Accelerating Health Care Improvement using Systems Engineering

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and Implementation Science

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

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Introduction

Global Public Health Issues

http://youtu.be/NO1uXp1s6O8

Local Successful Care Models

http://youtu.be/mYSig0UHJKk

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Problem Statement

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

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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.

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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

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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.

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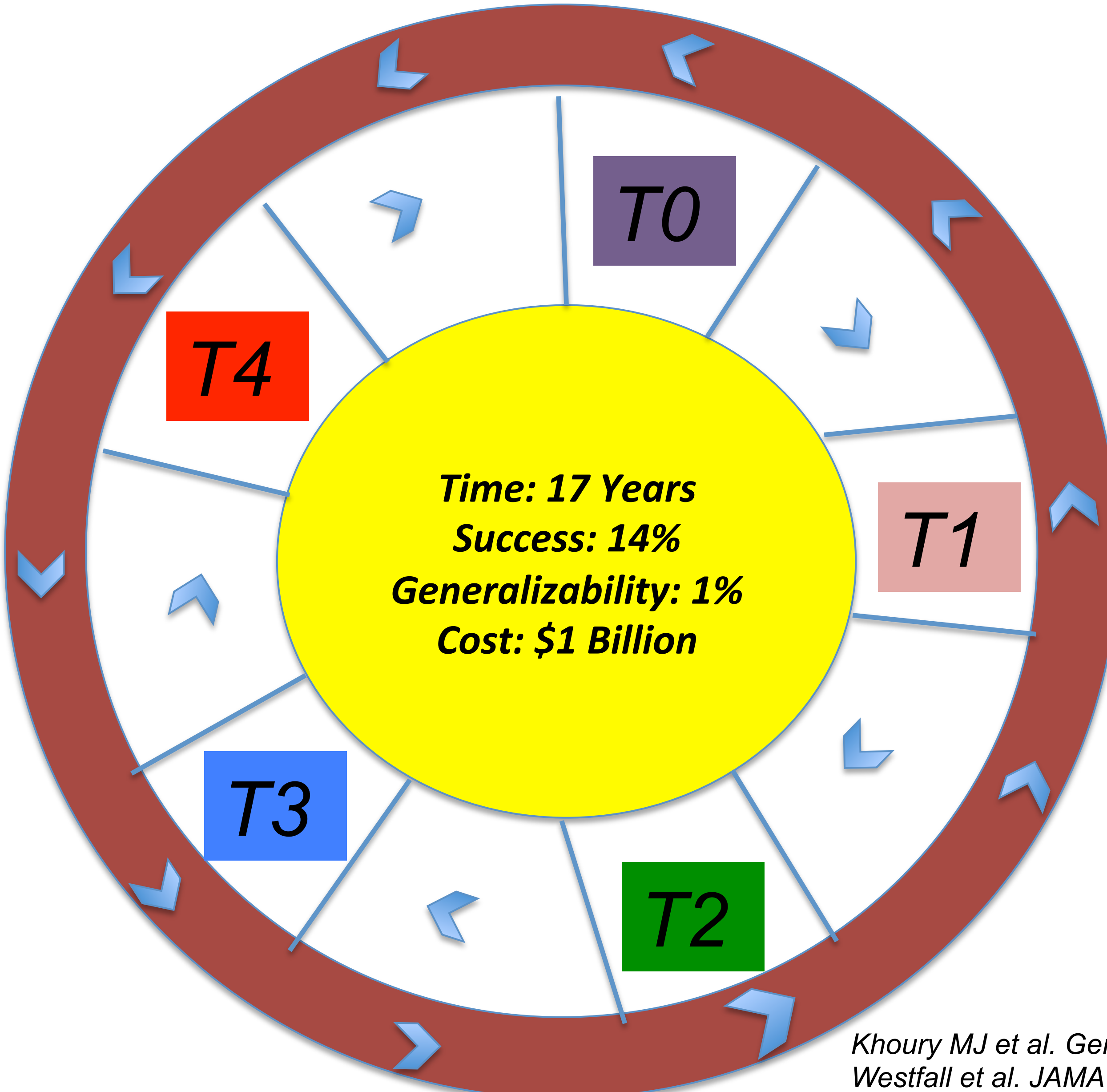
Khoury MJ. Et al. Genet Med 2007

Current Discovery to Delivery Translational Cycle



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

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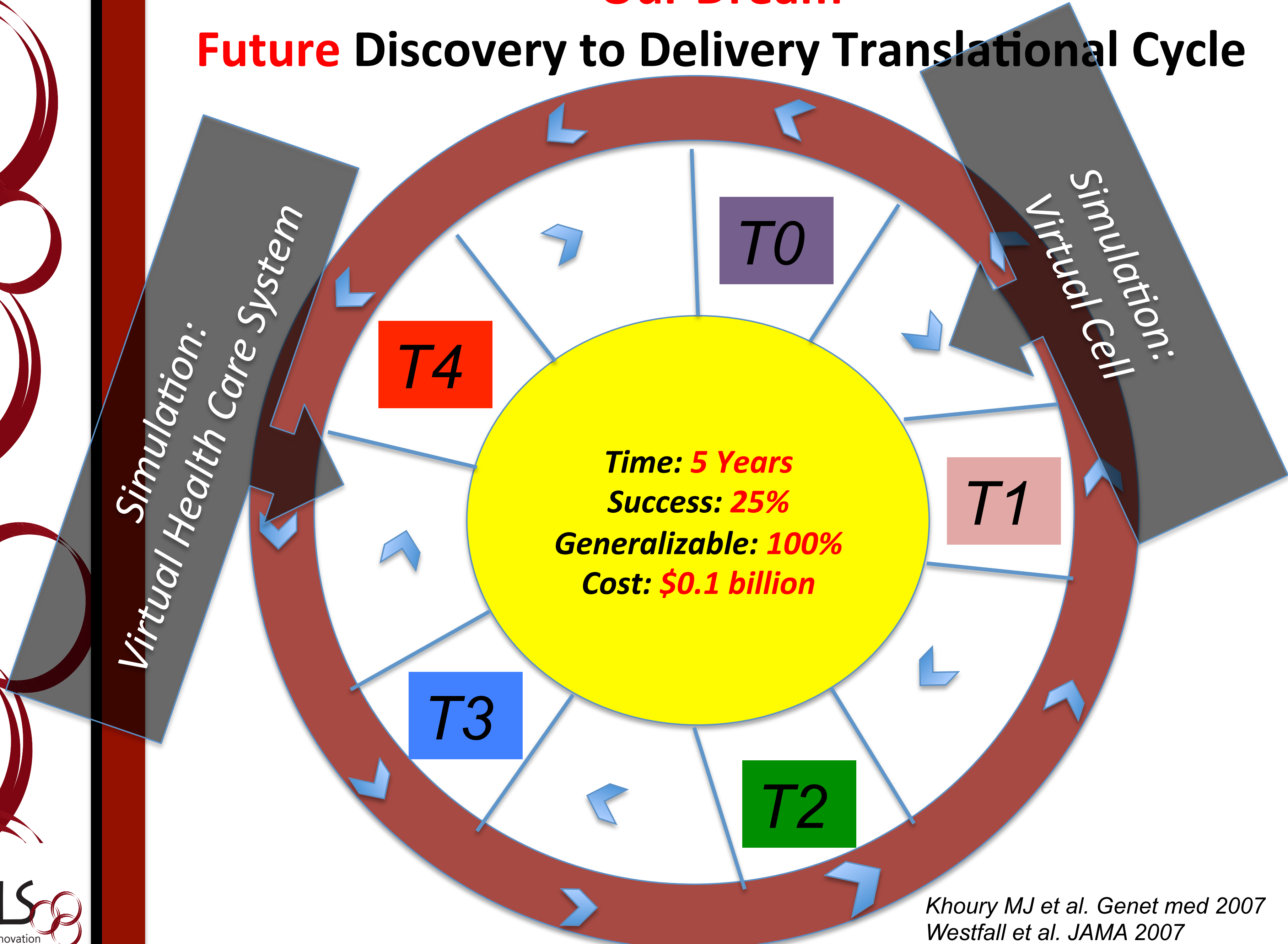
Our Dream

Future Discovery to Delivery Translational Cycle



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?

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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.

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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

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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

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THE AGING BRAIN CARE MEDICAL HOME – COMPUTER SIMULATOR

ABC

PATIENT, PROCESS, OPERATIONAL, AND ECONOMIC FACTORS

ECONOMIC LEVEL

Healthcare Inflation Rate (from 0 to 1): 0.05

Economic Inflation Rate (from 0 to 1): 0.03

Discount Rate (from 0 to 1): 0.03

OUTPATIENT VISIT

Minimum Cost: 50.0

Most Likely Cost: 80.0

Maximum Cost: 500.0

HOSPITALIZATION

Min. Cost per Day: 100.0

Most Likely Cost per Day: 800

Max. Cost per Day: 7000

EMERGENCY VISIT

Minimum Cost: 50.0

Most Likely Cost: 300.0

Maximum Cost: 1000.0

OPERATIONAL LEVEL

ABC Annual Cost: 500000.0

Patient Population Size: 1 — 2,000 — 10,000

Annual Hours per Staff: 2000.0

CARE COORDINATOR

Total Number of Care Coordinators: 1 — 3 — 100

Maximum Number of Visits per Day: 1 — 5 — 12

Hourly Rate (in $): 35.0

CARE COORDINATOR ASSISTANT

Total Number of Care Coordinator Assistants: 1 — 11 — 100

Maximum Number of Visits per Day: 1 — 5 — 12

Hourly Rate (in $): 17.0

PROCESS LEVEL

CARE COORDINATOR

Meet with Patient after Emergency Visit within ___ days: 1 — 7 — 90

Meet with Patient after Inpatient Discharge within ___ days: 1 — 3 — 90

☐ with Care Coordinator Assistant (both)

CARE COORDINATOR ASSISTANT

PHASE I

Total Number of Visits after Patient Enrollment: 0 — 4 — 5

Time Interval between Visits (in days): 14 — 30 — 60

PHASE II

Time Interval between Routine Visits (in days): 30 — 90 — 365

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: 0.05

Following an Inpatient Admission, the likelihood, from 0 to 1, of __________ is =

going Home: 0.5

leaving ABC: 0.5

Following an Outpatient Visit, the likelihood, from 0 to 1, of __________ is =

going Home: 0.99

being Admitted: 0.01

Average Inpatient Length of Stay: 1 — 5.7 — 14

Average Time between Emergency Visits: 1 — 365 — 365

Average Time between Outpatient Visits: 1 — 90 — 365

Average Total Time to Depart: 1 — 1,825 — 1,825

Number of Days until Patient's Healthcare Usage Worsens following an intervention interruption: 90 — 90 — 365

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

being Admitted: 0.03

Average Inpatient Length of Stay: 1 — 7 — 14

Average Time between Emergency Visits: 1 — 300 — 365

Average Time between Outpatient Visits: 1 — 90 — 365

Average Total Time to Expire (or other): 1 — 1,825 — 1,825

Average Time to Enroll a New Patient following another patient's departure from ABC: 1 — 30 — 365

Statistical Collection Controls

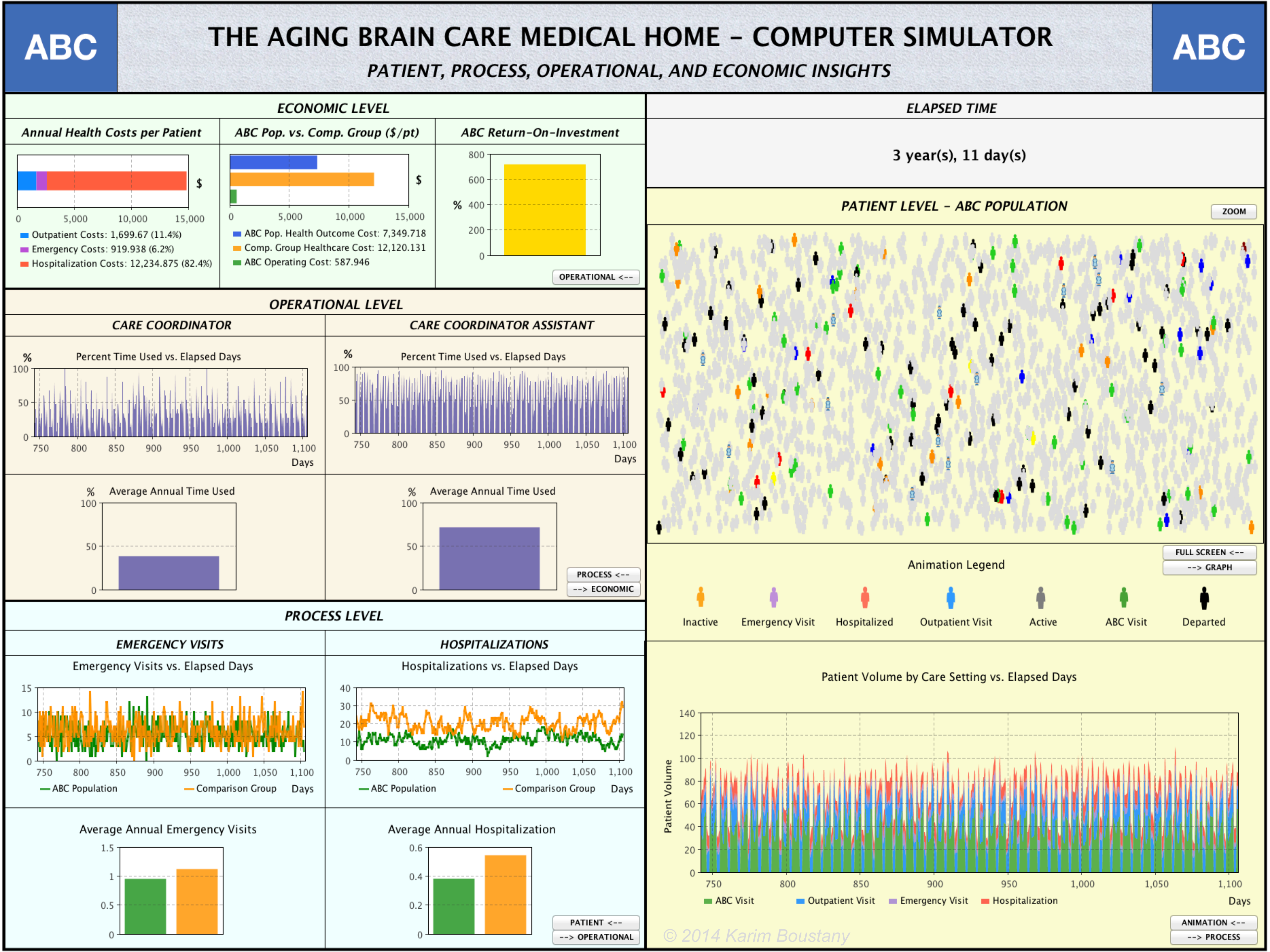
☑ ABC Operational ?

☑ ABC to No ABC Comparison?

☐ Initial Enroll as Active?

Warmup Period (days): 90

CLICK HERE TO RUN THE ANALYSIS



ABC
THE AGING BRAIN CARE MEDICAL HOME – COMPUTER SIMULATOR
PATIENT, PROCESS, OPERATIONAL, AND ECONOMIC INSIGHTS
ABC
ECONOMIC LEVEL
Annual Health Costs per Patient
$
0
5,000
10,000
15,000
Outpatient Costs: 1,699.67 (11.4%)
Emergency Costs: 919.938 (6.2%)
Hospitalization Costs: 12,234.875 (82.4%)
ABC Pop. vs. Comp. Group ($/pt)
$
0
5,000
10,000
15,000
ABC Pop. Health Outcome Cost: 7,349.718
Comp. Group Healthcare Cost: 12,120.131
ABC Operating Cost: 587.946
ABC Return-On-Investment
800
600
%
400
200
0
OPERATIONAL <--
ELAPSED TIME
3 year(s), 11 day(s)
OPERATIONAL LEVEL
CARE COORDINATOR
%
Percent Time Used vs. Elapsed Days
100
50
0
750
800
850
900
950
1,000
1,050
1,100
Days
CARE COORDINATOR ASSISTANT
%
Percent Time Used vs. Elapsed Days
100
50
0
750
800
850
900
950
1,000
1,050
1,100
Days
%
Average Annual Time Used
100
50
0
%
Average Annual Time Used
100
50
0
PROCESS <--
--> ECONOMIC
PATIENT LEVEL – ABC POPULATION
ZOOM
FULL SCREEN <--
--> GRAPH
Animation Legend
Inactive
Emergency Visit
Hospitalized
Outpatient Visit
Active
ABC Visit
Departed
PROCESS LEVEL
EMERGENCY VISITS
Emergency Visits vs. Elapsed Days
15
10
5
0
750
800
850
900
950
1,000
1,050
1,100
ABC Population
Comparison Group
Days
HOSPITALIZATIONS
Hospitalizations vs. Elapsed Days
40
30
20
10
0
750
800
850
900
950
1,000
1,050
1,100
ABC Population
Comparison Group
Days
Average Annual Emergency Visits
1.5
1
0.5
0
Average Annual Hospitalization
0.6
0.4
0.2
0
PATIENT <--
--> OPERATIONAL
Patient Volume by Care Setting vs. Elapsed Days
Patient Volume
140
120
100
80
60
40
20
0
750
800
850
900
950
1,000
1,050
1,100
ABC Visit
Outpatient Visit
Emergency Visit
Hospitalization
Days
ANIMATION <--
--> PROCESS
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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

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Statistical Findings

```
. table pair, contents(min numcc min numcca mean roitopayerforcostofabc sd roitopayerforcostofabc)
```

Pair	min(numcc)	min(numcca)	mean(roitop~c)	sd(roitop~c)
1	1	5	336.217	253.3818
2	1	6	377.0779	193.6971
3	1	7	453.6066	252.8822
4	1	8	444.5587	210.9832
5	1	9	515.3602	239.9711
6	1	10	535.0736	89.63446
7	1	11	523.5916	118.684
8	1	12	588.259	209.7758
9	1	13	551.083	136.3413
10	1	14	536.0817	178.3898
11	1	15	605.3631	145.7209
12	2	5	308.9023	163.9797
13	2	6	318.4013	165.4835
14	2	7	405.8997	244.5514
15	2	8	499.0824	196.196
16	2	9	490.3589	235.0602
17	2	10	474.3696	167.9797
18	2	11	511.1903	130.6546
19	2	12	532.5858	93.66481
20	2	13	454.7399	123.2592
21	2	14	529.0909	146.0487
22	2	15	566.3605	135.736
23	3	5	384.1864	221.2107
24	3	6	427.6495	184.2418
25	3	7	463.8857	184.7767
26	3	8	477.0465	161.4533
27	3	9	440.9914	132.2369
28	3	10	507.0577	150.4626
29	3	11	506.8737	115.6929
30	3	12	568.704	152.6059
31	3	13	492.3044	162.6197
32	3	14	486.921	122.7383
33	3	15	535.4307	122.5665

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

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Boustani et al, JCIA 2010

Methodology

- The theory of complex adaptive system as the frame work 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

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Perioperative Simulator

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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*

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Real-Time Outcomes

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Demand and Supply Planning

METHODIST PERIOP MODEL

PARAMETERS

AVG SURGERY VOLUME (PER MONTH)

○ Default ◉ Increase By ○ Decrease By

1,400 | 40 % | %

CONFIG | **PARAMETERS**

GENERAL | DEMAND | **ROOMS** | RESOURCES

	AM Shift	PM Shift
OR19	Ob/Gyn	Ob/Gyn
OR20	Ob/Gyn	Ob/Gyn
OR21	Ob/Gyn	Ob/Gyn
OR22	Ob/Gyn	Ob/Gyn
OR23	CV	CV
OR25	CV	CV
OR26	Urology	Urology
OR27	Urology	Urology

	AM Shift	PM Shift
OR29	CV	CV
OR30	CV	CV
OR31	Emergency	Emergency
OR32	Emergency	Emergency
OR33	Emergency	Emergency
OR34	Closed	Closed
OR35	Closed	Closed
OR36	Closed	Closed

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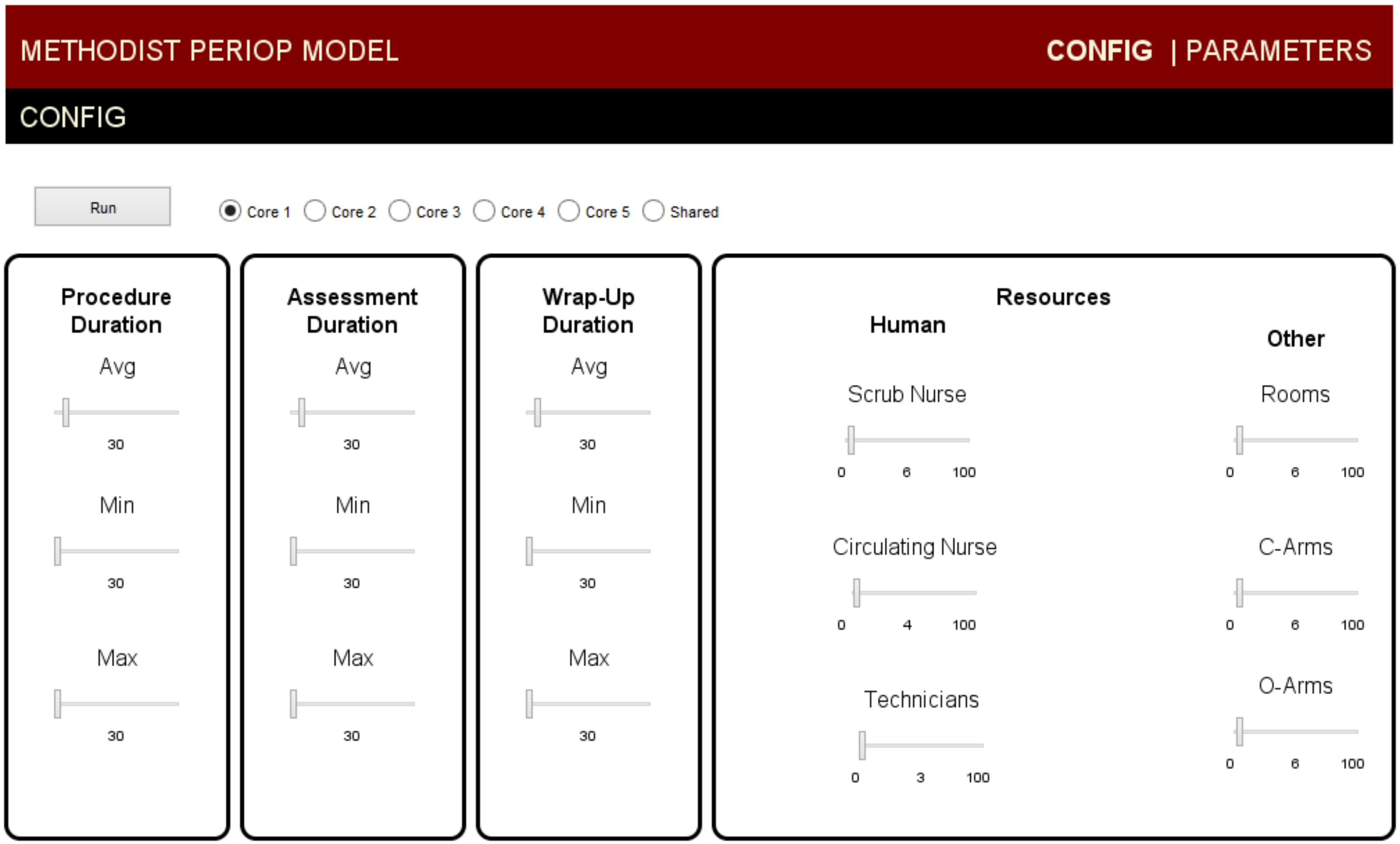
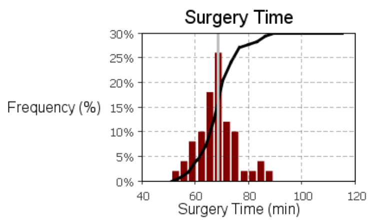
Resource Levels

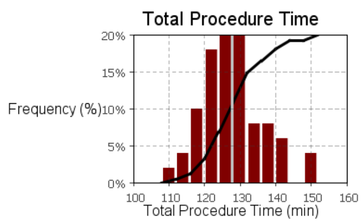


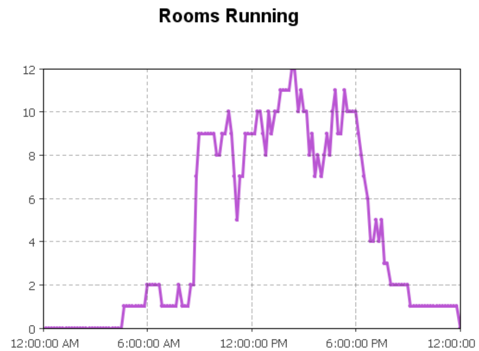
Outcome Dashboard

METHODIST PERIOP MODEL VISUALIZATION | LOGIC | **OUTPUT**

OUTPUT VALUES | **GRAPHS** | DASHBOARD







METHODIST PERIOP MODEL VISUALIZATION | LOGIC | **OUTPUT**

OUTPUT VALUES | GRAPHS | **DASHBOARD**

Service

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

Approach

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

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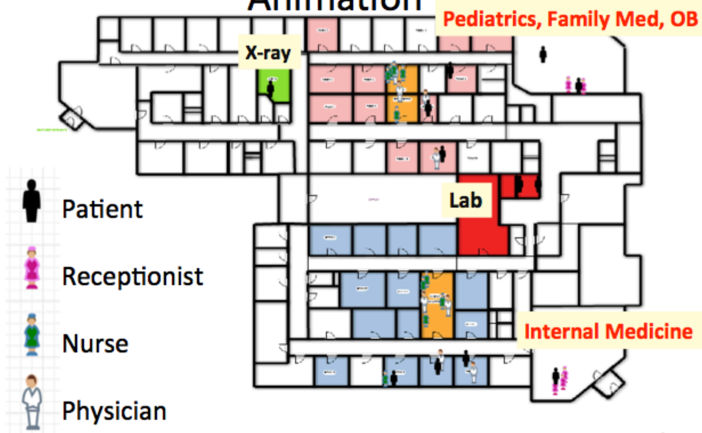
Improve Floor Plans

Web Access: http://www.runthemodel.com/models/644/

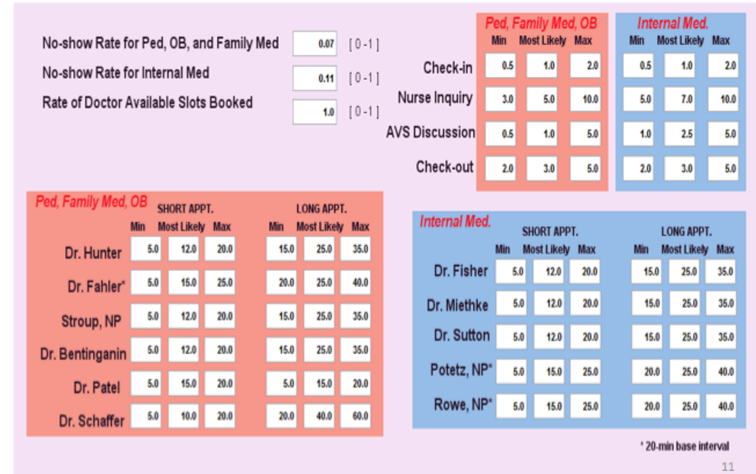
Current Facility Patient Flow Animation



Web Access: http://www.runthemodel.com/models/647/

New Facility Patient Flow Animation

Simulation Input Dashboard



No-show Rate for Ped, OB, and Family Med	0.07	[0-1]
No-show Rate for Internal Med	0.11	[0-1]
Rate of Doctor Available Slots Booked	1.0	[0-1]

	Ped, Family Med, OB			Internal Med.		
	Min	Most Likely	Max	Min	Most Likely	Max
Check-in	0.5	1.0	2.0	0.5	1.0	2.0
Nurse Inquiry	3.0	5.0	10.0	5.0	7.0	10.0
AVS Discussion	0.5	1.0	5.0	1.0	2.5	5.0
Check-out	2.0	3.0	5.0	2.0	3.0	5.0

Ped, Family Med, OB	SHORT APPT.			LONG APPT.		
	Min	Most Likely	Max	Min	Most Likely	Max
Dr. Hunter	5.0	12.0	20.0	15.0	25.0	35.0
Dr. Fahler*	5.0	15.0	25.0	20.0	25.0	40.0
Stroup, NP	5.0	12.0	20.0	15.0	25.0	35.0
Dr. Bentinganin	5.0	12.0	20.0	15.0	25.0	35.0
Dr. Patel	5.0	15.0	20.0	5.0	15.0	20.0
Dr. Schaffer	5.0	10.0	20.0	20.0	40.0	60.0

Internal Med.	SHORT APPT.			LONG APPT.		
	Min	Most Likely	Max	Min	Most Likely	Max
Dr. Fisher	5.0	12.0	20.0	15.0	25.0	35.0
Dr. Miethke	5.0	12.0	20.0	15.0	25.0	35.0
Dr. Sutton	5.0	12.0	20.0	15.0	25.0	35.0
Potetz, NP*	5.0	15.0	25.0	20.0	25.0	40.0
Rowe, NP*	5.0	15.0	25.0	20.0	25.0	40.0

* 20-min base interval

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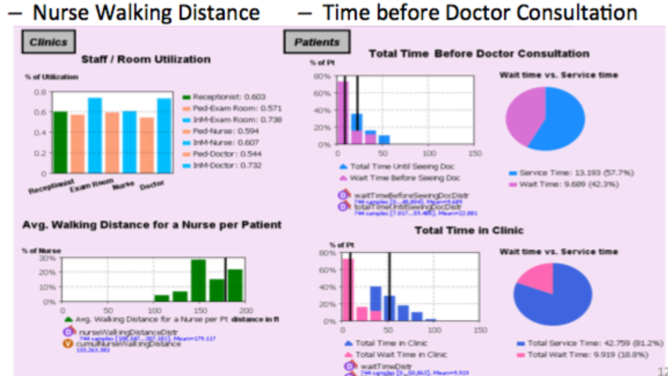
Simulation Output Dashboard

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



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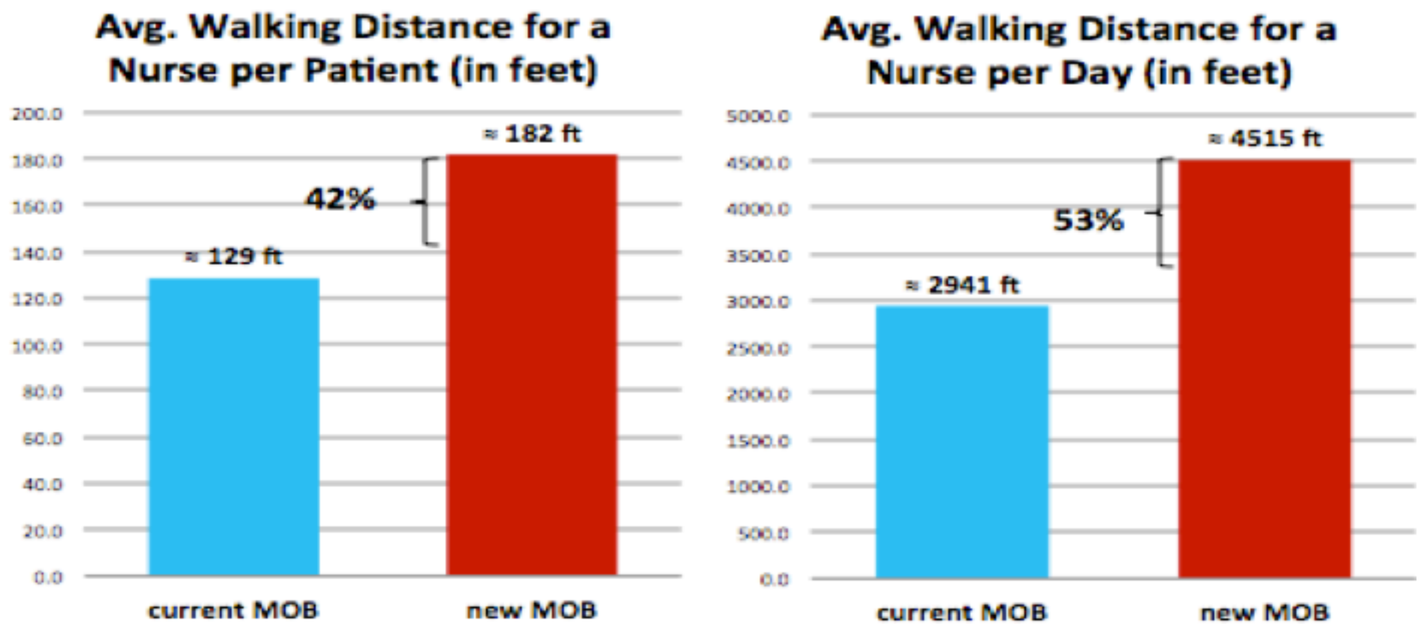
Decrease Staff Fatigue



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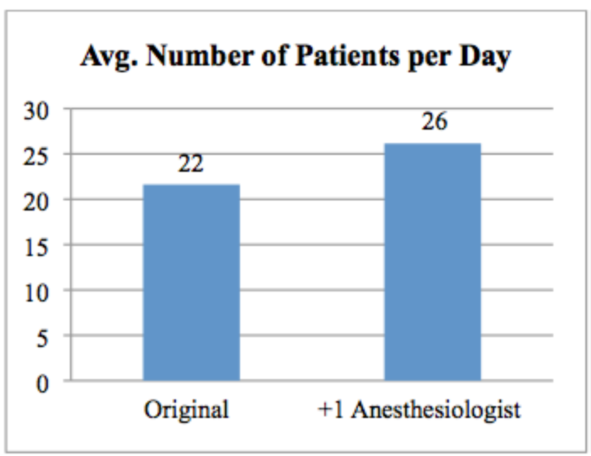
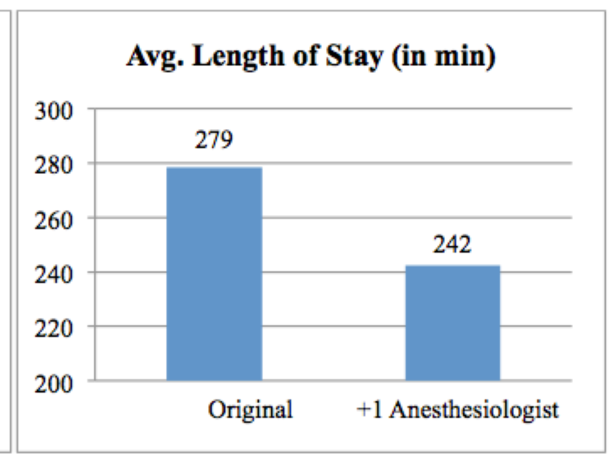
Improve Surgery Throughput





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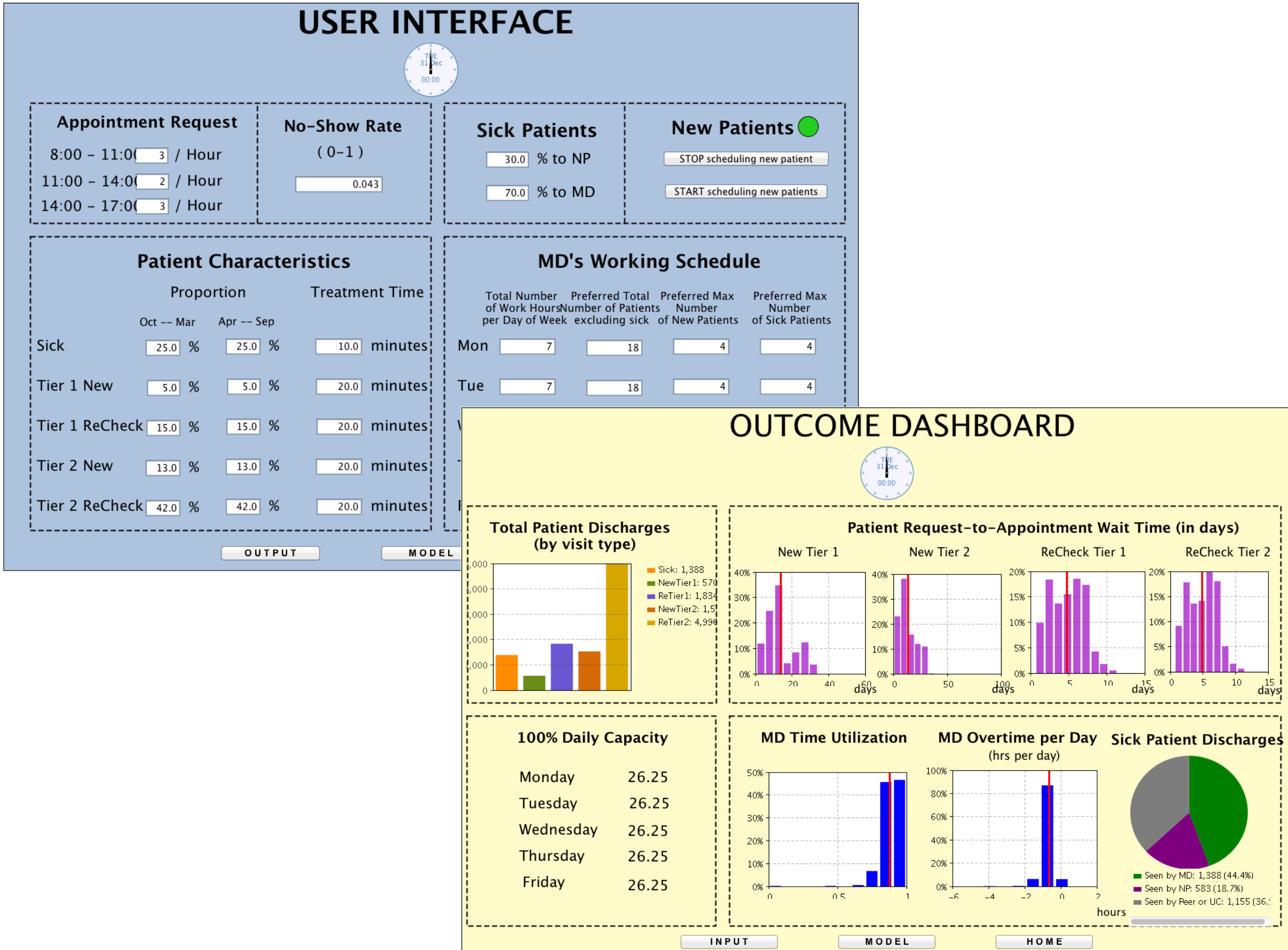
Improve Clinic Access



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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

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