LAI Healthcare Research

Prof. Debbie Nightingale
Jorge Oliveira and Jordan Peck
Massachusetts Institute of Technology
October 14, 2009
Agenda

• Research Motivation and LAI Alignment
• LAI Healthcare Research Pipeline
• Overview of Research Projects
• Final Comments
Research Motivation

**Cost**
- Over 16% of US GDP spent in healthcare expenses
- Hospital care represents 30.8% of total expenditure
- 49% of expenditure concentrated in only 5% of population
- Individuals over 65 years old expected to increase over 50% by 2020

**Quality**
- 98,000 deaths attributed to medical errors
- Adults on average only receive 55% of recommended care
- Emergency Departments are overcrowded nationwide
- Provider fragmentation unable of creating sufficient volume

**Access**
- 45 million Americans are uninsured
- Fragmented provider network, 75% being small or single practices
- Recent survey indicated 40% of Americans received uncoordinated care
- Fragmented payment systems, health plans, information systems, etc

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Cross Industry Enterprise Challenges

Aerospace

• Overarching commitment to ensure global peace and security
• Incumbent higher, faster, farther mindset
• Declining defense dollars after Cold War (fewer military aircraft programs; industry consolidation)
• Inherently complex industry:
  • Multiple stakeholders with misaligned objectives and numerous constraints
  • Capital Intensive
  • Complex product development
• Uncertain outcome in contract awarding

Healthcare

• Overarching commitment to provide world class medical care
• Incumbent overuse, underuse, and misuse mindset
• Overburdened healthcare expenditure as a % of GDP (proliferation of fragmented disjointed providers)
• Inherently complex industry
  • Multiple stakeholders with misaligned objectives and numerous constraints
  • Capital Intensive
  • Complex service provision
• Uncertain outcome in value sharing
LAI - A Consortium Dedicated To Cross Industry Enterprise Performance

- Enable Enterprises to effectively, efficiently and reliably create value in a complex and dynamic environment
- Enable focused and accelerated transformation of complex enterprises
- Collaborative engagement of all stakeholders in Government, Industry and Academia
- Understand, develop, and institutionalize principles, processes, behaviors and tools

Parallel issues/needs in healthcare!
Agenda

• Healthcare Research Motivation and LAI Alignment
• LAI Healthcare Research Pipeline
• Overview of Research Projects (JO, JP, and JM)
• Final Comments
Ongoing Research

- High Performing Hospital Enterprise Architectures (*Jorge Oliveira*)
- New England Veteran Affairs (*Jordan Peck*)
- Multiple Class Projects from Integrating the Lean Enterprise and Enterprise Architecting
- NEWDIGS Drug Development ESAT (*Judy Maro* and *Debbie Nightingale*)
- Impact of Advanced DNA Sequencing Technologies on Clinical Microbiology Processes (*Rob Nicol*)

Existing Proposals in Enterprise Systems

- NEWDIGS Phase II
- PTSD Systems Study
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  - PTSD (Debbie Nightingale)
  - DNA Sequencing
- Final Comments
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Health Care is a Complex Socio-Technical System

“Simply stated, the US does not have a health care system.”
William Brody, President of Johns Hopkins University, 2007

 “…the strategies [hospitals] develop and implement to compete have a significant effect on costs, quality, and access to care.”
(Devers et al. 2003)
Greater Boston Hospital Case

- Leading multi specialty physician led group practice with national and international recognition (i.e. neuro, liver, heart & vascular, etc)

### 2006 Highlights
- Emergency Visits: 38,631
- Total Beds: 293
- Total Staff: 4263
- Total Income: $679,454,000
- Total Expenses: $628,525,000
- Operating Income: $50,929,000

### Problem Statement
- Emergency Department (ED) struggling to keep up with demand
- Long wait times in the ED and patient leaving without being seen
- ED staff blame inpatient staff and vice versa
- ED staff churn levels significant

What can be done to speed patient flow in the ED? Where should a process improvement initiative focus?
Emergency Department VSM

Patient Arrives

T System: Patient chief complaint
Registration: Patient chief complaint
T System: Patient demographic, insurance, etc.
Patient Orders (paper)
Complete Check-in
ED waiting area
Triage (room 1)
First EKG, blood draw, then external tests
Conduct tests (room 2)
ED waiting area
Patient placed in ED bed

Priority assignment (L1 :: L5)

Information flow
Patient flow
Patient idle
Number of operators
Information flow
Patient flow
Patient idle

Follow-up if tests show an issue
Patient placed in ED bed
Discharge
Patient leaves

Note: (1) if bed not available, creative process comes into play whereby a bed is found for the patient (i.e. hallway, other)
Note (2): Check in initiated over phone and completed once patient arrives.
Note (3): Some hospitals have an agreement with Lahey where patients just roll through the ER. “x” is a fill-in until we know what to call these types of facilities.

Note (1)
Note (2)
Note (3)

Patient in ED bed
Waiting for admitting physician

Pre Admit Tracking System: Bed request
Patient leaves

Admit Physician arrives and checks patient (visual & paperwork)
Admit patient

Sign orders

Note (1)
Note (2)
Note (3)

Patient in ED bed

“Kick the tires”

Hospital staff available?

Patient ready? No / “Tourist”
Yes

Yes
No

Note: (1) may involve additional tests, or lab work
Note (2): Receiving floor requests ED to ‘hold onto’ patient for a period of time to complete shift change or catch up on work
Note (3): After 11:00 p.m. Need to call Head Nurse shift supervisor for bed assignment.

Number of operators
Information flow
Patient flow
Patient idle
Emergency Department Analysis

Description of patient time spent in ED

<table>
<thead>
<tr>
<th>Average Total Time Spent in the ED</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients Not Admitted:</td>
<td>4.14 hrs</td>
</tr>
<tr>
<td>Patient Admitted:</td>
<td>7.85 hrs</td>
</tr>
</tbody>
</table>

Description of patient arrivals and departures

Simulation Modeling

Average time for each step of the patient process

Key Points:
- Start with largest blocks of time
- How much of each process step is value vs non-value adding?
- What are the causes for non-value adding time? (root cause analysis)

Further work is necessary

Simulation patient levels in ED over three days
### Main Findings

- ED average length of stay considered problematic, but **non-admitted** patients took 4 hours, whereas **admitted** patients took over 8 hours.
- ED interacted well with some patient wards but not with others.
- ED heroic employee efforts said to be common rather than sporadic.
- ED metrics and strategic goals misaligned with overall hospital (X-Matrix).

### Questions For Further Study

- Why was the ED managed as a silo rather than end-to-end?
- Was the varying performance of ED interactions due to the payment model?
- Could it be that different observed EA configurations were directly related to the different observed performance levels?

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“The problem of redesign gets harder and the evidence weaker as one moves from the microsystem to the organization.”

*Donald Berwick, President of Institute for Healthcare Improvement, 2002*
Focus on revenue generating elective surgery; 16 strategic objectives; ED absent of strategic plan

Non-standardized admitting process; patient boarding (i.e., admitted patients held in ED due to lack of inpatient beds); costly bolt-ons

Timely provision of care compromised; overall hospital image compromised

Uninsured population; primary care unavailability; safety net compromised; fee-for-service payment model

Reliance on heroes and bed czars; incomplete patient record; high variation of evidence-based medicine within and across providers

Low staff morale; physician cultural rifts; high volume of staff churning; lack of productivity; finger pointing between ED and elsewhere

Fragmented information systems; costly proprietary software
"As Is" Enterprise Architecture
"To Be" Enterprise Architecture

Patient In the center of the architecture (Service-centered architecture)

Hospital processes oriented around the patient (Process-centered architecture)

Information Technology connects patient, knowledge, process, organization (IT/knowledge centered)
Overview of Research Methodology

- **Exploratory Case 1 (Boston)**
- **Literature Review**
  - Mostly health care
  - Healthcare payment model evolution (FFS, capitation, etc)
  - Hospital management (functional, DRG, service lines)
  - Institutional dimension (uninsured, cost, quality, access)
  - Lean best practice (Virginia Mason, Mayo Clinic, etc)
Overview of Research Methodology

- Research Questions
  - How should hospital enterprise performance be measured?
  - How does hospital enterprise architecture relate to hospital enterprise performance?
Overview of Research Methodology

Exploratory Case 2 (London)
- Multi specialty hospital: 872 beds, 43 wards, 18 operating rooms, ED, UK leader
- Burning platform: meeting 18 Week target
- Method: 1 month onsite; grounded theory methodology
- Despite different contexts hospitals shared strategic and operational issues
- Multiple configurations present with varying performance
Overview of Research Methodology

- Extended Literature Review
  - Multidisciplinary performance literature (categorical, process, systems)
  - Longitudinal in-depth study of Organizational theory literature (organizational effectiveness criteria; ideal and hybrid organization types; configurations; frameworks; proven relevant constructs; etc)
  - Healthcare literature (hospital typology for sampling, hospital internal structures for theoretical sampling, etc)
  - Research method refinement (multi-level analysis; embedded case studies; grounded theory; hybrid methods; theory maturity; etc)
Overview of Research Methodology

- Refined Research Questions

Does hospital enterprise architecture relate to hospital enterprise performance? How?
  a) How is hospital enterprise performance currently measured?
  b) How could hospital enterprise performance measurement be improved using lean enterprise architecture principles?
  c) What are different internal organizational design configurations capable of supporting higher performance for different service complexity artifacts?
Overview of Research Methodology

- Refined EA Framework
  - Augmented version of LAI EA Framework conveying theoretical richness, clear constructs, and guidelines to allow for subsequent empirical testing and refinement.
  - Enhanced knowledge of EA characterization.

[Diagram showing the research methodology flow:

1. Exploratory Case 1 (Boston)
2. Literature Review
3. Research Questions
4. Refined Research Questions
5. Extended Literature Review
6. Exploratory Case 2 (London)
7. Refined EA Framework]
Overview of Research Methodology

Exploratory Case 1 (Boston) → Literature Review → Research Questions

Refined Research Questions → Extended Literature Review → Exploratory Case 2 (London)

Refined EA Framework → Remaining Field Work → Write Up
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VA Mental Health – Boston

ESD.62J/16.852J: Integrating the Lean Enterprise

Ellen Czaika
Clayton Kopp
Orietta Verdugo
Zakiya Tomlinson
Jordan Peck, Facilitator
Metrics vs. Objectives

- Very strong alignment with most metrics on target
  - Goals are not formal or documented
  - Research is a goal but not measured locally

Metrics vs. Processes

- Strong alignment with outpatient treatment and clinic wait times
  - Missing metrics for key processes
    - Transfers to inpatient
    - Program referrals

Values vs. Goals

- Strong alignment with areas in service, care, & research
  - Gap lies in aligning goals to values such as:
    - Operating within budget
    - Well-documented monetary transactions

Processes vs. Values

- Strong alignment in areas of service, research, & quality
  - Processes addressing the least stakeholder values are primarily patient movement

X-Matrix

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### Metrics vs. Strategic Objectives

- **Very Strong Alignment Between Strategic Goals and Metrics**
- **Indicative of a Strong Top Level**
- **Metrics are chosen by national and reported regularly**

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The table and diagram below illustrate the X-Matrix, which helps in aligning strategic objectives with key processes and stakeholder values.

<table>
<thead>
<tr>
<th>Vocational Industry Program</th>
<th>Substance Abuse Outpatient Program</th>
<th>Substance Abuse Intensive Outpatient Program</th>
<th>Residential Program (REACH)</th>
<th>MHICM Program - Day Program</th>
<th>Methadone Clinic</th>
<th>Mental Health Outpatient</th>
<th>Impatient Service</th>
<th>Waiting Times - Clinic</th>
<th>Tobacco Measure</th>
<th>MH: SMI - MHICM Capacity</th>
<th>Mental Health Access</th>
<th>Mental Health Measure</th>
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</tbody>
</table>

- **Serves Boston Healthcare System**
- **Team Oriented - Integrated Care**
- **Quality Improvement**
- **Compliance - VA Code of Patient Concern & JCAHO**
- **Evidence Based Care (inc. Through Educational Residencies)**
- **Become World Class Research Hospital**
- **Accessible Care**

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### Key Processes

<table>
<thead>
<tr>
<th>Key Process</th>
<th>Strategic Objectives</th>
<th>Metrics</th>
<th>Stakeholder Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer from VA ER to Inpatient</td>
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<tr>
<td>Transfer from Urgent Care to Inpatient</td>
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<tr>
<td>Transfer from Outside ER to Inpatient</td>
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<tr>
<td>Inpatient Treatment</td>
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<tr>
<td>Transfer from Inpatient to Residential</td>
<td></td>
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<tr>
<td>Discharge from Inpatient</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Residential Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transfer from Residential to Inpatient</td>
<td></td>
<td></td>
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<tr>
<td>Transfer to Outside Facility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outpatient Treatment</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Referral to Inpatient</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Referral to Residential</td>
<td></td>
<td></td>
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<tr>
<td>Walk-in to Outpatient</td>
<td></td>
<td></td>
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<tr>
<td>Purchasing (Supplies &amp; Services)</td>
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<td>Patient Data Management</td>
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<td>Research</td>
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<td>Facilities and Maintenance</td>
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<tr>
<td>Human Resources</td>
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</table>

### Metrics vs. Key Processes

- **Week alignment between key processes and metrics.**
- **Metrics seem to be measuring secondary results rather than directly measuring process outcomes.**
Key Processes vs. Stakeholder Values

- Key Processes are primarily focused on satisfying specific stakeholders however all are taken into account.
Stakeholder Values vs. Strategic Objectives

- Once again the top level design of the VA system leads to strong strategic objectives that are carefully aligned to the stakeholder values as seen from the top.
Stakeholder Value Comparison

Methodology
- Inferred Stakeholder Importance from Strategic Objects & Value Delivery from the Key Processes
- Used weighting algorithm to calculate positions
- More research & data needed on weights, and to validate results.
Stakeholder Value Comparison

Methodology
- Inferred Stakeholder Importance from Strategic Objects & Value Delivery from the Key Processes
- Used weighting algorithm to calculate positions
- More research & data needed on weights, and to validate results.
Veteran Affairs
Boston Mental Health

Enterprise Architecting
May 13, 2009

Team:
Oladapo Bakare
Jordan Peck
Orietta Verdugo
Candidate Architectures
Candidate Architectures

Illness Based

Pros:
- Continuous care in a given category can be easily tracked and traced
- Flexible if new mental disorders, programs, or illnesses arise in the future

Cons:
- Many patients fall into more than one category
- Wasted resources on programs that have low volume or excess capacity

Patient Length of Stay

Pros:
- Resources can be maximized through each department

Cons:
- Unbalanced system with excess capacity in some units and overflow in others
- Patients currently transition between some or all of the programs
- Metrics will be focused on local maximization rather than focusing on optimal flow across the organization
Candidate Architectures

Profession Expertise

Pros:
- Allows medical staff to create optimal treatment plans by working within their specialty
- There is a direct connection with leadership team and employees

Cons:
- Difficult to collaborate with other specialties
- Supervisors will not be capable of treating specific illnesses

Area Based

Pros:
- Leadership oversight is more direct and site specific
- Initiating change in each location is more manageable

Cons:
- Scalability of any one location is limited to capacity constraints
- Quality of treatment programs may vary across locations
Axiomatic

Pros:
- Director responsibilities are clear and aligned
- Connection between leadership and treatment professionals are more transparent

Cons:
- Departmental imbalance due to program sizes and patient needs
- Requires significant re-organization of the enterprise
Architecture Evaluation
### Concept Scoring Matrix

**Architecture Evaluation**

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Weights</th>
<th>Rating</th>
<th>Weighted Score</th>
<th>Illness</th>
<th>Weighted Score</th>
<th>Area</th>
<th>Weighted Score</th>
<th>Axiom</th>
<th>Weighted Score</th>
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<tbody>
<tr>
<td>Agility</td>
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<td>3</td>
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<td>1</td>
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<tr>
<td>Scalability</td>
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<td>Accessibility</td>
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<td>0.10</td>
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<td>Customizability</td>
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<tr>
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**Total Score**

- **Current State**: 3.00
- **Illness**: 2.16
- **Area**: 2.40
- **Axiom**: 2.61

**Rank**

- **Current State**: 2
- **Illness**: 6
- **Area**: 4
- **Axiom**: 3

**Continue**

- **Current State**: No
- **Illness**: No
- **Area**: No
- **Axiom**: No

**Develop**

1-5 Success Ranking for Architectures

- 5 = high, 1 = low
Proposed Architecture

Department of Administration
- Director
- Lean Leader
- Associate Director
- Quality Leader
- Department Heads

Supporting Infrastructure
- Purchasing
- Research
- Human Resources
- Patient Data Management
- Finance

Department of Treatment
- Off-Campus
  - Outpatient Clinics
  - Urgent Care
  - Hospital Office
- On-Campus
  - Other Resources
  - Drugs
- Women's Program
- SMI
- PTSD

Department of Patient Identification
- Homeless Program
- Center for Returning Vets
- Shelter Relations

Department of Patient Reintegration
- REACH
- RISE
- CWP
- Com. Res Care
- Private Homes
- Follow-Up Programs

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Transformation Plan
Predictability = Control

Health Care Professionals are starting to recognize predictability

Emergency Severity Index (ESI)—a five-level emergency department triage algorithm that provides clinically relevant stratification of patients into five groups from 1 (most urgent) to 5 (least urgent) on the basis of acuity and resource needs.
Simulation and Modeling

How can we model Control Options and Interventions

How do the people fit in?  How well can solutions cross between hospitals?

VA Boston, MA  VA Togus, ME  VA Manchester, NH

Source: www.VA.gov
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CBI’s NEW Drug Development ParadIGmS (NEWDIGS)
Mission – Objective - Measures

**Mission:**
To improve therapeutic product innovation in healthcare.

**Objective:**
Involving all stakeholders, catalyze true transformational change across the product development spectrum globally.

**Measures:**
Reduced cost and time-to-market for genuinely innovative products that significantly improve health and provide enhanced value for healthcare.
Core Issues - Driving Forces

- Changes in definition of “product”
- Changes in definition of “stakeholder/customer” needs
- Changes in appreciation of the complexity of the science & the multimodal nature of the solution
- Primacy of investor optics
- Changes in both internal and public perception of risk
- Conservative culture of industry and antique assumptions – e.g., competition & infrastructure
Key Organizational Attributes

• Delivers dramatically increased value over the current approach (faster, more efficient, reduced resource expenditure without compromise in outcomes).

• Is integrated with an outcomes-based reimbursement environment, finding solutions focused on patient outcomes driven by patient and payor value as well as scientific/medical community value.

• Understands market and customer(s) health needs.

• Focuses on integrated healthcare solutions and is not tied to developing one particular product (i.e., responsive to market need, flexible, adaptive).
Key Organizational Attributes

- Designs solutions that intervene earlier in the disease continuum including prevention.
- Lean and highly collaborative with all stakeholders from across the entire value chain.
- Informed by knowledge generated internally and externally (through pre-competitive, cross-stakeholder data sharing/collaboration) and processes that enable rapid-cycle learning (e.g., Learning Healthcare System).
- Has relationships with best-in-class providers of solution components (industry, academia, non-profits), and collaborates effectively with them to develop solutions.
10-15 Year Vision (?): NEWDIGS Innovation Spheres

1) Discovering & Developing New Products (current focus of NEWDIGS)

2) Enhancing the Value of Existing Products (eg, personalized medicine, drug combos, ? biosimilars, etc.)

3) Optimizing Care Delivery Processes (e.g., integrating personalized medicine into care delivery; pt. “compliance”)
Proposed Initial Workstreams

Workstreams

1) New Paradigms: Modeling, Simulation, & Decision Support
2) Data, Evidence, and Decision-making
3) Regulatory Policy Design
4) Organizational Design (? hold for now)
5) Other TBD….

- What decisions must be made, when, and by whom?
- What evidence is required to inform these decisions?
- What data is required to generate the necessary evidence?
- What can we do in NEWDIGS to optimize all of the above?
Agenda

• Research Motivation and LAI Alignment
• LAI Healthcare Research Pipeline
• Overview of Research Projects
  • Jorge Oliveira
  • Jordan Peck
  • NEWDIGS (Debbie Nightingale/Judy Maro)
  • PTSD (Debbie Nightingale)
  • DNA Sequencing
• Final Comments
Phase I - Current State Analysis: Descriptive Research designed to understand the system

- Model each phase of the lifecycle ("system") of PTSD and the interfaces between each phase
- Multi-scale: Top down/Bottom up
- Outcome: Define Problem

Phase II - Model Creation and Validation: Descriptive Research designed to represent the system

- Drill down into identified gaps to develop possible solutions
- Outcome: Recommendations

Phase III - Implementation

** Will take into account multiple deployments.
Motivation for Application to PTSD

- Rising suicide rates among returning veterans and the potential PTSD precursors
- PTSD impact on health and well-being of servicemembers and their families
- PTSD impact on health services utilization within the military and in affected communities
- PTSD impact on national priorities for DoD
Potential Outputs

• Generate **models** as tools so that policymakers can:
  • Develop Insight on PTSD’s systemic impacts
  • Identify Missed Opportunities and Misalignment among current PTSD-related functions
  • Inform Resource Allocation for PTSD-related functions
  • Direct R&D Funding to Needed Areas
  • Reshape PTSD-related metrics to Monitor System Performance
Starting Points for Research

- Resource Allocation among Functions
- Capacity Utilization and Demand Modeling for Services
- At-Risk Subpopulations
- Active v. Reserve v. Guard Health Dynamics on Return
- Effects of Changing Suicide Policies
- Effects on Family and Community
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  • DNA Sequencing (Rob Nicol – ESD/Broad Institute)
• Final Comments
Motivation / Problem

> Antibiotic Resistance Surveillance: Key Healthcare Problem
- Rapidly increasing resistance
- Few effective antibiotics remain
- Limited system level surveillance
- Process improvement difficult

> Complex Healthcare Processes
- Large number of tasks and rapidly changing technology
- Numerous disconnected stakeholders
- Vast technical design space
- Highly distributed information (tacit and explicit)

> Severe Health and Cost Impacts
- 2 Million hospital acquired infections per year
- $5 Billion (est.) and over 90,000 deaths per year (source: IDSA)
Key Questions

> How can the true system level complexity of healthcare processes be modeled and measured?

> How does this system level process model and complexity measures work on a real world healthcare process design and implementation effort?

> How does process complexity impact change and adoption in healthcare?
Contributions

> Novel Network Based Process Representation and Complexity Analysis Methodology (model)

> Novel Theory for Process Innovation Adoption as a Function of Process Complexity (model observations)

> First Specification of a Whole Genome Clinical Microbiology Process for MRSA Surveillance (test case for model)

> First Operational Demonstration of a Whole Genome Clinical Microbiology Process for MRSA Surveillance (test case for model and complexity measures)

> First Whole Genome MRSA Diversity Study (real biological results showing policy change needed)
Contributions (Significant Biology Too...)

MRSA Surveillance Process designed and implemented as part of thesis yielded significant insight into MRSA biology which in turn suggests system policy changes needed.

Reference (should all be the same as this)

Multiple Genome Alignment of BWH Samples Compared to Reference at the Top

> 50 Genomes Sequenced
  (<15 existed previously)
> All Supposed to be identical based on current hospital diagnostics
> Significantly different! (look at length)
> Highlights need for surveillance and policy changes
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