By Tarun Mohan Lal and Dustin Kuchera

Editor's note: This is another in a series of articles profiling members of the INFORMS Roundtable.

Mayo Clinic

Famed medical group boasts long history of applying O.R. to improve delivery care systems.

Mayo Clinic's hospital-setting headquarters in Rochester, Minn.

Mayo Clinic has a long history and culture of using systems thinking and operations research (O.R.) to improve patient care delivery processes. More than 100 years ago Dr. Henry Plummer, one of the first few physicians of Mayo Clinic, had a strong interest in engineering and was instrumental in bringing forth the unified medical record, conveyors and pneumatic tubes to transport medical records and correspondence, as well as the exam room color coded light system. He also applied systems engineering principles in planning Mayo's facilities, developing its system of subways, and establishing policy and form development, all with the vision of building patient-centered delivery processes. In 1947, under the leadership of Ernest Schlitigus, a small industrial engineering team known as Procedures and Records was formed with the foresight to make systems engineering services available to support projects related to scheduling, workflows analysis and process improvement.

> *"Everybody wants better performance for less money, and that's exactly what we want to help create in healthcare, through the Systems Engineering and Operations Research teams at Mayo Clinic. This growing field touches every aspect of our patients' healthcare experience. It's about their next visit to the doctor or the unexpected trip to the emergency room. And it's about how well the experience goes for patients, how long they have to wait, how much it costs and how effective the treatment turns out."*
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> **– Dr. Veronique Roger, director, and Mark Hayward, administrator, Center for Science of Healthcare Delivery, Mayo Clinic**

As Mayo Clinic evolved into one of the largest academic medical centers in the world, the organization realized the need to include advanced analytics and O.R. to address the growing complexity in the healthcare environment. Today Mayo approaches strategic planning, process redesign, integrated care delivery science and enterprise project management by applying systems engineering and O.R. methods. Mayo Clinic hires industrial engineers and operations researchers in the following groups to address challenges in healthcare operations and delivery.

The Center for Science of Healthcare Delivery has a team of research consultants with advanced training in O.R. disciplines, including MDs, Ph.D.s and master's degree recipients. The Healthcare Systems Engineering Program's purpose is to integrate and apply advanced O.R. expertise to practice, research, and education within healthcare delivery operations. The program supports the infrastructure and expertise to proactively provide objective research, analysis and re-engineering advocacy that will enhance and develop Mayo Clinic's healthcare delivery system. The program facilitates knowledge to delivery as outlined in Figure 1 by increasing the capacity and skill in systems engineering/O.R. to provide the highest levels of care and health at optimal cost.

All About the Roundtable

The Roundtable consists of the institutional members of INFORMS with member company representatives typically the overall leader of O.R. activity. The Roundtable is composed of about 50 organizations that have demonstrated leadership in the application of O.R. and advanced analytics. The Roundtable culture is peer-to-peer, encouraging networking and sharing lessons learned among members.

The Roundtable meets three times a year. Roundtable goals are to improve member organizations' OR/MS practice, help Roundtable representatives grow professionally and help the OR/MS profession to thrive. Further information is available at http://roundtable.informs.org.

The Roundtable also has an advisory responsibility to INFORMS. According to its bylaws, "The Roundtable shall regularly share with INFORMS leadership and advise the INFORMS Board on its views, its suggested initiatives and its implementation plans on the important problems and opportunities facing operations research and the management sciences as a profession and on the ways in which INFORMS can deal proactively with those problems and opportunities." The Roundtable meets with the INFORMS president-elect each spring to discuss practice-related topics of interest to him or her, and with the entire INFORMS Board each fall to discuss topics of mutual concern.

This series of articles aims to share with the INFORMS membership at large some information and insights into how O.R. is carried on in practice today.

The Division of Systems and Procedures, Mayo Clinic's internal business consulting team, has more than 120 staff members with a variety of backgrounds, including systems, industrial and management engineering. The division offers three primary service lines: Business Strategy and Planning, Business Process Engineering and Business Transformation. O.R. methods are applied on a variety of projects. The division also has a team of experts who help all analysts, including MBAs, apply O.R. tools and approaches to projects.

The Department of Lab Medicine employs a team of 11 industrial engineers that support the process improvement and redesign initiatives within the Mayo Clinic's department of lab medicine and pathology. This department performs more than 20 million laboratory tests annually in support of the Mayo Clinic practice and more than 4,000 Mayo Medical Laboratories clients around the world.

In addition to having dedicated staff with specialized training in O.R. methods, an education program exists for training staff on quality improvement methods and tools through the Quality Academy to facilitate better translation of these methods into clinical practice. A Systems Engineering and Operations Research collaborative, which began in 2005, brings together Mayo Clinic staff with expertise in areas such as business analysis, healthcare policy and research and quality management. The group helps build awareness of O.R., provides professional development opportunities and studies how systems engineering and O.R. could be used to improve healthcare.

Over the past few years, the collaborative has sponsored a number of educational opportunities for Mayo staff, including a monthly seminar, external speakers, discussion forums, professional society memberships, annual conference on healthcare systems engineering and O.R., educational workshops and a master's-level Mayo Graduate School course.

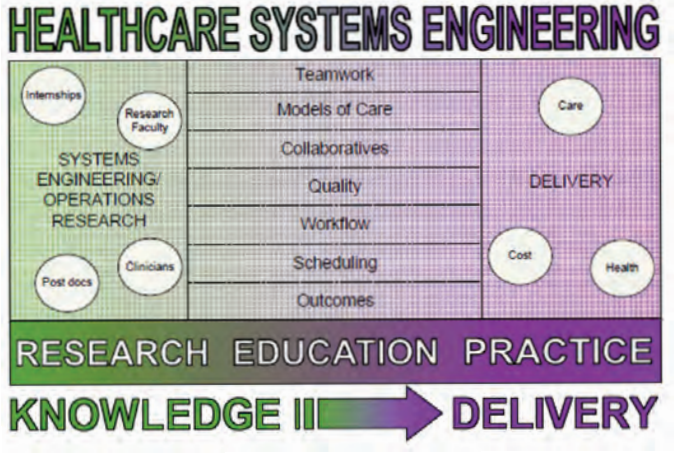

Figure 1: Mayo Clinic's Healthcare Systems Engineering Program facilitates knowledge to delivery care by increasing the capacity and skill in systems engineering/operations research.

"The advantage Mayo Clinic has is the collaboration of engineers and physicians, in a real hospital setting. This gives us the opportunity to design solutions around the patient."

– Dr. Jeanne Huddleston, associate medical director for Health Systems ngineering Program, Center for Science of Healthcare Delivery, Mayo Clinic

Success stories

IN THE PAST SEVERAL YEARS, Mayo Clinic's systems engineering teams have applied several O.R. methodologies in different clinical settings to improve care delivery. Figure 2 represents the use of O.R. methodologies in healthcare settings at Mayo Clinic. Each engineering method is leveraged in any clinical setting on a need basis, as represented by all of the stars in the figure. The blue stars designate a moment in time when the tools and expertise of specific methods are prioritized to specific practice directed initiatives in the respective settings.

Following are some example projects that demonstrate the application and use of O.R. methods at Mayo Clinic:

Patient Flow Design: Creating Care Congruency: Aligning Staffing and Care Geography around Cardiac Surgical Care Redesign

The traditional model of cardiac surgical care was based on the hospital service of the attending cardiac surgeon. The geographic location of the patient, the staffing support for patient care and the process of care were based on a "solution shop" model. One of the fundamental changes in redesign of cardiac surgical services at the Mayo Clinic was to create a "Rapid Recovery Pathway" for cardiac surgical patients whose care could largely be standardized. While about 50 percent of the cardiac surgical population was identified as better suited to the traditional model, the remaining 50 percent was shown to be suitable for a path consisting of integrated protocols driving

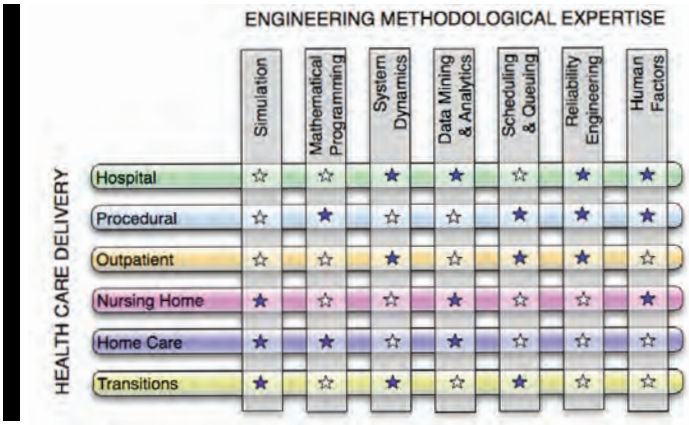

Figure 2: The use of operations research methodologies in health care settings at Mayo Clinic.

each major process step from induction of anesthesia to discharge from the hospital. Implementation of the Rapid Recovery Pathway demanded that care, geography and staffing be congruent with the process of care.

Advanced analytics and O.R. methods were integrated to develop electronic support mechanisms to designate patients to beds in a care "zone" and drive all the major process steps in those zones. The team also evaluated how a changed care model has implications for staffing and facilities planning and analyzed facilities' use and provided decision-support for facility redesign based on new models of postoperative care. The advanced analytics and O.R. methods helped to better predict outcomes of process changes/improvements before implementation. Decision support also enabled the testing of multiple process improvement initiatives simultaneously and estimated the combined performance of the major initiatives. The outcomes from the cardiac surgical care design resulted in a reduction in cost per case by 7 percent and a reduction in length of day by 1.5 days in 2010 from a baseline of 2008.

O.R. methods were integral to evaluating on-going improvement initiatives, as well as planning for future efforts to support the cardiac surgical care redesign. The results of a two-year cardiac surgical care redesign led to a demand for a new model of staffing built around a new process of postoperative care. The cardiac surgical redesign effort transformed the process of care by creating a clinical pathway, based on a "focus-factory" model, within the cardiac surgical service line. The new clinical pathway cares for 50 percent of the approximately 2,700 patients annually undergoing cardiac surgery at the Mayo Clinic-Rochester. Pathway implementation changed designated bed utilization, ICU staffing and facilities planning.

Capacity Planning and Scheduling: Nuclear Medicine: Improving PET Scanner Capacity

Patient access is an important focal point of healthcare delivery. If someone who needs to see a doctor is unable to make an appointment, it can be detrimental to the diagnosis and treatment of his condition. He may be forced to suffer with the condition for a longer period of time or, even more concerning, his condition may worsen while waiting to get an appointment.

One such access issue was related to the PET scanners in nuclear medicine, which were under high demand; there was constant pressure to add additional patient scans on certain days and times of the year. The use of scanners for research added additional complexity as it interrupted the natural schedule of regular clinical scans. Nuclear Medicine, under budget constraints, wanted to improve access to the scanners without impacting patient waiting time or adding more scanners. Simulation modeling was used with scheduling theory to evaluate different patient sequencing and scanner slot length intervals. As a result, not only was the PET scanner access improved by 10 percent, but it also reduced the patient waiting time over current practice.

Quality and Safety: Improving clinical access and continuity through Physician Panel Redesign

Population growth, an aging population and the increasing prevalence of chronic disease are projected to increase demand for primary care services. Computer simulation methods were used to design physician panels for 39 physicians with more than 20,000 patients. Panel design specifically took into account panel size and case mix (based on age and gender). The new panel design included a new appointment system with shorter waiting time and higher continuity over a wide range of practice panel sizes. The optimized panel design decreased the waiting time by 44 percent and increased continuity by 40 percent over baseline.

Summary

THE COMPLEXITY of the act of delivering care while achieving quality, safety and high value has defined a new science. Care delivery systems face formidable challenges due to the intersection of enormous complexity and the imperative to contain costs. To optimize quality and reduce costs, care delivery has to be continuously re-engineered. Mayo Clinic has realized this and will continue to grow and develop systems engineering and O.R. infrastructure, as it is a vital component to creating a delivery system of high-quality, cost-effective and patient-focused healthcare. **IORMS**

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