Northeastern University
Healthcare Systems
Engineering Program

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Northeastern’s researchers are exploring critical issues in drug discovery and delivery, medical imaging, urban health, healthcare delivery and rehabilitation medicine to address health issues integral to our quality of life.

With its proximity to some of the nation’s top hospitals and a rich environment of community health centers and pharmaceutical firms, the University is in an unparalleled position to pursue research with direct applications to medicine and health.
Northeastern University's healthcare engineering program has focused for over 30 years on improving efficiency, quality, logistics, safety, flow, effectiveness, and access in much the same way manufacturing, airline, or service companies optimize their operations — including academic programs, student projects, and 2 federally-awarded centers. We welcome partnerships of any kind to advance the shared mission of improving healthcare processes.

Healthcare Systems Engineering (HSE) methods range from lean six-sigma tools to advanced mathematical models used in many other industries to study, improve, and optimize process quality, delays, cost, efficiency, and effectiveness - national priorities also identified by the IOM. Recent healthcare applications include improvements in scheduling, readmissions, cost reductions, cancer
Why healthcare?

Nowhere near best care nor system
  - Worst system, 5-8 industrialized nations (CWF)
  - U.S. 37th of 191 countries (WHO)

~ $2.3 trillion / year spent on U.S. health care ≈ 16-17% of GDP
  - ~ 30% costs = waste ($760b / year)
  - 40% per capita > next expensive country. Increasing at 4-10% / year

~ 160,000 caused deaths annually

~ 55% patients receive scientifically indicated care

Significant redundancy, rework, and practice/process variation abounds
Why systems engineering?

Approaches to Improving Processes

Basic methods
- Basic process improvement
- Lean, Six sigma, PDSA

Systems engineering (IE, OR, SE)
- Systems engineering
- Industrial engineering
- Operations research
- Management science

% of Benefits

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What is systems engineering?

**Models:**
- (mathematical, computer, graphical)

**Uses:**
- Improve, optimize, control

**Foci:**
- Systems, processes

**Models**
- Mathematical, statistical *models*
- Computer *models*
- Physical, graphical *models*
- Cognitive *models*

**Who uses**
- American airlines, Boeing
- Federal express, UPS
- McDonalds, Disney
- Manufacturing, Hotels, Military
- Power companies, Ski resorts
- Forestry management
- Almost everyone else…

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Why use systems engineering?

(Conservatively quantified benefits from documented projects, realized plus at most 2 years anticipated, in 2009 dollars)

- Typically, six finalists per year sorted with highest impact first.
- Many important benefits from the 225 documented finalist projects did not lend themselves to monetary evaluation. Even so, a conservative total of reported monetary impacts approaches 160 billion in U.S. dollars.

First competition in 1972. Missing documentation for first two years.

Billions of Dollars Saved (ONE project per year)
Northeastern HSE program

Research centers
- VA: 6 states, 1.3m vets, 2.5m visits, $2.2b/yr
- NSF healthcare engineering center (CHOT)
- 32 (47) hospitals, 76 ambulatory, 4 long term

Academic programs
- Undergrad / graduate curricula, internship, coop programs. Staff ≈ 21
- Research internships, assistantships, applied projects

Immersion / experience mechanisms
- Summer faculty sabbaticals
- Pilot seed grants
- 3-12 month Fellows program
- Post-docs, post-MS’s, RA’s
Mission statement

Broad national impact on healthcare through application of systems engineering methods

This involves:

- Robust partnerships
- Like-minded healthcare organizations
- Leading healthcare academics and practitioners in U.S.
- *Will*, experience, focus
# NU Healthcare Systems Engineering Program

## Research Labs
- **Methods research**
  - NSF, ARHQ, NIH, NIDA, SBIR (NIH)
  - VHA
  - USAF SGO
  - Boston+ hospitals
  - Center for Nanomfg
  - Others

## Collaborative Research Center (NSF-IUCRC)
- **Collaborative research**
  - TAMU
  - Georgia Tech
  - Northeastern
  - Rural health
  - Treatment optimize
  - Systems engineer
  - Public policy

## Collaborators
- **Partners in both directions**
  - Mass Gen Hospital
  - Brigham & Womens
  - Beth Israel Med Center
  - Boston Childrens Hosp
  - Mayo Clinic
  - MD Anderson Cancer Institute for Healthcare Improvement
  - Glasgow Health Board
  - Dana Farber, Pharma
  - Others...

## Curriculum Development
- **Education**
  - **Graduate**
    - Fellows, postdocs
    - Courses (1-3)
    - Named fellowships
  - **Undergraduate**
    - HIE minor (w.i.p)
    - Senior projects
    - Coop positions (8)
  - **Future (2010-2013)**
    - Inter-disc program
    - Professional MS
    - Faculty, named chair

## New England Health Care Engineering Partnership
- **Implementation (Applied research)**
  - Veterans Health Administration
  - Northeastern (lead)
  - MIT, WPI, BU, Dartmouth, others
  - 153 medical center
  - 1400+ care sites
  - 25.5M US veterans

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**Network / Like-Minded Collaborators / Partners**
### Project examples

#### VA VERC Center
- Pharmacy & lab logistics
- Patient transport
- Exam scheduling (many)
- Care team scheduling
- Facility/services/patient (location-allocation)
- Stochastic patient location
- Facility layout
- Disease screening policies
- Primary care, mental health

#### NSF CHOT Center
- Readmissions
- Compliance models and measurement
- Overbooking & no-shows
- Inter-facility flow
- Inventory, supply chains
- Scheduling (many)
- ED overcrowding
- Ambulatory & cancer care
- Academic medicine
1. Basic example: Patient transport

**Single Unit: 3N**

- **Patient needs Escort**
- **Nurse calls Dispatcher for Escort**
- **Dispatcher records info in log book**
- **Dispatcher writes info on appointment card**
- **Dispacher enters request into Excel**
- **Dispatcher places appointment card in job queue**
- **Escort takes appointment card**
- **Dispacher gives appointment card to Escort**
- **Dispatcher places appointment in job queue**
- **Escort takes appointment card**
- **Escort locates needed resource**
- **Escort reports back to Escort Department for next assignment**
- **Dispatcher hands appointment card to Escort**
- **Dispatcher writes info on appointment card**

**VA Intra-Hospital Patient Transportation**

**Dispatcher Form**

**ESCORT JOB QUEUE**

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2. Intermediate: Appointment overbooking

Optimal no-show overbooking

\[ E(TC) = \sum_{x=0}^{N-1} C_u \times (N - x) \times P(X = x) + \sum_{x=N+1}^{M} C_o \times (x - N) \times P(X = x) \]

where \( P(X = x) = \left( \frac{M}{x} \right) (1 - p)^x p^{M-x} \)

System-wide implementation

- $236,000 savings (pilot)
- One location
- One department
- Spread…
3. Advanced engineering research examples

**Preventable readmissions**
- $23-26$ billion/yr problem
- IEOR models to detect, intervene, optimize process
- Policy implications

**Downstream scheduling**
- Probabilistic/predicted demand
  - ED-to-inpatient beds
  - Chemo infusion chairs
- Real-time adaptive resource models

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VA Example: Traumatic brain injury (TBI)

- Signature injury of Iraq and Afghanistan wars
- \(~19.6%\) of US servicemen, \(>\$1B\)
- \(D_x\): None, mild, moderate, severe
- Models: Screening, treatment, capacity, resource location

Q1. Who is most at risk for which type of TBI?

Q2. Where to locate TBI care units?
Number TBI treatment units?
Which patients to treat at which centers?

Other Examples

Readmissions model
- $20 billion/yr problem
- Transition of patients from discharge, thru various health states, to readmission
- Study & test visit/other intervention strategies

Panel composition
- Which patients assign to which PCP panels
- 50% increase in access & continuity
- 10% larger panels, same performance

Surgery scheduling
- What surgeries to schedule when, where

Telemedicine
- What devices to allocate where

(Balasubramanian H et al)

(Denton, B., and Gupta, D)
For further information

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