Application of Lean to Healthcare Processes: A Complex System Perspective

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Associate Director,
Lean Advancement Initiative Educational Network
Talk Outline

• Part I: Lean and Healthcare
  • Healthcare – a complex system of processes behaving badly
  • Lean – a method for process improvement
  • Some local lean successes in healthcare

• Part II: Effects of Variability and Complexity
  • Participatory and Computer simulations
  • Impact on application of lean to healthcare
  • Conclusions and paths forward
Imperatives – United States

**Cost**
- Over 16% of GDP spent in healthcare expenses (2007)
- 117% increase in worker insurance premiums, 99 to 08
- 119% increase in employer insurance premiums, 99 to 08
- US spends 75% more on healthcare than G-5 countries (2006)

**Quality**
- 44,000 - 98,000 deaths attributed to medical errors (1999)
- 32% of patients report medical mistake, medication error or lab error in past two years (2007)
- 12-79% gap between delivered vs recommended care (2003)

**Access**
- 45 million Americans are uninsured
- Individuals over 65 expected to increase over 50% by 2020
- Fragmented provider network, IT systems, insurance, etc.
- 40% of patients not treated or medicated due to cost (2004)

**Trouble**
- 60% of doctors would not recommend career to young people
- 50% of ED caregiver time spent on paperwork (2001)
- 315,250 shortage of RNs predicted for 2015
Comparison of Spending

Average spending on health per capita ($US PPP*)

Total expenditures on health as percent of GDP

* PPP = Purchasing Power Parity. ** All 30 OECD countries except U.S.
Source: OECD Health Data 2009, Version 06/20/09.

As reported by Eric Dickson, MD
LAI Lean Academy Jan. 2011

McManus – Lean Healthcare – March 2012 – © LAI EdNet
Comparison of Results

Preventable* deaths per 100,000 population

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* Countries’ age-standardized death rates before age 75; including ischemic heart disease, diabetes, stroke, and bacterial infections.

Data: E. Nolte and C. M. McKee, London School of Hygiene and Tropical Medicine analysis of World Health Organization mortality files (Nolte and McKee 2008).

from Eric Dickson, MD
LAI Lean Academy Jan. 2011
US Healthcare - A Value Crisis

Value ≈ \frac{Delivered\ Care}{Cost}

- Lean can increase healthcare value delivery by:
  - Improving healthcare quality
  - Decreasing healthcare costs
- It is one piece of a puzzle to solve the US healthcare crisis

Percent of Known Care Delivered (2003)

Healthcare Spending (% of GDP) and Medicare & Medicaid (% of Federal Budget)

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Lean Arises From Japanese Auto Industry

Selected Metrics for US & Japan Automobile Manufacturers

<table>
<thead>
<tr>
<th>Product Development (mid 1980s)</th>
<th>Japanese Producers</th>
<th>American Producers</th>
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<tr>
<td>Avg. Engineering Hrs per New Car (millions)</td>
<td>1.7</td>
<td>3.1</td>
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<tr>
<td>Avg. Development Time per New Car (months)</td>
<td>46.2</td>
<td>60.4</td>
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<tr>
<td>Employees in Project Team</td>
<td>485</td>
<td>903</td>
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<tr>
<td>Supplier Share of Engineering</td>
<td>51%</td>
<td>14%</td>
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<td>Ratio of Delayed Projects</td>
<td>1 in 6</td>
<td>1 in 2</td>
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Summary of Assembly Plant Characteristics for Volume Producers, 1989

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<th>Japanese in Japan</th>
<th>American in N Am</th>
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<tr>
<td>Productivity (hrs/veh)</td>
<td>16.8</td>
<td>25.1</td>
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<tr>
<td>Quality (defects/100 veh)</td>
<td>60</td>
<td>82.3</td>
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<tr>
<td>Inventory (days for 8 sample parts)</td>
<td>0.2</td>
<td>2.9</td>
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<tr>
<td>Work Force on Teams</td>
<td>69.3%</td>
<td>17.3%</td>
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<td>Suggestions per employee</td>
<td>61.6</td>
<td>0.4</td>
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<td>Number of Job Classifications</td>
<td>11.9</td>
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<tr>
<td>Training Hrs of New Production Workers</td>
<td>380.3</td>
<td>46.4</td>
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Trends have continued since this 1989 data reported in *The Machine That Changed The World*
Lean as a discipline

- North American (mostly) research captured and codified Toyota practices
- Emphasis on transforming legacy organizations
- Initially focused on manufacturing, but always intended to apply to entire value stream

Lean is a method for process improvement – *It can be applied to any process, including those of Healthcare*
Lean Improves Processes by Eliminating Waste

- Wastes require excess work, excess capacity, excess time (and excess costs) to deliver product
- Standardize, stabilize, smooth workflow to make poorly-performing processes apparent
  - Only make what is needed—buffers hide problems
  - Just in time requests/deliveries/production, linked by a visual process, reveal weak links
- Never deliver or accept a defective product
- Don’t overburden people/processes or otherwise threaten their performance reliability

Principles are generic—they apply to any process
Lean Concepts, Terms and Tools
You Will Learn

- 5 Whys
- 6S
- 8 wastes
- A3 thinking and tool
- Andon
- Balanced work
- $C_p$, $C_{pk}$
- Capacity, throughput,
- Flow
- Future state
- Gemba (Genba)
- Genchi Genbutsu
- Histograms
- Integrated teams
- Kanban
- Kitting
- Relational coordination
- RPIW
- Single piece flow
- Spaghetti diagrams
- Stakeholder value
- Standard work
- Takt time

Actually, no.
We will talk about how lean has been and can be applied to knowledge and service work, including Health Care

- Cycle time
- DMAIC
- Enterprise stakeholders
- Enterprises
- Plan-do-study-act (PDSA)
- Process maps
- Processing time
- Pull
- Variation impact
- Visual control
- Wait time
- ..... and more
Lean Thinking Fundamentals

- Specify *value* – from the standpoint of the end customer (the patient)
- Identify the *value stream* – all value-added steps across departmental boundaries (the *value stream*), eliminating steps that do not create value
- Make value *flow* continuously – eliminate causes of delay, such as batches and quality problems
- Let customers *pull* value – avoid pushing work onto the next process or department; let work and supplies be pulled as needed
- Pursue *perfection* – through continuous process improvement

Defining Value

• Customer is willing to pay for activity
• Activity is transformative, moving the product closer to what the customer wants
  • or activity reduces risk and/or uncertainty in the product or process
• Activity is done right the first time
  • or iterations or experiments are planned and controlled
Value-Added vs. Non-Value Added Activities

**Value-Added Activity**
- Transforms patient, material, information, decisions, or risks
- And the customer wants it (or would if they understood it…)
- And it’s done right the first time (or as right as possible…)

**“Needed” or “Enabling” Activity**
- No value is created, but cannot be eliminated based on current state of process, technology, policy or thinking
- Team coordination, corporate reporting, required record-keeping…

**Non Value-Added Activity (WASTE)**
- Consumes resources but creates no value to the customer
- Pure waste - if this activity is removed, can the process continue?
- Waiting, Inventory, Movement, Excessive/defective processing…
<table>
<thead>
<tr>
<th>1. Over-production</th>
<th>Doing more than is needed by the customer or doing it before it is needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Inventory</td>
<td>Excess inventory cost through financial costs, storage and movement costs, spoilage, wastage</td>
</tr>
<tr>
<td>3. Transportation</td>
<td>Unnecessary movement of the product in the system (patient, specimen, materials)</td>
</tr>
<tr>
<td>4. Motion</td>
<td>Unnecessary movement by employees</td>
</tr>
<tr>
<td>5. Waiting</td>
<td>Waiting for the next event to occur or the next work activity</td>
</tr>
<tr>
<td>6. Defects</td>
<td>Time spent doing something incorrectly, inspecting errors, or fixing errors</td>
</tr>
<tr>
<td>7. Over-processing</td>
<td>Doing work that is not valued by the customer, or caused by definitions of quality not aligned with patient needs</td>
</tr>
<tr>
<td>8. Human Potential</td>
<td>Waste and loss due to not engaging employees, listening to their needs, and supporting their careers</td>
</tr>
</tbody>
</table>

Waste in Healthcare

• “20-30% of Healthcare Spending is Waste”*
  • overtreatment of patients
  • failure to coordinate care
  • administrative complexity
  • burdensome rules
  • fraud

• Only 31-34% of nurse time spent with patients**

*Donald Berwick, former administrator of the Centers for Medicare and Medicaid Services, former President, Institute for Healthcare Improvement

**Data collected from multiple sources by Mark Graban
Much of the PATIENT’S time is spent WAITING

Notional example of Triage/test/Treat cycle

- Waiting
- Triage
- Move
- Wait
- Tests
- Wait
- Treat
- Out-process

= Value Added Time
= Non-Value Added Time (WASTE)
80% or more of the *time* spent in a healthcare processes is *waste*

Source: University of Iowa Hospitals and Clinics

Less than 20% Value Added

**A real medical example - a test-and-treat cycle**

*Most of the patient time is spent waiting, moving, etc.*
Lean Focuses on Reducing Waste

Increase % Value Added Work and reduce Waste to Increase Throughput, Lower Cost and Improve Quality
Interesting Analogy: Waste in Product Development

- Most aerospace engineering tasks are idle much of the time.
- The actual work done by engineers is about 1/3 waste, 1/3 enabling, and 1/3 value added.
- Work is varied and unpredictable.
- Tasks are often similar, even repetitive.

10+ years of lean PD work can be leveraged.

Survey of aerospace PD process time (2000)

- 77% of time is PURE WASTE
- 15% pure waste activities
- 11% necessary NVA activities
- 12% value-added activities
- 62% job idle
- 38% job active
• Healthcare has many processes and lots of waste
• Lean is an overall method (with many tools) for improving processes by removing waste
• There are many opportunities for lean application in Healthcare.
Identify the **Value Stream**

- All the actions required to transform a good or service from an initial state to a outcome desired by the customer
  - Actions include: problem solving, physical transformation, information management
- Something “flows” in a value stream. E.g. in healthcare:
  - Patient value streams
  - Meds and materials value streams
  - Information (records) value streams
For a given medical condition, the patient value stream has many actions and is fragmented among numerous care givers.

Much lean to date focuses on this portion of the full patient value stream.
Process Maps

- Only understood processes can be improved
- Understanding a process is easier when it can be visualized
- A Process Map is an organized visualization of all the interrelated activities which combine to form a process
Value Stream Map includes data

Source: Jefferson Healthcare, Port Townsend, WA
Other graphical representations useful for particular purposes

Spaghetti Chart example - BEFORE

Steps Triage Nurse takes to place patient in room

Total distance traveled = 1250 ft.

Spaghetti Charts are a powerful visual tool for seeing unnecessary movement

Source: University of Michigan Health System, Ann Arbor, MI
Value Stream Mapping
Applied to Product Development

- Same basic techniques apply
- Flows are knowledge and information flows rather than physical products
- Process steps may overlap or involve planned iterations
- Value added steps add or transform knowledge, or reduce uncertainty (role of analysis steps)
- Quantifies key parameters for each activity (cycle time, cost, quality defects, inventory, etc.)
- 2005 document does NOT represent current knowledge; update in progress
Value Stream Mapping Applied to Healthcare

- Same basic techniques apply
- Flows are varied and include the patient (customer!), products, and information
- Process steps may overlap or involve planned iterations
- Value added steps can add or transform knowledge, or reduce uncertainty (diagnosis and test)
- Quantifies key parameters for each activity (cycle time, cost, quality defects, inventory, etc.)
• There are many value streams in a Healthcare Enterprise

• There are lean tools for uncovering and visualizing them
Creating flow:
- Focus on what is flowing through the process
- Eliminate bottlenecks, minimize buffers
First, avoid bottlenecks

- GP Referral: 100/day
- Appointment Made: 100/day
- Outpatient Visit: 50/day
- Surgery: 15/day
- Add to Waiting List: 150/day
- Follow-up: 60/day
- Discharge: 140/day

Bottleneck!
All steps need *Capacity* to handle work

- **Theoretical Capacity:** Maximum sustainable flow rate at an activity
- **Effective Capacity:** Capacity of the activity accounting for detractors

Source: http://www.pbase.com/echolsteam/image/68404368
Capacity Detractors

• Example: Rework (defects) as a detractor

• Other detractors include unevenness and unreasonableness, multitasking, equipment downtime…

• The more complex the system, the greater the likelihood of detractors
Capacity Calculation

\[
\text{Time per shift} \times \text{x number of resources} \times \text{x % Time Available} \times \text{Touch Time} \times \text{x number repeats needed to finish one unit} = \frac{\text{Time available}}{\text{Time/unit}} = \text{Capacity (units/shift)}
\]

• Local terminology and practices will vary
• Basic concepts do not
Capacity Calculation – Typical Example

Assume “perfect” availability and no repeats

Appointment system:
• 7 hour shifts
• 4 minutes per call
• 1 operator

7 hrs  Time per round (shift)
1  x number of resources
1  x % Time Available
4 minutes  Touch Time
1  x number repeats needed to finish one unit

420 min  Time available  =  Capacity (units/shift)
4 min/appt  Time/unit

105 appts/day
Capacity Calculation – Realistic Example

Assume 2 hours lost per day to meetings, coordination, slack time etc.

Assume 30% of the appointments need a second call to resolve conflicts and correct mistakes.

Time per round (shift) = 7 hrs

Number of resources = 1

% Time Available = 0.71

Touch Time = 4 minutes

Number of repeats needed to finish one unit = 1.3

Time available = 300 min

Time/unit = 5.2 min/appt

Capacity (units/shift) = 58 appts/day

Complexity of system has halved capacity.
Lean Interventions to achieve flow on the Value Stream

• Eliminating waiting
  • better synchronization of processes
  • making sure “bottleneck” processes have capacity

• Smaller “batch sizes”
  • Intermediate checks on customer satisfaction and technical performance to avoid long rework loops

• Working to *Takt*
  • Do the work on a regular pace

• *Lowering Complexity*
  • Simplify processes, limit multitasking and confusion
  • Tools include visual management, co-location, knowledge capture and sharing…
Use SIMPLE tools: Visual Control

Resident status chart in long term care facility

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<td>1270</td>
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</table>

Source: Faten Mitchell, Quality Improvement Advisor, Health Quality Ontario

Hydration Chart for residents
- Each column represents a resident
- Each row represents a day
- Each cell is daily fluid intake in ml
- Colors show fluid intakes levels relative to desired amounts

Source: Virginia Mason Medical Center
• Flow can be created by removing bottlenecks from the value stream
• However, complexity of healthcare environment, and associated detractors, make this difficult
Let Customers *Pull* Value

- In a **Push** system, each activity delivers its output when it is done.
  - Results in build up of batches with lots of inventory. Defective goods pile up
- In a **Pull** system every activity delivers its output just as the next activity needs its input.
  - Triggered by the end customer
  - Results in smooth flow with no batches or voids
  - Minimizes inventory and rework due to defects.
- **Pull** systems can be implemented in material flow using a *Kanban* approach.
- Implementation for people flow is more challenging
Various meanings of *Pull*

- **Pull** also means the organization responds, as a whole, to the needs of the stakeholders.
- Customers perceive pull if you have:
  - Rapid response, inside the customers' expectations
  - Rapid development, inside the customer’s decision cycle
- Healthcare examples:
  - Walk-in clinics (if you can walk out quickly...)
  - On-line pharmacy

*From Newton-Wellesley Hospital website nwh.org 3/27/12*
Perfection: Building a Continuous Improvement Culture

• Much of this is learning by doing
• Training and participation plays a role
• Best practices: All employees have familiarization training, participate in event(s) with JIT tool training
• Training should be adapted to local environment/culture
LAI Lean Academy one-day Lean Healthcare course

Lego® Clinic Sim

• Realistic and fun
• Lego people move through 5 initially separate clinics
• Objective: Apply lean concepts to increase throughput, reduce Pt stay, reduce chaos

Case Study

• Jefferson Healthcare, WA
• Same lean fundamentals applied to improvement of 5 legacy clinics
• Objective: Increase throughput and revenue, improve patient satisfaction

Photo by James Schlosser

McManus – Lean Healthcare – March 2012 – © LAI EdNet 42
Simulation Elements

- Clinics of 6 participants
- Participants are process owners
  - Scheduling, registration, triage, examination, diagnostic testing, discharge or hospital admission
  - Initial process rules specified
  - Processes may be improved
- Process variation
  - Patient arrival
  - Patient symptoms and pathways based on head, torso, leg colors
  - Dice roll for process variation & rework
- Budget based improvement choices
• Pull in the eyes of the customer can be achieved in healthcare processes
• The drive for perfection requires strong leadership, pervasive training, and persistence over time
• Next: The biggest barrier to classic lean in Healthcare
Application of Lean to Healthcare Processes:
A Complex System Perspective

Part II – Variability and Complexity
Wasteful Processes = Targets for Lean

- **Static Muda wastes**
  - the 7 (or 8 or 10 or 30) wastes applied to both the material and the *information* value streams
  - Note from PD research: Information “rots” at around 6% per month (!)

- **Even more important to complex processes:**
  - *Muri* – Overburden of people or equipment
  - *Mura* – Unevenness or instability in operations or outputs

---

Complex and variable nature of healthcare processes indicates focus on *Muri* and *Mura* (not typical of current lean implementations)
Intuitive and non-intuitive cases

- “Simple” overburden
  - Find actual capacity accounting for iteration and rework
  - Obtain resources (which may take a while)
  - Adjust workload and/or control “batch sizes” to synchronize

- Variability/instability the harder problem
  - A perfectly balanced, “flow” system will behave very badly if there is instability in either input or process!
Direct Participatory Simulation

• 5-step clinic value stream
• Dice (provides variation) and a poker-chip “patients” (flowing value)
• Everyone, simultaneously,
  • Rolls die
  • Passes that many patients (or all in the waiting room, whichever is smaller) to the next step
  • Record number of patients in the waiting room
• Repeat for 20 “shifts”
Spreadsheet Simulation
Balanced flow system *but* performance modeled by a six-sided die
Queue Time

• Based on the equation for queue cycle time,

\[
\text{Time\_in\_Queue} = \text{Activity\_Time} \times \left( \frac{\text{Utilization}}{1 - \text{Utilization}} \right) \times \left( \frac{CV_a^2 + CV_p^2}{2} \right)
\]

• \( CV_a \) is input variation
  • which we may not control

• \( CV_p \) is process variation
  • which we want to minimize

• Utilization rate is Demand/Capacity
  • Note to be “efficient” this should be 1…
Controlling Variability

- Heroic reductions in variability required if utilization is high
- This is the motivation behind the 6-Sigma approach
Controlling Utilization (overburden)

• For any variation level, some level of utilization makes queue time explode
• This is *muri* and *mura* in action
• Often, slight easing makes a dramatic difference
Adapting to Variation

• Standardized system for adjusting staffing, resources, or schedule to absorb variation
  • Reserve capacity: for critical situations
  • Flexible staffing: “2-1/2 jobs”
  • Working to a pace: “pseudo-Takt”

• Not a solved problem, but plenty of ideas…
Adapting to Variation: Healthcare

- Standardized system for adjusting staffing, resources, or schedule to absorb variation
  - Reserve capacity: for critical situations
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  - Working to a pace: “pseudo-Takt”

- Not a solved problem, but plenty of ideas…
Reducing Complexity

• Standardizing and simplifying systems to self-regulate without additional management
  • Daily management systems (self-organizing teams)
  • Organizing, Kitting and *Kanban* of supplies
  • Standardizing of common procedures (checklists)

• Moderate *local* payoff (less work)

• Potentially huge *systems* payoff through reduced variation and overburden
  • Do not “monetize” local savings – use them to make the system perform better
• Variation will disrupt even a “perfect” system
• Badly
• Variation (Mura) and Overburden (Muri) are linked in a nasty way
• Both must be reduced, if anything more aggressively than static wastes
• Input variations (patients) may not be controllable; internal variations and complexity are
Lean Produces Results in Healthcare

A few of many examples:

• Waiting time for orthopedic surgery reduced from 14 weeks to 31 hours (from first call to surgery) – ThedaCare, WI

• 48% readmission rate reduction for COPD patients - UPMC St. Margaret Hospital, PA

• $180M capital spending cost avoidance from lean improvements – Children’s Hospital, WA

• 72% reduction in lab results turnaround time from 2004-2010 without addition of head count or instrumentation – Alegent Health, NE
Case Study

Jefferson County, WA – Population 29,542 (2008 est.)

Photo by Earll Murman

Source: Google
Improving JHC Outpatient Clinics Through VSMA & Lean Thinking

• Situation
  • Five legacy outpatient clinics
  • Few standard processes
  • Little coordination between clinics and with other parts of JHC
  • Patients per day per doctor under national norms
  • Poor flow and facility layout

• Primary Event Focus:
  • Identify standard patient flow for clinic encounters; improve patient access and provider productivity

Photos by Earll Murman
Jefferson Healthcare Clinic - Current State Map

Source: Jefferson Healthcare, Port Townsend, WA
Standard Rooms and Central Supplies

5S Events in each Clinic

Source: Jefferson Healthcare

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Daily Management System

Implement daily huddle

Photos by Earl Murman
McManus – Lean Healthcare – March 2012 – © LAI EdNet

Lean Events Targeting Each Step in the Clinic Value Stream

Standard Work creates a foundation to build on

FIW Dec 2007
FIW Mar 2008
FIW Mar 2009

RPI Jun 2008
RPI Mar 2009

RPI Sep 2008

Check In
Confirm and update your personal information

Preparing for Your Visit
• Why am I here?
• Has any medical information changed since my last visit?

Visit with Your Providers
• Time with your Nurse or Medical Assistant:
  Check vital signs, review medications and today’s concerns
• Time with your Doctor, Physician Assistant, or Nurse Practitioner

Check Out
Pick up any prescriptions, lab or x-ray orders, handouts, arrange follow up appointments

FIW = Focused Improvement Workshop

Source: Jefferson Healthcare
Results

Project Access RPI (Feb 2009):

• Reorganized Medical Staff Structure

• Consolidate Provider meetings reducing meeting hours.

• Revise scheduling guidelines (20 min vs. 40 min vs. 60 min)

• Create schedule management strategies using daily huddle

Cumulative Available Clinic Hours 2007, 2008, 2009

Source: Jefferson Healthcare
Results

Cumulative Additional Visits in 2009 vs 2008

- January: 39
- February: 351
- March: 762
- April: 1175

Source: Jefferson Healthcare
• Lean has been successfully applied to Healthcare processes
• Little projects can provide dramatic (local) improvements
• Consistent reduction of complexity and variation across the value stream provides significant overall performance gains
What affects the bottom line? Jury is out, but a PD analog exists...

- **LAI / McKinsey study***
  - 300 subjects, 28 companies
  - what PD practices correlated with project success?
- High performing companies consistently did better on a variety of metrics
- High performing companies tended to employ a lot of advanced PD practices
- No “silver bullet” practice, but a few correlated particularly strongly with success

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*Mike Gordon, Chris Musso, Eric Rebentisch, and Nisheeth Gupta, The Path to Developing Successful New Products, WSJ, November 30, 2009*
The Main Differentiators between Top and Bottom Performers

1. High level of upfront project preparation
   - Scoping of project
   - Staffing of project
   - Handling of “Fuzzy Front End”

2. Focus on project team
   - Emphasize on Project Organization over Line Organization
   - Strong project leadership

3. Keep eyes on the ball
   - Exploration of customer needs at each step of the project
   - Close customer integration, constant feedback loops

These LEAN characteristics correlate with business success

List from Dr. Josef Oehmen
Where to start?

- LAI study of lean practices. Difficulty, impact, interdependencies considered.

<table>
<thead>
<tr>
<th>Process Standardization</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workload Levelling</td>
<td>14</td>
<td>13</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Specialist Career Path</td>
<td>20</td>
<td>19</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Strong Project Manager</td>
<td>11</td>
<td>9</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Responsibility-based Planning and Control</td>
<td>35</td>
<td>34</td>
<td>33,36</td>
<td></td>
</tr>
<tr>
<td>Simultaneous Engineering</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Rapid Prototyping, Simulation and Testing</td>
<td>30</td>
<td>29</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>Supplier Integration</td>
<td>26</td>
<td>25</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>Product Variety Management</td>
<td>21</td>
<td>22,24,23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set-based Engineering</td>
<td>39</td>
<td>37</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>Cross-project Knowledge Transfer</td>
<td>41</td>
<td>42</td>
<td>43</td>
<td>44</td>
</tr>
</tbody>
</table>

- Process Standardization, Workload leveling suggested as first steps.

Wrapup

• Lean does apply to Healthcare
  • There is plenty of waste to be found
  • The Value, Value Stream, Flow, Pull, Perfection model works (roughly in order)
  • Tools must be selected and customized base on your needs

• Variation and Complexity challenge traditional application of lean (but not the concepts)
  • Reduce Muri (overburden) and Mura (variation) as well as static wastes
  • Don’t monetize modest savings – apply them across the value stream to improve system performance

__Lean does not tell you how to treat patients – it frees you to do it more and better__
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QUESTIONS?
References

- John Toussaint, *On the Mend: Revolutionizing Healthcare to Save Lives and Transform the Industry*, Lean Enterprise Institute, 2010