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Short communication

Highlights of the 2011 Mayo Clinic Systems Engineering and Operations Research conference

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ABSTRACT

In this report, we share highlights of the fourth annual Mayo Clinic Systems Engineering and Operations Research conference. The conference provided a forum for system engineers, operations researchers, clinicians, managers and administrators to share experiences, learning and success stories from their work in applying analytical and modeling tools to a range of problems. This report represents a snapshot of the challenges faced in acute health care, the techniques being deployed and the progress being made by engineers and operations researchers in helping to improve the quality and value of services.

1. Introduction

The Fourth Annual Mayo Clinic Conference on Systems Engineering and Operations Research (SEOR) in Health Care was held in August 2011 in Rochester Minnesota, USA [1]. The conference was held in association with the Production and Operations Management Society (POMS) and the Society for Health Systems (SHS). The continuing mission of the conference is to gather a multidisciplinary group of systems engineers, clinicians, administrators, and academic professors to discuss the translation of systems engineering methods to more effective health care delivery [2]. The challenges outlined in the 2001 Institute of Medicine Report, Crossing the Quality Chasm, are still relevant today [3]. New to the 2011 Conference was the ability for attendees to attend the conference through Second Life® [4]. The conference concluded with a powerful story from a patient and their care team on the importance, and urgency, to use the tools of systems engineering and operations research to improve the health of all patients.

2. Conference workshops

The conference started with a series of workshops. Dr. Franklin Dexter, University of Iowa, focused on decision-making on the day of surgery. As a practicing anesthesiologist with a long interest in operations research, Dr. Dexter brings a unique perspective to the issues of effectively staffing the operating room. Dr. Dexter led participants through numerous scenarios for improving the safety and efficiency of the operating room.

Continuing the theme of surgery, Dr. David Cook and Jeff Thompson, Mayo Clinic, discussed their work in cardiovascular surgery to reduce costs while simultaneously improving care for their patients. Using tools from six sigma to obtain baseline information and to identify the key variables, the project team used computer simulation modeling to evaluate different scenarios related to staffing models, number of operating rooms used, hours of operation, and the impact of reducing variation in case length to explore the influence on costs and efficiency. The insights from examination of the historical information along with the modeling led the team to develop new protocols, theater schedules, and streamlined methods to deliver better patient care. The workshop highlighted the importance of combining the traditional tools of quality improvement and systems engineering.

The importance of applying OR tools to the issue of patient access in ambulatory care settings was highlighted in the workshop by Hari Balasubramanian, Ph.D., University of Massachusetts. Dr. Balasubramanian outlined the tradeoffs in ambulatory clinics on patient panel size [5], the mix of each clinician's empaneled patients, length of appointments, patient satisfaction, continuity in seeing a familiar provider, and the flexibility of the ambulatory care staff in providing timely care to their patients. Probability and computer modeling showed the tradeoffs associated with the complexity of a problem faced by every ambulatory care clinic.

The final two workshops revolved around computer simulation modeling. Mayo Clinic colleagues, Thomas Rohleder, Ph.D., Todd Huschka, and Brian Bailey, led participants through a tutorial on the basics and value of simulation. They stressed that success in simulation is only possible through a well-defined problem,

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knowledge in computer simulation modeling, and available expertise on the clinical processes concerned.

Dr. Yue Dong, Fazi Amirahmadi, Chris Schieffer, and Ashish Gupta, all of Mayo Clinic, took computer simulation into the intensive care unit, applying the skills to sepsis resuscitation. Using discrete event simulation they were able to evaluate differing scenarios for patients with suspected sepsis in a cost effective manner to identify the options leading to optimal care and costs.

3. Opening keynotes

Mark Hayward, conference co-chair, Mayo Clinic, opened the general conference and introduced Dr. John Noseworthy, Chief Executive Officer, Mayo Clinic. Dr. Noseworthy discussed the many different ways engineers have helped Mayo Clinic since its founding. From engineers helping build devices for Mayo Clinic physicians and scientists to the staff in the Division of Systems and Procedures, an internal consulting group at Mayo Clinic staffed by individuals with skills in industrial and process engineering. Dr. Noseworthy pointed to Mayo Clinic's first system engineer, Dr. Henry Plummer, one of the partners with the Mayo brothers. In concluding his remarks, Dr. Noseworthy challenged conference participants to leverage their engineering skills to partner with clinicians to make connections to our patients, wherever they may be in the world.

Dr. Albert Mulley, Director of the Dartmouth Center for Health Care Delivery Science, discussed his long research in the area of informed medical decision-making. Dr. Mulley's research has focused on the use of decision theory and outcomes research to distinguish between warranted and unwarranted variations in clinical practice. Dr. Mulley encouraged participants to review the recent report from the Institute of Medicine, *Engineering a Learning Healthcare System: A Look at the Future—Workshop Summary* [6]. Dr. Mulley went on to describe the work of Dr. Jack Wennberg and his colleagues at the Dartmouth Atlas [7]. This work shows widespread variability in the amount of care and cost of care across the United States. An article by Dr. Atul Gawande, "The Cost Conundrum" [8] brought this variability to life by describing the differences between two communities in Texas. These are the challenges facing system engineers. Teamwork between clinicians, engineers, and other team members in the process will be critical.

Dr. David Lane, London School of Economics (LSE), illustrated the use of system dynamics (SD) through two public health examples. The United Kingdom National Audit Office and LSE staff constructed a simulation model to understand and control clostridium difficile outbreaks [9]. Different contamination stages, various transmission mechanisms and bed, toilet and staff hand cleaning were represented. In the second example, SD qualitative systems mapping approach was used to structure child and family social workers' understanding of the problems with the existing system. Dr. Lane highlighted the benefits of involving people in building SD models to establish understanding, and buy-in, of the system, better solutions, and a commitment to action.

The first day of the conference concluded with a panel discussion describing Mayo Clinic's methods for providing increasing value in health care. Dr. Veronique Roger, Dr. Robert Nesse, and Robert Chase pointed to Mayo Clinic's commitment to continually explore new ways to bring higher value to patients. Dr. Roger, chair, Mayo Clinic Center for the Science of Health Care Delivery, pointed to numerous articles on methods to improve health care. Dr. Roger also stressed the need for rigor in our approaches, to ensure the solutions are generalizable [10]. Dr. Nesse, Chief Executive Office, Mayo Clinic Health System, described efforts by leading healthcare organizations to collaborate to improve care through the High Value Health Care Collaborative (HVHC) [11]. Nesse, Roger, and Chase emphasized the need for health care groups to move to new models of care, align research and measures, and focus on delivering value in a cost-effective manner.

4. Improving care and patient safety in the operating rooms

The second day of the conference featured a wide array of applications of SEOR tools in a variety of clinical settings.

Dr. Robert Cima, Mayo Clinic, shared how the use of technology in the operating rooms has helped to reduce the number of retained foreign objects to near zero. Extensive data analysis from over 190,000 operations revealed the majority of those retained foreign objects were sponges. Through bar-coded technology, supporting hardware and process changes, Mayo Clinic in Rochester, Minnesota, has gone three years without a retained sponge in the operating room. Dr. Cima emphasized the multidisciplinary nature of the project team along with extensive data and financial analysis leading to project success [12].

Vikram Tiwari, Ph.D., University of Houston, and David Berger, MD, Baylor University, laid out of the case for real-time flow control of the operating room. Their project entailed a real-time location system for patients, personnel, critical equipment, and activities. Real-time visual displays are also an important part of the changes to help personnel track and react to the hourly changes. Improved operating room utilization, reductions in delays between cases and timeliness of first cases were just a few of the successes seen by the project.

Dr. Brian Rothman, Vanderbilt University, shared work underway at his institution to provide real-time decision support in the operating rooms. The Vanderbilt Perioperative Information Management System (VPIMS) is an integrated electronic medical record with real-time anesthesia and nursing documentation and providing notification information to staff throughout the operating rooms via electronic in-room whiteboards, desktop computers, and conventional pagers. Rothman noted timely delivery of this information can provide clinical teams better opportunities for safe and effective care.

5. Data mining for making better decisions in health care

The extensive use of data mining and analysis in health care was illustrated in a session hosted by three clinical practitioners from Vanderbilt University. Dr. Stephan Russ addressed the difficult problem of patient placement in the hospital setting. Through a switch to a centralized bed assignment system, the hospital was able to reduce the time it takes to assign a bed and increase inpatient occupancy without an adverse affect on the rate of patient transfers.

Dr. Brian Rothman discussed the need for capacity planning for facilities through an illustration on the number of operating rooms needed in Obstetrics for handling unpredictable cases. The team looked at three years of historical data in the obstetrics suite and showed through statistical process control charts, the probability of needing an additional operating room. Use of the model helped decision-makers make an informed decision regarding an expensive resource.

Dr. Jesse Ehrenfeld concluded the session by pointing to the usefulness of the extensive information available in the operating rooms.

6. Optimizing patient flow

Craig Froehle, Ph.D., University of Cincinnati, addressed the complex issue of providing continuity of care for patients with complex health issues. These patients may see a different, customized subset of providers during their visit. Using mixed integer programming, the team was able to develop patient and provider schedules to minimize patient wait times, provider idle time, and the duration of the clinic. Implications for spreading the scheduling model to a larger facility were discussed during the session.

Denise White, Ph.D., Cincinnati Children's Hospital Medical Center, continued the discussion on clinic flow by exploring the