounds persist
  - 94 incidents since 10/2002
  - 10/13 aggregate RCA related to BCMA

BCMA Medication Pass
- Steps per patient: 181 steps
- Attempts: 3.3
- Total time per patient: 18 mins
- Supply time per patient: 9 mins
- Med administration time: 9 mins

Med/Isolation Carts – Current State
Supplies & Equipment – PCA Process

1. Supervisor brings PCA pump to floor.
2. Nurse gets patient chart.
3. Supervisor brings PCA pump to floor.
4. Nurse goes to pharmacy to get medication.
5. Nurse goes to supply room to get tubing.
6. Nurse programs PCA in room Rm 875.
7. Nurse goes to pharmacy to get medication.
8. Nurse goes to supply room to get tubing.
9. Nurse goes to pharmacy to get medication.
10. Nurse goes to supply room to get tubing.
11. Nurse goes to pharmacy to get medication.
12. Nurse goes to supply room to get tubing.
13. Nurse goes to pharmacy to get medication.
14. Nurse goes to supply room to get tubing.

14 minutes in the life of a Pharmacy Tech

INTENSIVE GLYCEMIC CONTROL

- Intensive Glycemic Control (80-110 mg/dl) has been shown to reduce mortality morbidity in critically ill patients.
- Components include:
  - Frequent glucose monitoring – 4 hours in critically ill patients
  - Continuous infusion of insulin and glucose
  - Frequent glucose monitoring (30-60 minutes) until stabilized

INTENSIVE GLYCEMIC CONTROL

Example spaghetti diagram for glycemic control process:

<table>
<thead>
<tr>
<th>Rm1</th>
<th>Rm2</th>
<th>Rm3</th>
<th>Rm4</th>
<th>Rm5</th>
<th>Rm6</th>
<th>Rm7</th>
<th>Rm8</th>
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</tbody>
</table>

Process Observation Worksheet

<table>
<thead>
<tr>
<th>Process Observation Worksheet</th>
<th>Minutes</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Initial patient chart</td>
<td>16</td>
<td>0:16</td>
</tr>
<tr>
<td>2. Intensive Glycemic Control</td>
<td>20</td>
<td>0:20</td>
</tr>
<tr>
<td>3. Frequent glucose monitoring</td>
<td>25</td>
<td>0:25</td>
</tr>
<tr>
<td>4. Continuous infusion of insulin and glucose</td>
<td>30</td>
<td>0:30</td>
</tr>
<tr>
<td>5. Frequent glucose monitoring (30-60 minutes) until stabilized</td>
<td>35</td>
<td>0:35</td>
</tr>
</tbody>
</table>
Intensive Glucose Control Implementation

![Graph showing daily glucose levels before and after implementation.]

% of glucose specimens within guidelines by week, 2/1-6/30/2006

![Graph showing % of glucose specimens within guidelines by week.]

Everyone doing his best is not the answer. Everyone is doing his best.

-W. Edwards Deming
Forward, The Deming Management Method

Clinical Practice Implementations

Evidence Based Practice

- Use of scientific evidence to guide practice and improve the quality of healthcare
- “Integration of practice changes through EBP can be complex…” (Titler, 1999)
- Education is necessary, but not sufficient to change practice. (Camiletti and Huffman (1998))

Evidence Based Practice

- Clinical Practice Bundles
  - “a structured way of improving the processes of care and patient outcomes: a small, straightforward set of practices - generally three to five - that, when performed collectively and reliably, have been proven to improve patient outcomes.”
  - IHI – Institute for Healthcare Improvement
    - IHI.org
    - 100,000 lives campaign
    - 5 million lives campaign
**Ventilator Associated Pneumonia (VAP bundle)**

- Ventilator Associate Pneumonia Bundle
  - Head of bed elevation 30-45°
  - Daily assessment for weaning
  - Peptic Ulcer Disease (PUD) Prophylaxis
  - Deep Vein Thrombosis (DVT) Prophylaxis

**VAP Bundle Implementation**

What does this process look like at week 15?

**Sustainability**

What happened?


**VAP Occurrences Jan 2006-May 2006**

- No VAP on unit since Feb 2006
- Decrease in # of vent days 6.2 → 4.8 days
- Decrease in ICU LOS 6.3 → 5.7 days

**Repenning QI Model**


**The “Work Harder” Loop**

* Systems Engineering:
  - Improve Process Reliability
  - Reduce Reliability Erosion Rate
The “Work Smarter” Loop

Process

Reliability

Socio-technical Model

PARiHS Model

Behavioral Components

Normative/Context

Self-Efficacy

Systems Engineering:

• Improve Efficacy/Effectiveness of Improvement Cycle

What factors impact Diffusion of Innovations? [1]

1. Perceived Benefit - organizational and personal
2. Compatibility with existing systems, values, beliefs, current needs
3. Simplicity — Simple innovations spread faster than complicated ones due to the role of adaptation in spread of innovation.
4. Trialability — Changes should be tested and verified prior to full implementation.
5. Observability — Tests of change should be conducted in such a way so as to be readily observable by other ‘early adopters’


QI Methods

“I think that people expect miracles….management thinks that they can just copy from Japan….but they don’t know what to copy…”

- W. Edwards Deming (attr.)
Key Factors for Lean Tool Application to Healthcare

- Focus on enabling the cultural transformation, rather than building technical skills
- Simplify, Simplify, Simplify
- Require immediate application
- Use readily accessible materials
- Use Healthcare terms and examples rather than those from Lean Manufacturing
- Facilitate through repeated applications of tools for at least 2 additional cycles

Workflow Analysis

Workflow analysis is used to:
1. Baseline existing clinical processes prior to the improvement cycle
2. Validate process outputs following improvement
- Workflow analysis includes qualitative and quantitative assessments of work processes.

Tools for performing workflow analysis...

- Current State Process Maps
- Checksheets
- Process Observation Worksheets
- Spaghetti Diagrams
- Value Stream Map
Apply Lean Tools

- Apply Lean Tools to reduce or eliminate waste
  - 5S
  - Visual Controls
  - Visual Workplace rules
  - Workstation Design
  - Setup Reduction

AHRQ “Radically Reducing MRSA” Project

MRSA project Operational Barriers

- Availability of equipment and supplies
- Isolation Signs
- Patient Transportation Processes
- Environmental Services Processes
- Significant gaps in behavioral intent

Isolation Sign - Clarian

Contact Isolation Precautions:

- To Enter: Place Gloves
- To Exit: Place Hands
- Remove Gloves
- Hand Hygiene

Contact Isolation St. Francis

Precauciones de Contacto:

- To Enter: Lave Manos
- To Exit: Lave Manos
The Research Imperative

"...we have... witnessed recent [QI] initiatives that emphasize dissemination of innovative but unproven strategies, an approach that runs counter to the principle of following evidence in selecting interventions that meet quality and safety goals..."

-Auerbach, Landefield NEJM 2007 357;6

Questions?
Improving Healthcare Supply Chains & Logistics

By Ronald L. Rardin, White Distinguished Professor of IE, and Director – Center for Innovation in Healthcare Logistics
University of Arkansas, Fayetteville (http://cihl.uark.edu)

Healthcare Engineering Symposium
North Carolina State University - April 2008

Center for Innovation in Healthcare Logistics (CIHL)

• An industry-university partnership leading a nationwide effort to identify and foster systemic adoption of ground-breaking healthcare supply chain and logistic innovations
  • Outgrowth of March Wal-Mart HIT Conversation
  • Led from University of Arkansas - Fayetteville
  • Current sponsors including Wal-Mart, regional Blue Cross Blue Shields, VHA hospital network, Procter & Gamble, IBM and AHRMM
  • Began operations in May 2007 with sustaining funds for initial level of activity through five years

CIHL Research Colleagues

Faculty Investigators
• Nebil Buyurgan
• Bill Hardgrave
• Russ Meller
• Scott Mason
• Heather Nachtmann
• Ed Pohl
• Sarah Root
• Manuel Rossetti
• Craig Thompson

Graduate Students
• Julie Ann Braden
• Angelica Burbano
• Josh Eno
• Jen Pazour
• Behlul Saka
• Brian Smith
• Yacin Unlu

Collaborating Healthcare Providers

The Backroom of Healthcare

Healthcare Supply Chains

COMMODOITIES
• Medical/Surgical
• Pharmaceuticals
• Implantable Devices
• Portable Clinical Equipment
• Biological Samples
• Lab/Imaging Results
• Sterilized Instruments
• Food Laundry
Why Logistics & Supply Chains

- Supply chains are biggest cost after personnel (at least $11B savings, 40%+ of hospital spend)
- Overlapping providers, inadequate end-to-end collaboration
- Pervasive under-investment in IT
  - Particularly transparency technologies (barcoding, RFID)
- Unnecessary confusion and unreliability
  - About identity, availability, procurement, and location
  - Wrong products or delays create patient safety risks
- Wasteful caregiver “foraging” diminishes time with patients
- Long-term, rural & ambulatory care are poorly understood and under-investigated
- Plagued with “one-off” solutions too often unreplicated

Some Example Topics

Increasing Patient Safety Through Unit-Dose Medications

- **The Challenge:** Medications are typically distributed by manufacturers in bulk, but to increase patient safety, they are often administered to in-patients in unit-doses and to home patients in smaller bulk containers. Frequently the implied repackaging and labeling is done manually or at least with considerable manual intervention.
- **Opportunities for Research:**
  - Determine the most economical and reliable automated manner to repack bulk medications to unit-doses in healthcare institutions of varying size.
  - Determine the overall potential for dose-pack solutions where medications for home use are distributed in time-phased packaging showing intended consumption over the prescribed period.

Healthcare Supply Chain Simplification

- **The Challenge:** Healthcare supply chains are unusually complex with many overlapping players
- **Opportunities for Research:** Adapt findings of supply chain research in other industries to identify cost-effective collaborations and simplifications

Identifying Opportunities for Cost and Quality Improvements in Healthcare Logistics

- **The Challenge:** As healthcare costs continue to rise, there is a lack of clear understanding of achievable cost and quality improvements in various parts of the delivery system. Healthcare supply chains in particular are believed to be highly inefficient and expensive, but the magnitude of potential cost and quality gains is not well documented.
- **Opportunities for Research:** Classify the sources of inefficiency within the healthcare supply chain, identify key elements of the value stream within the supply chain, develop a set of quality indicators, and quantify the potential gains.

Dock-to-Patient Hospital Supply Chain Digitalization

- **Challenge:** Medical and surgical material handling from hospital receiving to the point of care is often fragmented, low tech, and ad hoc. This leads to inconsistent procurement and inventory control on the floors & wings, including unnecessary stockouts & outdates/obsolescence, plus excessive staff time spent foraging for materials.
- **Opportunities for Research:** Investigate how digital technologies familiar in retail inventory and stock management settings can be cost-effectively adapted to automate dock-to-patient material tracking and inventory management.
Procedure Pack Supply Chains and Customization

- The Challenge: Hospital supply chains use pre-manufactured procedure packs for medical interventions such as operating procedures and ambulatory surgeries. Each is a collection of expendable medical supplies configured for a specific procedure, and sometimes for a specific physician. The challenge is to select the minimal set of preconfigured supplies and packs while assuring all materials are available when needed.

- Opportunities for Research:
  - Investigate the re-engineering of surgical supply chains to utilized more standardized procedure packs
  - Document potential cost and safety savings from procedure pack innovations

Logistic Support of Rural and Home Care

- The Challenge: Large parts of the United States lack access to physicians and full service hospitals. Furthermore, more and more healthcare is likely to migrate to being delivered in-home because of patient preferences and cost.

- Opportunities for Research:
  - Identify cost-effective ways to deliver needed healthcare materials to low-density remote or home settings including
  - Risk pooling of inventories for small clinics
  - Routing of deliveries and personnel in rural and home-care settings
  - Managing supply chains for biological samples, imaging, and lab results

What It’s Not About

- Logistics and supply chain research in healthcare does not need to wait for policy level decisions about payment systems, etc.
  - These do affect the available investment funds
  - But the basic opportunities remain everywhere

- Although there are obvious connections, the work is mostly not about medicine and clinical practice
  - It’s about operations -- different from other industries but sharing many of the same challenges
Design and Operation of Surgery Delivery Systems: Open Problems

Brian Denton, PhD
Edward P. Fitts Department of Industrial & Systems Engineering
North Carolina State University
April 8, 2008

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Collaborators
Hari Balasubramanian (Mayo Clinic)
Angela Bailey (Mayo Clinic)
Bjorn Berg (Mayo Clinic)
Todd Huschka (Mayo Clinic)
Heidi Nelson (Mayo Clinic)
Ahmed Rahman (Mayo Clinic)
Ayca Erdogan (NC State)
Jill Iser (NC State)
John Fowler (Arizona State)
Andrew Miller (University of Wisconsin)
Andrew Schaefer (University of Pittsburgh)

Project Overview
- Objective: Develop new engineering models and methods to improve efficiency of surgical care delivery
- Challenges: Changing mix of surgery types, uncertain surgery times, unpredictable add-on cases, multiple and competing performance measures
- Systems Engineering Methods: process mapping, computer simulation, optimization modeling

Major Activities
- Patient Intake: administrative activities, pre-surgery exam, gowning, site prep, anesthetic
- Surgery: incision, one or multiple procedures, pathology, closing
- Recovery: post anesthesia care unit (PACU), ICU, hospital bed

Complicating Factors
- Many types of "resources": surgeons, anesthesiologists, nurses, ORs, equipment, materials
- Large number of activities to be coordinated in a highly constrained environment
- Fixed time to complete activities
- Uncertainty in daily mix of surgeries, urgent add-on cases, and duration of activities
- Many competing criteria

Open Problems
- Optimal design of a surgical suite
  - Number of ORs vs PACU beds
  - Layout to minimize wasted travel time
  - Reconfigurable systems
- Medium range planning
  - Urgent and emergent vs. elective cases
  - Staffing decisions
  - Equipment investment
- Short range scheduling
  - Day of surgery schedule design
  - Case cancellations
  - OR closure decisions
Optimal Design

• Design decisions are one-time decisions with cost implications for years to come
• There are many feasible design options

Systems engineering models can be used to test alternative designs under different operating conditions before committing to one.

Alternate Designs

Capacity Investment

• How many and what type of ORs?

ORs

Surgery Types

• How many and what type of recovery beds?
• Mobile or fixed diagnostic equipment?

Planning

• Planning involves resource allocation in advance of the week, month, or year of surgery.
• Planning decisions must tradeoff many sources of uncertainty

Systems engineering models leverage large data sets to manage uncertainty.

Raw Materials – Process Map

Raw Materials - Detailed Data
Intake, Surgery, and Recovery

Simulation Model

Model Outputs
- Maximum patient throughput
- Waiting time:
  - Patients
  - Surgeons
- Utilization
  - Procedure room
  - Surgeons
  - Recovery beds
- Overtime

Insights
- Operational Insights: The impact of reducing turnover times for ORs on all performance measures is limited to staffing scenarios in which endoscopists have 1 or 1.5 ORs.
- Policy Decisions: are their economies of scale associated with large endoscopy suites?

Appointment Scheduling
- Appointment scheduling systems are at the interface of many stakeholders:
  - Anesthesiologists
  - Nurses
  - Surgeons
  - Administrative Director
  - Patients

Systems engineering models provide a quantitative trade off between multiple criteria.
Basic Science

\[
\begin{align*}
\text{Average Cost of Waiting} & \quad \text{Average Cost of Idle} & \quad \text{Average Cost of Overtime} \\
\min \left\{ \sum_{i=1}^{n} C_i^* \cdot E_i^*[W_i] + \sum_{i=1}^{n} C^* \cdot E_i^{[S_i]} + C^* \cdot E_i^{[L]} \right\} \\
W = \max(W_i - i + Z_i - i - x_i, 0) \\
S_i = \max(-W_i - i - Z_i - i + x_i, 0) \\
L = \max(W_i + Z_i + \sum x_i - d, 0)
\end{align*}
\]

Efficient Frontier

Solutions in Criteria Space

Future Opportunities

- Heterogeneous patient scheduling systems
- Policies related to scope and scale
- Triage based capacity reservation
- Re-configurable health care delivery systems

A culture of efficiency is necessary to translate systems engineering methods into practice.

Questions?
First Annual Healthcare Engineering Symposium
Steve Witz
The Interface of Health Services Research and Healthcare Engineering

Five Questions to Guide Discussions

• What do we have in common?
• What is our common agenda?
• How can we collaborate?
• How do we impact healthcare?
• What are the action items?

What do we have in common?

• Shared understanding of problems with the current healthcare system?
  - disparity of services to the medically indigent
  - improved service distribution
  - improved quality
  - elimination of inefficiency
  - fragmented healthcare delivery system
  - appropriate financing
  - improved prevention
  - cost containment
  - better organization of services

What do we have in common?
We are in agreement with:
– Committee on the Cost of Medical Care – 1932
– National Health Conference – 1938
– National Health Assembly – 1948
– President’s Commission on the Health Needs of the Nation – 1952
– White House Conference on Health - 1965

What do we have in common?

• Common assets – unparalleled depth of expertise
• Common approach - belief in data based analyses and decisions
• Potential to share complementary research methodologies
  – identification and validation of issues of importance
  – integration of multiple variables into system analyses
  – clinical trials and hypotheses testing
  – modeling

What do we share in common?

• Frustration with implementation of research findings
• Academic time
• Competing incentives
  – academic scholarship and incentives
  – impact
• Hubris
What do we have in common?

- Agreement on goals, IOM six quality aims – Healthcare that is:
  - Safe
  - Effective
  - Patient-centered
  - Timely
  - Efficient
  - Equitable

What is our common agenda?

- How do we assure the relevance of our research?
  - transition from importance to subject to impact
- How will we implement and evaluate our research to demonstrate its valuing in achievement of the IOM six aims?
- Once evaluated, how will we disseminate our research findings to enable rapid implementation and impact?

How can we collaborate?

- In interdisciplinary teams
- Must overcome the problems of interdisciplinary research
  - language
  - discipline specific theoretical constructs
  - discipline specific research design and methodologies
- Applied research
  - research questions defined by operational / policy need
  - relevant to operations / policy problem solving
  - must pass the "so what" test – has my research had a demonstrable impact on achievement of the IOM 6 aims?

How can we collaborate?

- Expedite research cycle
  - parallel versus sequential theory testing and model development
  - multi-site replication to test reliability

How can we collaborate?

- Universities must address barriers associated with discipline orthodoxy
  - control and recognition of journal
  - standards of scholarship
  - career channels
  - discouragement of students with applied orientations

How do we have impact on healthcare?

- Involve healthcare to:
  - define research questions – relevance
  - participation in research – domain/environment expertise
  - interpretation of research findings – mutual cooptation
  - implement and evaluate research findings
    - effectiveness
    - sustainability
  - a priori plan for dissemination of findings
What are the action items?

• NSF challenge
• USF lead
• Parallel to VERC
• Challenge ourselves to perform against the “so what” test

Joint funding of 5 competitively awarded grants at $250,000 each to multidisciplinary teams of faculty willing to address one of 5 issues identified by leaders in of healthcare delivery – no students

• Healthcare leaders commit their organizations as living laboratories and participate through research, implementation and evaluation
• Agency and healthcare leaders award grants based upon respondents likelihood of resolving issue, ability to disseminate research findings, and achieve IOM 6 aims - impact

Follow an aggressive schedule
- identify issues by June 30, 2008
- select teams by August 30, 2008
- joint report (researcher / healthcare provider) of findings, implementation and evaluation at 2nd Annual Healthcare Engineering Symposium
- P4P grant award
• Successful grant awardees receive a second grant of $100,000 to evaluate sustainability of research of another research project at 3rd Annual Healthcare Engineering Symposium
• Goal – demonstration of an effective system of effective Healthcare R&I – research and impact.

The question is not how can HSR and HCE interface, but how will research collaborate with healthcare to delivery impact?

• Absolute confidence in the success of this collaboration and the resulting improvement of healthcare delivery and attainment of the IOM 6 aims
• Thank you participants for outstanding contributions, and NCSU, NC A&T, and UNC insightful organization of the symposium and for being gracious hosts!
Appendix C:
Symposium Posters
<table>
<thead>
<tr>
<th>Poster #</th>
<th>Presenter</th>
<th>University</th>
<th>Department</th>
<th>Title</th>
<th>Abstract</th>
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<tbody>
<tr>
<td>1</td>
<td>Anita Vila-Parrish</td>
<td>North Carolina State University</td>
<td>Edward P. Fitts Department of Industrial and Systems Engineering</td>
<td>Dynamic Inventory Management of Perishable Inventory with Applications in the Hospital Pharmacy</td>
<td>Hospital pharmacies throughout the United States are experiencing drug inventory problems that result in waste and shortages that affect patient outcomes due to delayed procedures and drug substitutions. We consider a pharmacist’s decision to order and hold multiple drug products in various inventory stages (i.e. raw material and dispensed form) and physical states (e.g. powder) with varying shelf lives. Through the creation of a series of Markov chains our objective is to create a dynamic order and inventory policy which is based on a characterization of patient demand for a set of critical drugs, as a function of patient condition and mix.</td>
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<td>2</td>
<td>Ayca Erdogan</td>
<td>North Carolina State University</td>
<td>Edward P. Fitts Department of Industrial and Systems Engineering</td>
<td>Stochastic Optimization of Appointment Based Health Systems with Uncertainty in Patient Demand</td>
<td>We focus on investigating the optimal appointment schedule while balancing two competing criteria: patient waiting time and health care service provider overtime. We present a Multistage Stochastic Programming Model as well as the Deterministic Equivalent Model to find the optimal appointment schedule when there is uncertainty in the number of patients to be served. This problem has many applications to healthcare delivery systems with uncertainty in patient no-shows and short notice demand from urgent or emergent patients. Numerical examples are included to demonstrate the value of the stochastic programming solution.</td>
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<td>3</td>
<td>Bjorn Berg</td>
<td>Mayo Clinic, North Carolina State University</td>
<td>A Systems Engineering Approach to Improve Operational Performance in an Endoscopy Suite</td>
<td>Colorectal cancer is a leading cause of cancer death and can be prevented with colonoscopic screening. We evaluate resource allocation and operational planning of high volume colonoscopy screening using a discrete event simulation model of an endoscopy suite. This involves determining several key aspects such as the optimal number of endoscopists operating, the number of operating rooms to use each day, and the number of patients that can be served on any given day.</td>
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<td>4</td>
<td>Bo Zeng</td>
<td>Purdue University</td>
<td>Weldon School of Biomedical Engineering</td>
<td>Stochastic Overbooking with Heterogeneous No-show Patients in Clinic Scheduling</td>
<td>A stochastic clinic overbooking model for patients with heterogeneous no-show rates have been studied. We show that model is not multimodular when patients are heterogeneous. Then, we identify properties of an optimal schedule with heterogeneous patients and propose a local search algorithm to find local optimal schedules. Then, we extend our results to sequential scheduling and propose two sequential scheduling procedures. Based on the analytical results and computational results, we finally present managerial insights for clinic practices.</td>
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<td>5</td>
<td>Chaitra Gopalappa</td>
<td>University of South Florida</td>
<td>Industrial and Management Systems Engineering</td>
<td>A Strategy for Removal of Hybridization and Scanning Noise from Gene Expression Values obtained from Microarrays</td>
<td>Random noise introduced during sample preparation, hybridization, and scanning stages of microarray processing creates inaccuracies in the estimates of gene expressions. We develop a methodology for identifying and removing hybridization and scanning noise from microarray images, by employing wavelet based denoising. Key elements of our methodology include considerations of specific characteristics of microarray images and that of noise, and do not require multiple samples or arrays. Statistical tests indicate an improvement in quality of data.</td>
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<td>6</td>
<td>Daiki Min</td>
<td>Purdue University</td>
<td>School of Industrial Engineering</td>
<td>A stochastic optimization model for elective surgery scheduling under uncertainty</td>
<td>The objective of this study is to investigate the stochastic optimization model which determines an optimal surgery schedule of elective patients with consideration of uncertain surgery activity. The model includes uncertain surgery duration, uncertain emergency demand, two-stage processes and multi-periods, which have not been considered in the previous researches. Sample Average Approximation (SAA) method is used for obtaining the optimal surgery schedule in terms of minimizing patients-related costs and overtime costs. A computational study is presented to evaluate the significance of the stochastic surgery scheduling model.</td>
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<td>7</td>
<td>Daiki Min</td>
<td>Purdue University</td>
<td>School of Industrial Engineering</td>
<td>Feasibility study of UHF Passive RFID technology for workflow analysis in a clinical environment</td>
<td>In the attempt to collect data for the purpose of workflow analysis many healthcare organizations have been exploring the possible opportunities of utilizing Radio Frequency Identification (RFID) technology. Our research consists of a technology assessment conducted to identify factors that impact the use of UHF passive RFID technology and optimal sensor network design in clinical environments. The analysis concludes with identifying obstacles and what is necessary to ensure system reliability.</td>
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<td>8</td>
<td>Eric Sherer</td>
<td>Purdue University</td>
<td>e-Enterprise Center</td>
<td>A mutation network model for predicting CRC prevalence and genetic characteristics</td>
<td>A sequential somatic mutation network model is used to describe colorectal cancer (CRC) prevalence data. This model will be used to predict the likelihood and genetic characteristics of an individual patient’s colorectal cancer based on results from colonoscopies. For example, the model predicts a greatly increased risk of CRC by age 70 if a polyp is present at age 50. The model is currently being tuned to such information with the collection of Lagrangian polyp and CRC prevalence throughout patients’ lifetimes. Future research will refine the genetic network by examining polyp and CRC biopsy characteristics collected throughout patients’ lifetimes.</td>
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<td>9</td>
<td>Feng Lin</td>
<td>Purdue University</td>
<td>Biomedical Engineering</td>
<td>Optimal Implementation of Non-Pharmaceutical Interventions During Pandemic</td>
<td>With the recent emergence and continuing presence of the H5N1 avian influenza, the world is closer to an influenza pandemic than at any time since 1968. The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) have suggested a range of non-pharmaceutical interventions (NPI) to minimize influenza spread before effective vaccines and adequate antiviral drugs become available. Typically, these NPIs reduce the spread by reducing contact between infected and susceptible persons. NPIs are not, however, without societal costs and thus must be used judiciously. We develop an optimal control approach based on an expanded epidemiologic compartmental model (SIR). The objective is to minimize expected person-days lost from influenza related deaths, illnesses, and NPI implementations. An optimal policy is derived for a deterministic control model with an exponentially distributed terminal time and two models of compliance, a static model in which compliance is constant during NPI</td>
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<td>10</td>
<td>Jill</td>
<td>Howard Iser, North Carolina State</td>
<td>Hospital Planning: How many PACU beds?</td>
<td>Generally, the Post-Anesthesia Care Unit (PACU) is fed by all Operating Rooms in a hospital (OR’s) spanning several perioperative services. When looking for the best surgery schedule for any OR we should consider the loading on the PACU resource, which can create a bottleneck for all upstream OR’s. We will begin to model this by considering a two-stage process that represents Surgery and Post-Anesthesia Recovery. This problem highlights the OR as a flexible resource because it can perform the function of both the first stage and second stage processes, where the patient can begin recovery even if they are blocked in an OR. We start by exploring this as an Arena model for simple cases of both the deterministic and stochastic case and recovery lengths.</td>
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<td>11</td>
<td>Jing</td>
<td>Yu, North Carolina State University</td>
<td>PSA Screening for the Detection of Prostate Cancer</td>
<td>Prostate cancer is the most common cancer (excluding skin cancer) that affects American men. Improving PSA-based screening strategies for prostate cancer may increase expected quality adjusted life years for the affected patient population and significantly reduce the total cost of prostate cancer to the health system. In this poster, we investigate the effectiveness of a new detection strategy based on based on PSA-percentage change over time (PSA-PC). We show how normality of PSA-PC and log-normality of PSA influences the optimal screening interval, and we compare PSA and PSA-PC by analyzing ROC curves. Finally, a new Hidden Markov Decision Process models is proposed to determine the optimal threshold of PSA and PSA-PC for biopsy.</td>
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<td>12</td>
<td>Laila</td>
<td>Cure, University of South Florida</td>
<td>Near-Miss Dynamic Analysis for Risk Assessment and Error Prevention in Outpatient Settings.</td>
<td>Estimates of deaths due to preventable errors in hospitals suggest that health care delivery involves risks beyond the inherent conditions of patients. Analyses of past adverse events result in system changes and introduce new forms of risk to be detected later. Near-misses offer significant information on risks when no harm has occurred. This research will develop a near-miss data driven model to dynamically quantify the latent risks in patient encounters to reduce/prevent adverse events.</td>
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<td>13</td>
<td>Po-Ching DeLaurentis</td>
<td>Purdue University School of Industrial Engineering</td>
<td>Game Theoretical Approach for Hospital Stockpiling Problem</td>
<td>This is a problem of medical stockpiling at hospitals in preparing for a flu pandemic. Taking into account the uncertain demand that may occur under various possible pandemic scenarios, we consider the problem of determining the stockpile quantity of one critical medical item. We take a game theoretical approach in order to capture any mutual aid agreement that a group of hospitals may have, and its impact on the stockpile decisions made.</td>
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<td>14</td>
<td>Rebeca Sandino</td>
<td>Purdue University School of Industrial Engineering</td>
<td>Characterization of Clinical Environments for Patient Scheduling</td>
<td>Environmental factors have a significant impact on the efficiency of clinical operations and on quality of care. Yet scheduling methods do not adequately accommodate many routine occurrences. In this work we propose a framework for incorporating many of these routine behaviors into the scheduling process.</td>
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<td>15</td>
<td>Renata Konrad</td>
<td>Purdue University School of Industrial Engineering</td>
<td>Using Information System Messages to Characterize Patient Flow</td>
<td>The Emergency Department is commonly misperceived as the source of hospital delays and overcrowding; however, these issues stem from uneven patient flow. Current decision models inadequately capture flow in failing to 1) distinguish patient condition and 2) provide a synoptic view. This study identifies a commonly existing data source capable of representing events a patient type undergoes-electronic messaging between hospital information systems. Information from these messages is mined to make explicit patient flow. Comparing the output of this approach against patient charts substantiated the viability of this method. By modeling patient flow, this research lays the groundwork for future modeling of a hospital’s operating environment, while providing insight into system wide delays.</td>
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<td>16</td>
<td>Sejal Patel</td>
<td>University of Michigan</td>
<td>Childbirth and Pelvic Floor Dysfunction: An Integrated Decision Analysis</td>
<td>This study models the decision process surrounding mode of delivery for women at their first childbirth in order to find the more cost-effective method. We examine some long term complications such as pelvic floor dysfunction (PFD). In making the decision of which mode of delivery to undergo, we consider both cost and effectiveness which is determined by maternal and infant health outcomes and utility. We conducted a comprehensive review of the current literature to locate information about outcomes associated with each mode of delivery. We considered a trial of labor versus elective cesarean section. This research will help women and their physicians decide whether they should undergo a trial of labor or elective cesarean section, and using decision analysis we hope to help to shape the policy related to elective cesarean section.</td>
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<td>17</td>
<td>Serhat Gul</td>
<td>Arizona State University Department of Industrial Engineering</td>
<td>Simulation Based Surgery Scheduling for an Outpatient Procedure Center</td>
<td>We present a simulation-optimization approach for scheduling of a Surgical Procedure Center. We first evaluate different surgery sequencing and patient arrival time setting heuristics with respect to performance measures: patient waiting time and overtime. We use a simulation-optimization method based on Genetic Algorithm to compute optimal sequences and patient arrival times. We present numerical experiments, based on real data from a large health care provider that compare optimal results to those of heuristics.</td>
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<td>18</td>
<td>Shao-Jen Weng</td>
<td>Arizona State University Department of Industrial Engineering</td>
<td>A Multi-Tool Integrated Methodology (MTIM) for Efficient Resource Allocation in Healthcare</td>
<td>The healthcare industry is one of the largest industries in the world and in the United States accounts for 16 percent of the gross domestic product (GDP). It is widely believed that the inefficiency of healthcare institutions contributes to high healthcare expenditures. This paper proposes a bi-level distributed framework to improve resource allocation and thereby improve hospital operation efficiency. The proposed framework integrates Data Envelopment Analysis (DEA), and a Genetic Algorithm (GA) to determine efficient staffing of hospitals based on a budget allocation from headquarters. Two scenarios: patient-oriented and business oriented are analyzed. Finally, a comparison study between our methodology and augmented resource pricing approach which was proposed by Jennergren (1973) demonstrates the effectiveness of our proposed model.</td>
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HIV patients and their families in Kenya receive nutritional supplements from the Academic Model for the Prevention and Treatment of HIV (AMPATH) nutrition program to complement medication in order to fight the disease. However, the number of the people enrolling in the program has been increasing dramatically, taxing manual recording systems and the Kenyan infrastructure to keep pace. As a result, a computerized nutrition distribution system is needed in order to record the patients’ nutritional information for later academic research and support the distribution of food to patients in the right amount and at the right time. In this project, IE skills have been applied successfully to solve the operational problems in the Kenya food distribution system.
Appendix D:
Symposium Registrants