ENGINEERING A HEALTHIER WORLD

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RESEARCH IN FOCUS:

HEALTHCARE ENGINEERING

CHALLENGE:

How do we ensure that our costly investments in health care lead to the best possible outcomes for patients and their families?

SOLUTION:

Apply engineering design principles to healthcare systems.

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THE POWER OF PARTNERSHIP

Each year Canadians spend over $200 billion on health care, or about $6,000 per person[1]. Healthcare spending can consume more than 40 per cent of the annual budget of some provinces. With numbers like these, even a small increase in efficiency could lead to significant savings. Mike Carter, a professor in the Department of Mechanical & Industrial Engineering, began investigating solutions to this problem 25 years ago.

Carter's insight was to apply the system design principles used to remove bottlenecks or minimize down-time in the manufacturing world to medicine. For example, in one hospital, Carter and his team were asked to help manage long patient wait lists. The hospital was booking patients into 30-minute appointments, but his team's analysis showed that the average patient visit only took 17 minutes. Simply by booking patients at 20-minute intervals instead of 30-minute intervals, the hospital was able to see 50 per cent more patients.

To date, Carter and his team have worked on over 100 projects in partnership with hospitals, healthcare organizations and governments. In 2008, he founded the Centre for Healthcare Engineering to bring together like-minded engineering researchers, healthcare practitioners, medical equipment manufacturers, policymakers and other stakeholders to build a better health system.

[1] Combination of public and private sector spending. Source: Canadian Institute for Health Information: http://www.cihi.ca/CIHI-ext-portal/internet/en/documentfull/spending+and+health+workforce/spending/nhex_product_2014

"Nobody designed the healthcare system we know today, but by studying how all the pieces fit together and coordinating them, we can improve outcomes for patients while saving time and money."

PROFESSOR MIKE CARTER
Founder, Centre for Healthcare Engineering

THE DETAILS

Carter has built computer models that can predict how resources in various sectors of the health system — hospitals, home care, rehabilitation, long-term care, etc. — will impact the total flow of patients in each area. He is also looking to the future; performing simulations to determine how many cardiac surgeons Canada will need in 20 years. By simulating the effects of such changes, Carter's models can help policymakers make better decisions to improve everyone's access to health care.

A few years ago, the Ontario Ministry of Health asked for Carter's help in developing a plan to reduce wait times for cataract operations, as well as hip and knee replacements. The goal was to reduce wait times from an average of one year to only six months. Carter built computer models that told the government how many additional surgeries were required to meet the target. The target was met for cataract surgeries, and although personnel limitations hindered progress on hip and knee surgeries, wait times dropped significantly. In both cases, Carter's models accurately predicted real-world outcomes.

Another project, carried out with Cancer Care Ontario, aimed to improve the outcomes for patients undergoing surgery for lung cancer. An expert panel had concluded that patients did better when treated by surgical teams who specialized in this type of surgery, compared to teams who only did it occasionally. Carter's team created a decision support tool that helped concentrate surgeries in a few hospitals, reducing complications and side effects.

PROFESSOR TIMOTHY CHAN
AMBULANCE DEPLOYMENT & CADIAC ARREST

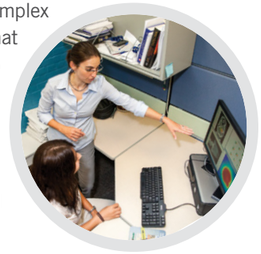
These days, we are awash in gigabytes of data from cell phones and more sophisticated e-health records. But how do we use all this data to make better decisions? Operations research is the answer. Professor Timothy Chan from the Department of Mechanical & Industrial Engineering is an expert in this area.

One of his projects involves ambulance deployment in Dhaka, Bangladesh. Unlike North American cities, Dhaka's roads are characterized by mixed-mode traffic (bicycles, pedestrians), which results in many barriers for ambulances. With funding from Grand Challenges Canada's Stars in Global Health program, Chan's team is developing computer models that use GPS data from cell phones to depict how traffic is moving in real time. The model then recommends the best routes to an emergency scene. This approach could significantly cut down on response times, helping to save more lives.

Another project looks at automatic external defibrillators (AEDs), which are publicly available electronic devices that can be used to treat patients suffering from cardiac arrest. Chan and his team use data on historical cardiac arrests, buildings and current AED locations to determine the ideal locations for these devices. Their models show that by using this comprehensive data, as opposed to merely placing AEDs according to population density, they can support three times the number of cardiac arrests within 100 metres of a defibrillator.

PROFESSOR DIONNE ALEMAN
CANCER TREATMENT ACCURACY

Radiation treatment for cancer is a complex balancing act. The goal is to ensure that the right amount of radiation gets into a tumour without too much getting into healthy tissues. However, there are many factors to consider: how the patient is positioned, how many beams of radiation, where they should go and their strength.



Professor Dionne Aleman and her team have simplified this problem by creating mathematical models and algorithms that can balance all of these factors, quickly and automatically generating an ideal treatment plan for each patient. These models target tumours with greater than 90 per cent accuracy, a significant improvement on current methods. Working with the Princess Margaret Cancer Centre, Sunnybrook Hospital and Elekta AB (a Swedish manufacturer of radiation treatment equipment) her team has demonstrated that using their models can save time and money in hospitals while delivering better treatment plans for patients.

Models can also be applied to operating room scheduling. The team is piloting a system of 'collaborative scheduling' whereby certain surgeries are shared between hospitals based on availability of surgeons and beds. Preliminary results indicate that University Health Network hospitals (Toronto General, Princess Margaret and Toronto Western) could reduce surgical costs by as much as 30 per cent by using this tool for collaborative scheduling.

Pictured above: Professor Dionne Aleman works with a graduate student on an algorithm in the Medical Operations Research Laboratory.

PROFESSOR MARK CHIGNELL
DIAGNOSING DELERIUM

Hospital-acquired delirium is a temporary but severe form of mental impairment experienced by up to a third of patients over age 70. Brought on by certain medications, surgery, dehydration or poor nutrition, delirium leads to longer stays in hospital and negative outcomes after discharge, yet it often goes undiagnosed. People with delirium tend to cycle between confused and lucid states, making the condition difficult to diagnose and treat, costing North American healthcare systems billions of dollars.

Professor Mark Chignell and his team — including PhD candidate Tiffany Tong and Dr. Jacques Lee at the Sunnybrook Health Sciences Centre Emergency Department — created a version of the classic carnival game 'whack-a-mole' that seniors can play on a tablet. Not only does their performance provide real-time assessment of key cognitive abilities, but game play also exercises skills in task management, coordination and visual perception. Over 100 Sunnybrook Hospital patients have already used the game.

In collaboration with Dr. Tammy Sieminowski, a project is also underway at Bridgepoint Health to develop a game that assesses the abilities of patients recovering from a stroke or other brain injuries. They are designing an app that simulates a shopping expedition. Patient performance can assist healthcare professionals in deciding when a person has recovered enough to be sent home, or into alternative care.