A Crash Course in Healthcare Systems Engineering

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“The fundamental problem with the quality of American medicine is that we’ve failed to view delivery of health care as a science. The tasks of medical science fall into three buckets.

- One is understanding disease biology.
- One is finding effective therapies.
- And one is insuring those therapies are delivered effectively.

That third bucket has been almost totally ignored by research funders, government, and academia. It’s viewed as the art of medicine. That’s a mistake, a huge mistake. And from a taxpayer’s perspective it’s outrageous.”

~ Peter Pronovost, MD

Industrial engineers are able to effectively address this “third bucket”.
These are just some examples of locations.

Additional locations include...
• Skilled nursing care facilities (nursing homes) - one type of LTC
• Rehabilitation facilities
• Mental health facilities
• Hospice care
• Home
• etc...
US healthcare industry is the largest employers in the US. (>3% of the workforce)

7 of the 10 fastest growing occupations for 2004-2014 are health related. (page 120)

Who Provides the Care?

• Physicians (MD or DO)

• Other Doctoral Level Practioners:
  – Dentists, Pharmacists, Podiatrists, Optometrists, Chiropractors, Psychologists.

• Nurses:
  – Registered Nurses (ADN, Diploma nurse, BSN)
  – Licensed Practical Nurse (LPN)
  – Advanced Practice Nurses: CNS, CRNA, NP, CNM. (NP and CNM also categorized as NPP - Nonphysician practitioners)

• Allied Health Professionals: health related areas
  – Technicians / assistants
  – Therapists / technologists

• Family members
Financing Healthcare

In 2005, national health care expenditures totaled $1.99 trillion, or 16% of the GDP.

Government
- Medicare
- Medicaid
- SCHIP
- Military Medical System
- Veteran’s Health Care System
- Indian Health System

Private
- HMO
- PPO
- Hybrids

Self-Pay
- Direct out-of-pocket
- Fee for service

There is a direct tradeoff between the amount of choice the beneficiary has and the amount (proportion) of the cost they tend to be responsible for out-of-pocket.

While there are a number of topics that are currently “Hot”, the increasing demand with fewer resources, (including a shortage of appropriately trained HC providers), the changes due to HC reform are going to continue being important

Current Hot Topics

• Increasing demand on the healthcare system
  – Baby boomers aging
  – Population getting sicker (rise in chronic illnesses)

• Healthcare workforce pipeline
  – Maldistribution of physicians
  – Shortage of Nurses

• Need to improve performance while decreasing cost

• Healthcare Reform
Industrial Engineering & Quality Engineering (IE) Tools

TECHNIQUES AND EXAMPLE PROJECTS
Where Do IEs Fit in Healthcare?

- Industrial engineers design, install, and improve the complex systems which provide goods and services vital to our society.

- IEs in a hospital environment are called **Management Engineers**
  - Helps integrate people, equipment, facilities, and other resources to improve work results.
  - The term “management engineering” seems more “palatable” to those in the field of health care (Smalley, 1982, p 21).

- “The philosophy of hospital management engineering rests on the premise that an increase in hospital productivity promotes the attainment of hospital objectives.”
  - A management engineering program should be viewed as one that “fosters wiser utilization of hospital resources.”
  - Performs cost-saving & quality improvement projects.

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Smalley (1982).
A Few Quality Engineering (IE) Tools

- Lean Engineering (for Healthcare)
  - Plan-Do-Study-Act
  - Spaghetti Diagrams (Workflow)
  - 5S
- Six-Sigma
  - Cause and Effect (Fishbone) Diagram
  - Pareto Analysis / Diagram
- Human Factors
  - Human Error
  - Checklists

There are far more tools than can be discussed in a single 50-minute session, so these are just a small sample of IE tools and how they can be applied to HC.
Introduction to ‘Lean’ Healthcare

- *Lean* is a systematic approach to improving the reliability of processes through the identification and elimination of operational barriers and sources of variability within a process or system.
  - Philosophy: *produce only what is needed, when it is needed, with no waste*

- Lean is derived from methodologies developed in the Japanese automobile industry. (*Toyota*)

- Waste is any activity that consumes resources but creates no value for the customer.
  - Time, activities, variability...
• The PDCA cycle was originated by Walter Shewhart.
• Modified by W. Edwards Deming to include Plan/Do/Study/Act for broader management action in later years.
• Now PDCA or PDSA is often referred to as the Deming Cycle... a classic tool of process improvement in the 1980s and 1990s.
• Became the core around which the Six Sigma DMAIC loop was designed.
Using Spaghetti Diagrams

- Method - a continuous line to trace the path and distance traveled of a specific object or person throughout a process
- Expose inefficient process layouts, unnecessary travel distance between process steps and overall process waste

Very simple, but powerful tool to identify transportation waste.
Example task analysis / process chart developed while completing a medication administration workflow study. (Presented at SHS in 2009)

Time Allocation – Waste Activities

- **Interruptions and delays** – break the workflow and create waste in process steps
  - In general:
    - Many interruptions are waste (45.6% in this study)
    - ~100% of Delays are waste
  - On average, nurses were interrupted 6.2 times during morning medication administration, (or once every 20 mins)

- **Transportation** increases time spent, but some transportation, like walking from one patient’s room to the next to begin their regime is required (not waste)
  - Transportation when looking for missing medications = waste
  - ~40% of transportation (walking) activities were for a “non-value” added purpose

- Inspection – necessary to increase safety in many regards, does increase time, and may be wasteful if too much time is devoted to that activity

What is 5S?

• An approach to waste and variability identification utilizing workspace organization techniques

• 5-step process focuses on cleaning, organizing, and arranging a workplace to eliminate the waste associated with looking for items required to complete a process.
  
  — Example: It is estimated that nurses spend 30% of their time locating information, equipment, or materials required for patient treatment

• 5S incorporates the standardization and discipline necessary to maintain the gains associated with any improvement initiative and the discipline to internalize those improvements

The benefits of 5S are:

• Allows everyone to be involved in the process
• Provides the foundation for a Lean Healthcare facility
• Assists in the elimination of waste
• Improves work flow
• Reduces employee stress
• Provides a systematic process for continuous improvement
• Focuses on the process and not the person

Key Points for 5S in Healthcare:

- 5S must be part of everyone’s daily work
- Make sure the first S: sort is done well, as it will set the stage for the other S’s.
- Ensure before and after photos are taken and displayed.
- Obtain testimonials from workers during the process and submit them to the facility newsletter.
- Be creative and adaptive to the changing healthcare environment.
- Make reward and recognition part of the process.

Local Example – Cannon Memorial Improving Layout of Supplies

• Desired: Development of a layout optimized to suit the OR department based on the following factors
  – Inventory levels
  – Frequency of use for each item,
  – Frequency of surgeries/cases performed
  – Movement around the department when developing kits

• Result: OR staff changed the layout of supplies within the department
  – Primarily consolidated parts of similar function size into the same area.

• OR Staff reports since implementation have been overwhelmingly positive

• Benefits of the improved layout include
  – Reduced travel distance around the department when retrieving supplies
  – Reduced time taken to build case kits and retrieve supplies
  – Reduced bending and reaching while building case kits and retrieving supplies
  – Reduced time taken to perform medical procedures in the OR
  – Shelving utilization increased from 53% to 72%
Results from our 5S project at Cannon Memorial Hospital were published in the Oct 2009 issue of Industrial Engineer Magazine.
Local Example - CMH
Lean vs Six Sigma

- While once believed to be opposing methodologies, they are now embraced together as Lean-Six Sigma
- Lean is more of a process improvements method
- Six sigma is more of a quality improvement method
- Typically Lean is applied first to eliminate the non-value added process steps and create flow
- Six sigma is then applied to improve quality
Cause and Effect Diagram

Also known as a fishbone diagram or Ishikawa chart

- Used to identify possible variable influencing a problem, outcome or effect.
- Displays structured results of ideas generated (brainstorming)
  - Graphic nature of the diagram organizes large amounts of information about a problem to pinpoint possible causes
  - Encourages investigation of causes at many levels, improving odds that root or basic causes will be identified
  - Used to find special or common causes of variation
- Main causes of the problem are displayed on ticker lines (bones)
- Specific causes are displayed within on thinner lines
Fishbone of Low Immunization Rates

- Poor patient compliance
- Study design problem
- Lack of info on immunization schedules
- Lack of info on documentation needs
- Data collection
- Data definition
- Access
- Economic
- Delivery
- Lack of supplies
- Poor provider compliance

Image from:
http://books.google.com/books?id=b0rLyO8t2UEC&pg=PA59&lpg=PA59&dq=%22fishbone+diagram%22+healthcare&source=bl&ots=jZGLOg9ejl&sig=S-OytO9rSb7dGr-9DaylTdhZB0I&hl=en&ei=MnnBSva_DYya8AaU6rmDBg&sa=X&oi=book_result&ct=result&resnum=1#v=onepage&q=%22fishbone%20diagram%22%20healthcare&f=false
Pareto Analysis (Diagram)

- Simple bar chart which ranks related measures in decreasing order of occurrence
- Principle based on the unequal distribution of things
- Law of the “significant few versus the trivial many”

When should you use a Pareto Diagram? When:
- analyzing data about the frequency of problems or causes in a process.
- there are many problems or causes and you want to focus on the most significant.
- analyzing broad causes by looking at their specific components.
- communicating with others about your data.

Pareto chart example from: http://asq.org/learn-about-quality/cause-analysis-tools/overview/pareto.html
HUMAN FACTORS PHILOSOPHY APPLIED TO HEALTHCARE SYSTEMS ANALYSIS
Human Error and Adverse Events

• Some variability (risk) will always be present due to patient factors

• Healthcare delivery “does not occur in a vacuum”
  – Organizational issues, cost-of-care, social pressure, scheduling

• Errors are prevalent in human action (with and without adverse consequences)

• Complications are not always avoidable, but must be investigated to ensure “standards of care” are maintained
Additional Human Factors

- Mental and Physical Stress
  - Fatigue (lack of sleep); long hours; shift work
  - Physical discomfort during procedures
  - Cognitive workload (overload)
  - Extraneous stimuli (more environmental)

- The Care Delivery Environment
  - Lighting; temperature; humidity; noise; ventilation
  - Workplace design; layout; equipment placement
  - Technology
Impact of Current Technology

- Medication administration often involves:
  - Computerized order entry
  - Barcode scanning of medications and patients
  - Electronic charting

- Expectations have changed with the method of how medications are ordered
  - Previous system: written (hard copy) orders ~2 hr cycle
  - CPOE: expect medication now!

- Technologies designed to improve safety often increase the complexity and time involved for the RN.

- Enabling technologies that fail to work as expected often force “workarounds”
  - Unintended consequence – increasing the risk of errors.

Checklists

- A checklist is a list of action items arranged in a systematic manner that allows the user to record the completion of the individual items (Heitmiller, 2009)

- Checklists are common in other critical settings including aviation and general industry

- Now becoming more common in healthcare
  - Daily goals checklist – ICU patient care (e.g. Dr. Provonost)
  - e.g. Surgical Safety Checklist developed by Dr. Gawande to prevent wrong site surgery and other never events
    - This is different from the Universal Protocol developed by the Joint Commission in 2003


# Operation Safe Surgery Surgical Safety Checklist

## Before Induction of Anesthesia
- **Name and anesthesiologist's name:**
- **Is the patient confirmed for their identity, site, procedure, and consent?**
- **Is the site marked?**
- **Yes / No**
- **Is the anesthesiologist and nurse present?**
- **Yes / No**
- **Is the anesthesia machine and emergency equipment ready?**
- **Yes / No**
- **Is the pulse oximeter on the patient and functioning?**
- **Yes / No**
- **Does the patient have a known allergy?**
- **Yes / No**
- **Has an airway aspiration risk been identified?**
- **Yes / No**
- **Are the equipment and assistance available?**
- **Yes / No**
- **Risk of 500 ml blood loss (7.5% of body weight)?**
- **Yes / No**
- **Are there plans for fluids, medications, or equipment?**
- **Yes / No**
- **Has oxygen therapy been initiated?**
- **Yes / No**

## Before Skin Incision
- **Will everyone please state name and role?**
- **Yes / No**
- **What is the patient's name?**
- **Yes / No**
- **What is the procedure planned?**
- **Yes / No**
- **Where will the incision be made?**
- **Yes / No**
- **Has antiseptic, prophylactic, been given to the patient?**
- **Yes / No**
- **Are there any sedatives?**
- **Yes / No**
- **Is there any relative present?**
- **Yes / No**
- **Are there any concerns for blood loss?**
- **Yes / No**

## Before Patient Leaves Room
- **Nurse verbally confirmed with the patient:**
- **Yes / No**
- **How will the patient be sent to the recovery area?**
- **Yes / No**
- **Are the instruments, sponge, and needle counts complete?**
- **Yes / No**
- **Are there any concerns for recovery and management of the patient?**
- **Yes / No**

## Before Leaving Room Check Complete
- **Nurse verbally confirmed with the patient:**
- **Yes / No**
- **How will the patient be sent to the recovery area?**
- **Yes / No**
- **Are the instruments, sponge, and needle counts complete?**
- **Yes / No**
- **Are there any concerns for recovery and management of the patient?**
- **Yes / No**

## Anticipated Critical Events
- **Surgery completion:**
- **Yes / No**
- **Has the surgery been completed?**
- **Yes / No**
- **Are there any concerns for recovery and management of the patient?**
- **Yes / No**

## Special Equipment
- **Is all essential imaging displayed?**
- **Yes / No**
- **Are there any concerns for recovery and management of the patient?**
- **Yes / No**

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*World Health Organization*
Resources for Students and Professionals

- Institute for Healthcare Improvement (IHI)
  - Open school - online course modules
Any Questions?

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