Accelerating Health Care Improvement using Systems Engineering

Karim Boustany, PhD, MSIE, BE
Mini-Bio

• PhD in I.E. from Purdue University
• Certified in Lean Healthcare Black Belt
• Speak English, French, Arabic, Spanish, and learning Russian and Mandarin
• Implementation Scientist at Center for Innovation and Implementation Science
• Process Analytics Specialist at Marion Hospital and Health Corporation (IN)
• Science and Technology Advisor
Introduction

Global Public Health Issues
http://youtu.be/NO1uXp1s6O8

Local Successful Care Models
http://youtu.be/mYSig0UHJKk
Problem Statement

How can we rapidly scale up successful care models from to larger populations?
Mission and Vision

• Mission:
  – To use implementation science and innovation to produce high-quality, patient-centered and cost-effective health care delivery solutions for the world.

• Vision
  – To assure every patient receives the most personalized, valued, safe and preeminent quality care wherever and whenever.
The Gap

• Our current research infrastructure:
  – Lacks organizational framework for harvesting local knowledge and innovation
  – Supports primarily investigator-initiated research projects
  – Is not set up for a rapid translation, implementation, and dissemination of health care delivery solutions to meet the needs of our health care services partners
The five Phases of Translational Cycle

- **T0**: Identify opportunities and approaches to health problems.
- **T1**: Move basic discovery into a potential health solution.
- **T2**: Assesses the value of a health solution leading to the development of evidence based practice.
- **T3**: Diffuse, disseminate, or implement evidence based practice.
- **T4**: Evaluate the impact of implementing evidence based practice on the health of population.

Current Discovery to Delivery Translational Cycle

Time: 17 Years
Success: 14%
Generalizability: 1%
Cost: $1 Billion

Khoury MJ et al. Genet med 2007
Westfall et al. JAMA 2007
Boustani et al. JCIA 2010
Our Dream
Future Discovery to Delivery Translational Cycle

Time: 5 Years
Success: 25%
Generalizable: 100%
Cost: $0.1 billion

T0
T1
T2
T3
T4

Simulation: Virtual Health Care System

Khoury MJ et al. Genet med 2007
Westfall et al. JAMA 2007
Boustani et al. JCIA 2010

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5 How’s

1. How can I lead a dynamic system?
2. How can I manage the challenges of uncertainty, variability, and dynamic interdependency?
3. How can I evaluate and select a meaningful change?
4. How can I identify early failures and successes?
5. How can I scale up success?
Our Goal

Support the ever-changing transformational needs of our local health care systems, and become a top-ranked “clinical laboratory” for innovative health care delivery solutions by developing an infrastructure to discover and implement patient-centric, value-based, sustainable, and safe models of care.
Background and Rationale

- > 3 million Medicare beneficiaries with dementia and 6 million with depression
- Conditions frequently co-occur
- Medicare costs: >30 billion $ annually
- PCPs report inadequate time resources to manage these complex patients
- Patients with dementia have 20% higher rate of ED use than older adults w/o dementia
- Current patient population size: 2,000
- Goal: reduce symptoms and utilization
- Location: Indianapolis metropolitan area
Aging Brain Care Medical Home Computer Simulator

- Simulator is a multi-level model of the ABC program:
  - Patient: transition likelihoods & care timings
  - Process: intervention by ABC care delivery team
  - Operational: operating cost, population, staffing
  - Economic: inflation & discount rates, outcomes

- Uses original research from 2006 onward
- Passed structural and face validation cycles
- Has an embedded lab sampling mechanism
# The Aging Brain Care Medical Home - Computer Simulator

## Economic Level

<table>
<thead>
<tr>
<th>Healthcare Inflation Rate (from 0 to 1)</th>
<th>Economic Inflation Rate (from 0 to 1)</th>
<th>Discount Rate (from 0 to 1)</th>
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<tr>
<td>0.05</td>
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### outpatient Visit

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<tr>
<th>Minimum Cost</th>
<th>$59.9</th>
<th>Min. Cost per Day</th>
<th>$100.0</th>
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<td>Most Likely Cost per Day</td>
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<td>Most Likely Cost</td>
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<td>Maximum Cost</td>
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<td>Max. Cost per Day</td>
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### Hospitalization

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### Emergency Visit

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<td>Most Likely Cost</td>
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## Operational Level

<table>
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<tr>
<th>ABC Annual Cost</th>
<th>$590000.0</th>
<th>Patient Population Size</th>
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<tbody>
<tr>
<td>Annual Hours per Staff</td>
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## Care Coordinator

- Total Number of Care Coordinators: 1
- Maximum Number of Visits per Day: 100
- Hourly Rate (in $): 35.0

## Care Coordinator Assistant

- Total Number of Care Coordinator Assistants: 11
- Maximum Number of Visits per Day: 100
- Hourly Rate (in $): 17.0

## Process Level

### Care Coordinator

- Meet with Patient after Emergency Visit within ___ days: 7
- Meet with Patient after Inpatient Discharge within ___ days: 3

### Care Coordinator Assistant

- Total Number of Visits after Patient Enrollment:
  - PHASE I: 4
  - PHASE II: 5
- Time Interval between Visits (in days):
  - PHASE I: 14
  - PHASE II: 30
- Time Interval between Routine Visits (in days):
  - PHASE I: 30
  - PHASE II: 90

## Patient Level

### ABC Patient

- Following an Emergency Visit, the likelihood, from 0 to 1, of ___ is =
  - going Home: 0.6
  - being Admitted: 0.35
  - leaving ABC: 0.65
- Following an Inpatient Admission, the likelihood, from 0 to 1, of ___ is =
  - going Home: 0.5
  - leaving ABC: 0.9
- Following an Outpatient Visit, the likelihood, from 0 to 1, of ___ is =
  - going Home: 0.99
  - being Admitted: 0.01

### Non-ABC Patient

- Following an Emergency Visit, the likelihood, from 0 to 1, of ___ is =
  - going Home: 0.5
  - being Admitted: 0.4
  - expiring (or other): 0.1
- Following an Inpatient Admission, the likelihood, from 0 to 1, of ___ is =
  - going Home: 0.4
  - expiring (or other): 0.6
- Following an Outpatient Visit, the likelihood, from 0 to 1, of ___ is =
  - going Home: 0.97

## Statistical Collection Controls

- ABC Operational?
- ABC vs No ABC Comparison?
- Initial Enroll as Active?
- Warmup Period (days)
Lab Sampling Experiment

• Independent Variables:
  – Patient Population Size = 2,000
  – Care Coordinators = 1 → 5
  – Care Coordinator Assistants = 5 → 15

• Dependent Variable:
  – Return On Investment (% savings / expenses)

• Random Number Generation:
  – random seed per run

• Number of Runs : 330 (10 per Scenario)

• Simulator Runtime : 72 minutes
## Statistical Findings

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Selecting a change in a complex adaptive health care delivery system

A. Selecting an overall content that is based on a systematic evidence review of past research or guidelines.

B. Develop ongoing implementation process to
   • Develop a simulation model of the local health system
   • Localize the content
   • Localize and or invent the delivery process
   • Monitor adherence to the delivery process
   • Monitor the impact of the selected change on the triple aims.
   • Detect unintended consequences
Methodology

• The theory of complex adaptive system as the framework to represent the health care system.

• Collaborative iterative process among experts in clinical content, process mapping, and computer simulation modeling.

• Hybrid Simulation Model:
  • Agent-Based Modeling
  • Discrete-Event Simulation
  • System Dynamics
Perioperative Simulator
Objectives

• Leverage 36 operating rooms
• Enhance perioperative efficiency
• Perform more elective surgeries
• Respond to emergency cases
• Guide staffing and procurement
• Connect organizational silos
• Connect organizational layers
• Experiment *in silico*
Real-Time Outcomes
## Demand and Supply Planning

### METHODIST PERIOP MODEL

**PARAMETERS**

**AVG SURGERY VOLUME (PER MONTH)**

- Default
- Increase By
- Decrease By

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<thead>
<tr>
<th></th>
<th>AM Shift</th>
<th>PM Shift</th>
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<td>Ob/Gyn</td>
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Resource Levels

METHODIST PERIOP MODEL

CONFIG

Run

Core 1  Core 2  Core 3  Core 4  Core 5  Shared

Procedure Duration
Avg
Min
Max

Assessment Duration
Avg
Min
Max

Wrap-Up Duration
Avg
Min
Max

Human
Scrub Nurse
Circulating Nurse
Technicians

Resources

Other
Rooms
C-Arms
O-Arms

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Outcome Dashboard

Service

<table>
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<tr>
<th>Metric</th>
<th>Target</th>
<th>Over/Under Goal</th>
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<tbody>
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<td>Same Day Surgery - % of Patients Ready 30 min before scheduled start</td>
<td>95%</td>
<td>Under</td>
</tr>
<tr>
<td>OR % First Cases started on time</td>
<td>95%</td>
<td>Above</td>
</tr>
<tr>
<td>OR % Subsequent Cases started on time</td>
<td>95%</td>
<td>Under</td>
</tr>
<tr>
<td>Avg. Turnover Time (Previous Patient Out to Next Patient In)</td>
<td>30 min</td>
<td>Under</td>
</tr>
<tr>
<td>% of Cases turned over in &lt;30 min</td>
<td>75%</td>
<td>Above</td>
</tr>
<tr>
<td>Avg. Turnaround Time (Prev Procedure End to Next Procedure Start)</td>
<td>45 min</td>
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Approach

- Business Requirements
- Process Mapping
- Data Analysis
- Prototyping
- Feedback
- Validations
- Implementation
- Support
Improve Floor Plans

Current Facility Patient Flow Animation


New Facility Patient Flow Animation


Simulation Input Dashboard

- No-show Rate for Ped, OB, and Family Med
- No-show Rate for Internal Med
- Rate of Doctor Available Slots Booked

Simulation Output Dashboard

- Clinics
  - Staff / Room Utilization
  - Nurse Walking Distance
- Patients
  - Total Waiting Time / Total Time in Clinic
  - Time before Doctor Consultation

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Decrease Staff Fatigue

Avg. Walking Distance for a Nurse per Patient (in feet)

- Current MOB: ≈ 129 ft
- New MOB: ≈ 182 ft
- Decrease: 42%

Avg. Walking Distance for a Nurse per Day (in feet)

- Current MOB: ≈ 2941 ft
- New MOB: ≈ 4515 ft
- Decrease: 53%
Improve Surgery Throughput
Improve Clinic Access

USER INTERFACE

Appointment Request
- 8:00 - 11:00 / Hour
- 11:00 - 14:00 / Hour
- 14:00 - 17:00 / Hour

No-Show Rate (0–1)
- 0.041

Sick Patients
- 10.0 % to NP
- 70.0 % to MD

New Patients
- STOP scheduling new patient
- START scheduling new patients

Patient Characteristics
- Proportion
  - Sick: 25.0 %, 25.0 %
  - Tier 1 New: 5.0 %, 4.0 %
  - Tier 1 ReCheck: 15.0 %, 15.0 %
  - Tier 2 New: 13.0 %, 13.0 %
  - Tier 2 ReCheck: 42.0 %, 42.0 %

- Treatment Time
  - 10.0 minutes
  - 20.0 minutes

MD’s Working Schedule
- Total Number of Work Hours/Number of Patients per Day of Week
- Preferred Total Number of New Patients
- Preferred Max Number of Sick Patients

<table>
<thead>
<tr>
<th>Day</th>
<th>Sick</th>
<th>New</th>
<th>ReCheck</th>
</tr>
</thead>
<tbody>
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<td>7</td>
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<tr>
<td>Tue</td>
<td>7</td>
<td>18</td>
<td>4</td>
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</table>

OUTCOME DASHBOARD

Total Patient Discharges (by visit type)

100% Daily Capacity
- Monday: 26.25
- Tuesday: 26.25
- Wednesday: 26.25
- Thursday: 26.25
- Friday: 26.25

MD Time Utilization

Sick Patient Discharges

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To Conclude ...

- Computer simulators can assist most healthcare leaders make much more informed decisions about the future.
- The creation of simulators requires that various different disciplines collide.
- This is feasible in most markets...
- Do you have any question or comment?
- Contact me at karboust@iupui.edu