L9
Enhance Safety and Reduce Cost by Improving Flow

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IHI Forum 2013

Disclosures

The speakers do not have any disclosures relevant to today’s session and discussion
Faculty

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  - President and CEO, Institute for Healthcare Optimization

Aims

The need to develop new ways to deliver health care has become more apparent with funding constraints and the failure of safety systems.

This session will demonstrate how to deliver safe and effective care in a cost-effective way.

Participants will learn why the application of operations management theory is the key to an affordable and safe health service.

The principles of the management of variability and queuing theory will be illustrated by case studies and participatory work.
Learning Objectives

After this session, participants will be able to:

- Explain the relationship between flow safety and cost
- Implement in a health care setting the principles of managing operations
- Describe the key challenges in redesigning the flow of patients to improve safety

Part 1
INTRODUCTION TO THE PROBLEM
The growing finance gap

Peter Lachman
Setting the Context

- Is the central problem in healthcare cost or quality?
- Does your organization need additional resources?
- Is your biggest problem deciding where to close services or how to improve quality …or both?
- Does managed care/capitation accompanied by reduced budget leads to poorer quality of care.
One-Quarter of Adults Reported a Gap in Coverage in 2011
More Than Half Were Uninsured for Two Years or More

Adults ages 19–64

Insured all year 74%
Uninsured during the year* 26%

* Combines “Insured now, time uninsured in past year” and “Uninsured now.”

Length of time uninsured

<3 months 12%
6–12 months 8%
1–2 years 12%
2 years+ 57%

Adults ages 19–64 uninsured during the year*

International Comparison of Spending on Health, 1980–2009

Average spending on health per capita ($US PPP)

Total expenditures on health as percent of GDP

Note: PPP = Purchasing power parity—an estimate of the exchange rate required to equalize the purchasing power of different currencies, given the prices of goods and services in the countries concerned.
Source: OECD Health Data 2011 (Nov 2011).
Hospital Spending per Discharge, 2009
Adjusted for Differences in Cost of Living

Dollars

* 2008.
** 2007.

Source: OECD Health Data 2011 (Nov. 2011).

Physician Incomes, 2008
Adjusted for Differences in Cost of Living

Dollars

Primary care doctors
Orthopedic physicians

**Outcome rankings**

Source: Calculated by The Commonwealth Fund based on 2007 International Health Policy Survey; 2008 International Health Policy Survey of Sicker Adults; 2009 International Health Policy Survey of Primary Care Physicians; Commonwealth Fund Commission on a High Performance Health System National Scorecard; and Organization for Economic Cooperation and Development, OECD Health Data, 2009 (Paris: OECD, Nov. 2009).

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**Mortality Amenable to Health Care**

Deaths per 100,000 population*

* Countries’ age-standardized death rates before age 75, including ischemic heart disease, diabetes, stroke, and bacterial infections. See Appendix B for list of all conditions considered amenable to health care in the analysis.

Data: E. Nolte, RAND Europe, and M. McKee, London School of Hygiene and Tropical Medicine analysis of World Health Organization mortality files and CDC mortality data for U.S. (Nolte and McKee, 2011).

Source: Commonwealth Fund National Scorecard on U.S. Health System Performance, 2011.
Spending more does not improve quality

CMS data:

Higher spending states have poorer quality


The NHS

£15-20bn productivity challenge

NHS expenditure by year

Illustrative figures only

demand, pay & price pressures
- scenario with “flat cash” from 2011/12
- actual and planned spend
Providers Will Find Increasing Pressures to Focus on Costs and Waste

Traditionally, healthcare providers have prospered without needing to focus on costs and waste...

...but several forces suggest that this will not continue

- Emphasis on revenue growth
- Little price transparency
- Less competitive than most industries
- Typically funded with insured dollars

- Cost inflation>incomes
- Increased out-of-pocket funding
- CMS initiatives focusing on efficiency and cost
- Threat of disruptive, lower cost entrants
- Better credit rating for high safety/high quality providers

The challenge to improve value

Can we look at ways of delivering health care at lower cost at the same time we increase quality and safety?
What is value?

Value should always be defined around the customer, and in a well-functioning health care system, the creation of value for patients should determine the rewards for all other actors in the system.

Since value depends on results, not inputs, value in health care is measured by the outcomes achieved, not the volume of services delivered, and shifting focus from volume to value is a central challenge.

Nor is value measured by the process of care used; process measurement and improvement are important tactics but are no substitutes for measuring outcomes and costs.
Innovation Advisors Program

The Innovation Center seeks to deepen the capacity for transformation by creating a network of experts in improving the delivery system for Medicare, Medicaid and CHIP beneficiaries.

The Innovation Advisors Program will inspire dedicated, skilled individuals in the health care system to deepen several key skill sets, including:

- Health care economics and finance;
- Population health;
- Systems analysis; and
- Operations research

Changing Patient Flow through the Parts of the System May Not Optimize Overall Patient Flow

- Can one reduce ED overcrowding just by improving patient flow through the ED?
- Can one improve ICU patient flow by increasing its size?
Reducing the Time of Patient Transfer…

… between two hospital units or the length of stay in the unit may not be right goal

- Do we really want to transfer patients from the ED to Med/Surg bed in one hour?

- Should we “fight” for reducing ICU length of stay?

High Census May Not be a Good Reason for Adding More Beds

- Midnight or midday census? The answer might be …“neither”

- Does the patient mix matter? Which patients mix?

- Does the size of your hospital/unit matter?

- What would you do when your waiting room is full?
Is Your Goal to Have a High Utilization of Your Resources?

- Is this a right goal?
  - What happens when your resources are highly utilized?
  - When utilization is high enough?

Can Your Hospital or Physician Office Reduce Overcrowding?

- Should this be your goal?
  - Do you want to attract more patients?
  - Would more patients reduce overcrowding and wait times?
What is the Right Goal for Patient Flow Improvement?

- Can Operations Management help you to achieve this goal?

- There is a right goal for patient flow improvement – patient throughput and access to care while improving or controlling quality of care!

The Central Health Care Problem:
Cost or Quality?
To Treat or To Save Money?
Operations Management: An Art or a Science

- Real life problems are not labeled
- Intuitive solutions are frequently wrong

Operations Management

- Complex scientific decisions in uncertain environment
Boundaries: Scientific Limitations, Intuition, and Politics

- Good theory or good results?
- To be right or to be helpful? (Mad bear story)
- What does a model? Simplification of reality or replacement of reality?
- A model for people or a model for robots?
- Unobtainable (?) data
- To be “good” or to be “lucky”?
- Problems unsolved and problems unsolvable

Operations Management

- Main Components
  - Optimization
  - Queuing Theory
  - Network Theory
  - Inventory Management
Part 3 – Table work
Why is Operations Management Theory Relevant to Health Care?

Jason Leitch

A case history - discuss in your groups

You are the duty manager on for the day at your hospital. What are the key issues that face you during the day to ensure there is a good flow and no delays?

10 minutes
Feedback

- How did you assess the problem?
- What data did you have?
- What solutions did you have?

10 minutes

Part 4
Introduction to Queuing

Eugene Litvak
Two Medical ICUs with the Same Patients Acuity

<table>
<thead>
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<td>Average LOS = 2.5 days</td>
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Do they have the same waiting times to be admitted to these units?

<table>
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<tr>
<th>1st ICU</th>
<th>2nd ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{T}_w = 0.13$ days</td>
<td>$\bar{T}_w = 0.012$ days</td>
</tr>
</tbody>
</table>
How Many Beds/Nurses/Exam Rooms Do You Need?

Suppose you are coming to a bank…
Service Mechanism

- Single Server
  00000

- Multiple Servers
  - Serial Servers
  - Parallel Servers

Types of Service

- Queues with waiting
- Queues with rejections
Service Discipline

- First come, first served
- Last come, first served
- Random
- Priorities

Service Time

- Constant service time
- Exponential service time
- Non-stationary service time
- Correlated service time (peak, off-peak hours)
Arrival Patterns

- Regular arrivals with unpunctuality
  - Request $n$ arrivals at the time $(t_n + \varepsilon_n)$
- Aggregated (group) arrivals
- Discrete-time arrivals $(t_1, t_2, \ldots, t_k)$
- Non-stationary arrivals (peak, off-peak arrivals)
- Correlated arrivals (length of the queue)
- Arrivals in a continuous flow (gas)

Main Characteristics

1. Queues with rejections
   - Absolute throughput – the average number of requests served during one time unit
   - Relative throughput – the ratio between the average numbers of requests served and arrived during one time unit
   - Average number of occupied service units
   - Average number of free service units
   - Probability of rejection
Main Characteristics

2. Queues with waiting
   - Average length of queue – the average number of requests waiting for service
   - Average number of requests in the system – the average total number of request being served and waiting for service
   - Average request’s waiting time
   - Average request’s time in the system – the average total time service and waiting time for a request

Notations and Parameters

- $S$ - Number of servers

- $\lambda$ - Average number of arrivals per unit of time, $\lambda = 1/t_a$ ($t_a$ – average interarrival time interval)

- $\mu$ - Average number of request served per unit of time, $\mu = 1/t_s$ ($t_s$ – average service time interval)

- $\rho = \lambda/\mu$

- $\bar{U} = p/ S$ – average system’s utilization rate

- $p_n$ – The probability of the system to be in the state $n$ when $n$ requests “arrive” to the system:
Queues with Waiting (Parallel Servers)

Queue with Random Arrivals and Exponential Service Time (M/M/S)

Notations and Parameters

- No requests \( n = 0 \)
  \[
p_0 = [1 + \rho/1! + \rho^2/2! + \ldots + \rho^{(S-1)}/(S - 1)! + \rho^S/S!(1 + \rho/S)]
\]
- No queue \( 0 \leq n \leq S \)
  \[
p_n = p_0\rho^n/n!
\]
- Queue \( n > S \)
  \[
p_n = p_0\rho^n/S!S^{(n-S)}
\]
Main Characteristics

- Probability $P(S_s)$ that all the servers are serving requests can be computed by the following formula:
  $$P(S_s) = \rho^S \cdot S \cdot p_0/S! \cdot (S - \rho)$$

- The average number ($\bar{R}_l$) of requests in line can be computed by the following formula:
  $$\bar{R}_l = P(S_s) \cdot \rho/(S - \rho) = [\rho^{(S+1)} \cdot S \cdot p_0]/[S!(S - \rho)^2]$$

- The average number ($\bar{R}_s$) of requests in service is equal to: $\bar{R}_s = \rho$

- The average number ($\bar{R}$) of requests in system can be computed by the following formula:
  $$\bar{R} = \bar{R}_l + \bar{R}_s$$

- The average waiting time ($\bar{T}_w$) for a request can be computed by the following formula:
  $$\bar{T}_w = \bar{R}/\lambda$$

- The average system time ($\bar{T}$) for a request can be computed by the following formula:
  $$\bar{T} = (\bar{R}_l + \bar{R}_s)/\lambda$$
Applying Queuing Theory: Examples

1. Triage
2. Two ICUs
Example: Triage on Monday

On Monday morning at 8am, there are 2 triage nurses on duty. They can each serve one patient every 3 minutes. The Monday morning arrival rate is 20.8 patients/hour.

What is the waiting time?

- The average patient waiting time ($\bar{T}_w$) can be computed by the following formula:
  - $\bar{T}_w = \bar{R}/\lambda$
- The average number ($\bar{R}$) of patients in line can be computed by the following formula:
  - $\bar{R} = P(S_s) \cdot \rho/(S-\rho)$
  - Probability $P(S_s)$ that all $S$ “servers” are busy:
  - $P(S_s) = \rho^S \cdot S \cdot p_s/S! \cdot (S-\rho)$ (Table)
\[ \lambda, \mu, S \]

\[ \lambda = 20.8, \mu = \frac{1}{3} \text{min} = 20, S = 2 \]

\[ \rho = \frac{\lambda}{\mu} = 1.04 \]

\[ P(Ss) \text{ (table)} \approx 0.33 \]

\[ \hat{R}_i = P(Ss) \cdot \rho / (S - \rho) = 0.33 \cdot 1.04 / (2 - 1.04) \approx 0.36 \]

\[ \hat{T}_w = \frac{\hat{R}_i}{\lambda} = 0.36 / 20.8 = 0.017 \text{ h} = 1.04 \text{ min} \]

**Example: Triage on Friday**

- On Fridays at 4 PM, the arrival rate is about 10.3 patients/hour. There is one triage nurse at this time, who can serve one patient every 3 minutes.
- What is the waiting time?
\[
\lambda, \mu, S
\]
\[
\lambda = 10.3, \mu = 1/3\text{min} = 20, S = 1
\]
\[
\rho = \lambda/\mu = 0.52
\]
\[
P(Ss) \text{ (table)} \approx 0.52
\]
\[
\tilde{R}_l = P(Ss) \cdot \rho/(S-\rho) = 0.52 \cdot 0.52/(1 - 0.52) \approx 0.56
\]
\[
\tilde{T}_w = \tilde{R}_l/\lambda = 0.56/10.3 = 0.054 \text{ h} = 3.28 \text{ min}
\]

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Two Medical ICUs with the Same Patients Acuity

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**Do they have the same waiting times to be admitted to these units?**
1\textsuperscript{st} ICU

\[\lambda, \mu, S\]
\[\lambda = 1, \mu = \frac{1}{2.5} = 0.4, S = 5\]
\[\rho = \frac{\lambda}{\mu} = 2.5\]
\[P(Ss) \text{ (table)} \approx 0.13\]
\[\bar{R}_i = P(Ss) \cdot \rho / (S - \rho) = 0.13 \cdot 2.5 / (5 - 2.5) \approx 0.13\]
\[\bar{T}_w = \bar{R}_i / \lambda = 0.13 / 1 = 0.13 \text{ days}\]

2\textsuperscript{nd} ICU

\[\lambda, \mu, S\]
\[\lambda = 2, \mu = \frac{1}{2.5} = 0.4, S = 10\]
\[\rho = \frac{\lambda}{\mu} = 5\]
\[P(Ss) \text{ (table)} \approx 0.036\]
\[\bar{R}_i = P(Ss) \cdot \rho / (S - \rho) = 0.036 \cdot 2.5 / (10 - 2.5) \approx 0.036\]
\[\bar{T}_w = \bar{R}_i / \lambda = 0.036 / 2 = 0.018 \text{ days}\]
Part 5
Introduction of Variability Concept and Methodology

Eugene Litvak
Institute for Healthcare Optimization
Building a safe and efficient health care delivery without managing patient flow: Phase I

Building a safe and efficient health care delivery without managing patient flow: Phase II
“Hospitals have direct control over operational efficiency, and have a number of variables within their control. They include such factors as impatient bed capacity, ancillary service delays, the scheduling of services and support staff…”

“4.1 Hospital chief executive officers should adopt enterprise-wide operations management and related strategies to improve the quality and efficiency of emergency care.”

Quotes from the 2006 IOM report *The Future of Emergency Care in the U.S. Health System (Hospital-Based Emergency Care: At the Breaking Point)*
“4.3 Training in operations management and related approaches should be promoted by professional associations; accrediting organizations, such as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and the National Committee for Quality Assurance (NCQA)…”

Quotes from the 2006 IOM report
*The Future of Emergency Care in the U.S. Health System
(Hospital-Based Emergency Care: At the Breaking Point)*

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**Gaps cited by the Institute of Medicine in Crossing the Quality Chasm (2001)**

- Ineffectiveness of care
- Lack of efficiency in delivery system
- Inadequate safety
- Insufficient patient-centerness
- Inadequate timeliness of care
Major health care delivery problems

- Patient Safety
- Nurse understaffing/overloading
- ED diversions/access to care
- High cost
- Hospital resources needed for bioterrorism preparedness

*Addressing variability is necessary, although not sufficient, to satisfactorily resolve these problems.*

Variability, Quality of Care, Safety and Economy

*The New England Journal of Medicine*

**Perspective**
Smoothing the Way to High Quality, Safety, and Economy,
October 24, 2013 | E. Litvak and H.V. Fineberg

“A reliable health system is one that functions properly in difficult and unanticipated circumstances as well as in normal or easy ones — indeed, difficult and unanticipated circumstances are par for the course in health care. Among the most common such conditions are periods of excess patient load that can overwhelm even the most conscientious physician or nurse and impair the quality of care.”
How does an unsmooth census looks like?
(no holidays, no weekends, weekdays only)

How did we staff, and how do we staff?
Systemic Effects of Peak Loads

- Internal Divert – Patients sent to alternative floors\Intensive Care locations
- Internal Delays – PACU backs up
- External Divert - ED divert
- Staff overload – medical errors and inability to retain staff
- System Gridlock – Increase in LOS
- Decreased throughput and revenue

Controlling the total cost, without knowing cost of delivery, decreases quality.

Take-out Pizza Example


- “By applying variability methodology, queuing theory and the I/T/O model, hospitals can identify and eliminate many of the patient flow impediments caused by operational inefficiencies”

- “By smoothing the inherent peaks-and-valleys of patient flow, and eliminating the artificial variabilities, that unnecessarily impair patient flow, hospitals can improve patient safety and quality while simultaneously reducing hospital waste and cost”

Quotes from the 2006 IOM report
The Future of Emergency Care in the U.S. Health System
(Hospital-Based Emergency Care: At the Breaking Point)
The Ideal Healthcare System

(100% efficiency)

1. All patients have the same disease with the same severity.
2. All patients arrive at the same rate.
3. All providers (physicians, nurses) are equal in their ability to provide quality care.

Can your health care delivery system become a Toyota product line?
1. Clinical Variability
2. Flow Variability
3. Professional Variability

- Random
- Can not be eliminated (or even reduced)
- Must be optimally managed

Designing and Testing Complex Mechanical Systems: The Family Car

- Hitting a pothole vs. high speed impact against the wall
- Health care “financial bumper”

Are the stresses an intrinsic part of health care delivery?
What makes hospital census variable?

- If ED cases are 50% of admissions
  and...
- Elective-scheduled OR cases are 35% of admissions
  then...
- Which would you expect to be the largest source of census variability?
The answer is...

The ED and Elective-Scheduled OR have approximately equal effects on census variability.

Why?
Because of another (hidden) type of variability...

Artificial Variability

- Non-random
- Non-predictable (driven by unknown individual priorities)
- Should not be managed, must be identified and eliminated
Why managing variability today is more important than before?

Does the healthcare system need more capacity?
At what cost?

Typical cost of new capacity

- Inpatient beds - $1M in capital and $250K-800K annual operating expense
- Operating rooms - $2 – 7 Million, $250K+ annual operating expense
- Major imaging (CT, MRI, PET/CT, etc.) – approx. $1M+
- Cardiac Catheterization Lab – approx. $2M

Nursing and other provider shortages?

Is this about access to care?
Variability and access to care

ED → ICU → Scheduled demand

Floors

Alternative to Managing Variability!
Can you solve your ED, ICU or Med/Surg units overcrowding without smoothing elective admissions?

Can you match your capacity and demand without throwing excessive resources at the system by other means without smoothing elective admissions?

After elective patient flow is smoothed (and only then!) the right size of the hospital units could be determined for both scheduled and unscheduled admissions.
Do you always place every patient into the appropriate bed? What happens if you do not?

How important is to know the right size of the unit?

Rapid Response Team

Does the Rapid Response Team help at your hospital?

Why?

Variability and health care-associated infection

“There was a significant association between patient-to-nurse ratio and urinary tract infection (0.86; P <.02) and surgical site infection (0.93; P <.04). In a multivariate model controlling for patient severity and nurse and hospital characteristics, only nurse burnout remained significantly associated with urinary tract infection (0.82; P <.03) and surgical site infection (1.56; P <.01) infection. Hospitals in which burnout was reduced by 30% had a total of 6,239 fewer infections, for an annual cost saving of up to $68 million.”

Variability and Readmissions

Does variability affect readmission rate?

“The main outcome variable is unplanned patient
readmission to the neurosciences critical care unit within 72
hrs of discharge to a lower level of care. The odds of one or
more discharges becoming an unplanned readmission
within 72 hrs were nearly two and a half times higher on
days when ≥9 patients were admitted to the neurosciences
critical care unit …” *)

“The odds of readmission were nearly five times higher on
days when ≥10 patients were admitted …” *)

*) Baker, David R. DrPH, MBA; Pronovost, Peter J. MD, PhD; Morlock, Laura L.
PhD, et al. Patient flow variability and unplanned readmissions to an intensive
care unit.  
Critical Care Medicine: November 2009 - Volume 37 - Issue 11 - pp 2882-2887

Is this about nurse staffing as well?

Can you provide an adequate nurse staffing
without smoothing elective admissions?
Impact of Census Variability on Patients per Nurse Ratio


Variability and Quality of Care*

- Inadequate numbers of nursing staff contribute to 24% of all sentinel events in hospitals. Inadequate orientation and in-service education of nursing staff are additional contributing factors in over 70% of sentinel events*

- “…higher numbers of nurse hours per patient, larger proportions of RNs and high levels of competition with other hospitals were all correlated with higher levels of NQF Safe Practices adoption.”**

* Dennis S. O’Leary - former president of JCAHO (personal communication)

Variability and mortality


http://www.ihi.org/NR/rdonlyres/E18D05FD-F4E5-448D-8CBE-217CB5C03B7C/0/ManagingUnnecessaryVariabilityinPatientDemand.pdf

“Each additional patient per nurse was associated with a 7% increase in the likelihood of dying within 30 days of admission and a 7% increase in the odds of failure-to-rescue”*


Example:

Assumptions:
- 200 surgical beds
- average census for surgical beds 160
- staffing level 40 nurses (1 nurse per 4 patients)
- average residual from 160 patients census is 20% or 32 patients
- patients are distributed evenly between the nurses

How the mortality rate will change with 20% increase in surgical demand?
Results:

- 32 additional patients will be distributed evenly between 32 nurses: 1 additional patient per nurse or $4 + 1 = 5$ patient per nurse
- these 32 nurses now will take care of 160 patients, whose mortality rate increases by 7%
- if these additional 32 patients will be distributed evenly between 16 nurses, then each such nurse will take care of $4 + 2 = 6$ patients
- these 16 nurses now will take care of 96 patients, whose mortality rate increases by 14%

Patient Mortality and Patient Flow

“There was a significant association between increased mortality and increased exposure to unit shifts during which staffing by RNs was 8 hours or more below the target level “

“The association between increased mortality and high patient turnover was also significant “

What is easier: to talk to your colleagues or to the lawyers?!


http://www.healthleadersmedia.com/content/LED-269595/PDH-Understaffing-a-Possible-Factor-in-Deaths-at-CRMC##

Five ways of staffing

Nursing August 2011

http://journals.lww.com/nursing/Fulltext/2011/08000/Nurse_staffing,_hospital_operations,_care_quality..1.asp
Physician Workload & Quality of Care

Impact of Attending Physician Workload on Patient Care: A Survey of Hospitalists
Michtalk H, Yeh HS, Peter J. Pronovost, MD, Ph.D.
JAMA Intern Med. 2013, Published online January 28, 2013

“Forty percent of hospitalists reported unsafe workloads at least monthly. Nearly one-quarter of hospitalists reported that excess workload adversely impacted patient outcomes by preventing full discussion of treatment options and worsening patient satisfaction. Twenty-two percent of physicians reported ordering potentially unnecessary tests, procedures, or consults because of not having adequate time to evaluate patients in person. Given the large number of patients cared for by hospitalists, the frequency with which workload exceeds safe levels, and the perceived impact of workload on patient outcomes, hospital administrators, researchers, and policymakers should focus attention on attending physician workload”.

Quality and Safety Corner at www.ihoptimize.org

The Institute for Healthcare Optimization’s approach to managing variability in healthcare delivery addresses some of the most intractable quality and safety issues such as readmissions, mortality, infections, ED boarding and others. Learn more »
Part 6
Applications to the health care problems
Applying theory to the front line

Eugene Litvak
Jason Leitch
Peter Lachman

How do you do this

Questions that you may have:

- Why are we doing this project?
- Why will this project succeed?
- What exactly are we going to do?
- How much additional work is this going to mean for me?
- How will we ensure this project doesn’t do damage to what currently works?
Why do this project?

- Bumped or delayed elective surgery cases
- Delays in securing OR access for urgent and emergent cases (transplantations)
- Overburdened nurses, medical errors, high overtime, excessive nurse vacancies
- Lack of timely access to nursing units
- Prevent ED overcrowding and boarding
- Improve patient, provider and staff satisfaction

"By smoothing the inherent peaks and valleys in patient flow, and eliminating the artificial variabilities that unnecessarily impair patient flow, hospitals can improve patient safety and quality while simultaneously reducing hospital waste and cost.” Institute of Medicine, June 2006

JCAHO's Patient Flow Leadership Standard: "LD.3.15 The leaders develop and implement plans to identify and mitigate impediments to efficient patient flow throughout the hospital.”

Expertise Necessary for Success

The key pillars of expertise that drive success in an OR redesign project are:

- Application of operations management to healthcare
- Clinical expertise
- Hospital management expertise
- Project management and data analysis experience
IHO Approach to OR Design and Patient Flow Improvement

Phase I
Separation of OR Flows

Phase II
Smoothing of Elective Flows

Phase III
Determination of Bed and Staffing needs

Project Overview

Phase I
Separation of OR Flows

Goals
- To assess the extent of artificial patient volume variability and patient flow bottlenecks in key areas of the hospital, and their ripple effects on quality and cost of care
- To separate flows of scheduled (elective) patients from that of unscheduled (emergent/urgent) and work-in patients through the OR

Expected Benefits
- Increase in surgical capacity / volume (Note: there will be absolutely no decrease in any individual surgeon’s volume as a result of this project)
- Decrease in patient wait times for emergent and urgent surgeries
- Decrease in OR overtime
- Increase in staff and patient satisfaction
**Expected Results**

**Phase I**
Separation of Scheduled v. Unscheduled OR Flow

- **Expected Benefits**
  - Increase in surgical capacity / volume (Note: there will be no decrease in any individual surgeon’s volume as a result of this project)
  - Decrease in patient wait times for emergent and urgent surgeries
  - Decrease in OR overtime
  - Increase in staff and patient satisfaction

**Phases II and IIb**
OR and Cath Lab Smoothing

- **Expected Benefits**
  - Further increases in capacity / throughput
  - Enhanced patient placement in preferred beds
  - Decrease in nursing stress
  - Decrease in mortality and medical errors related to delays and patient misplacement
  - Increase in transplantations volume
  - Prevention of ED overcrowding

**Phase III**
Determination of Bed and Staffing needs

- **Expected Benefits**
  - Further decreases in patient wait times where they exist
  - Further enhancement of patient placement
  - Decrease in staffing expense
  - Enhanced utilization of existing resources
  - Accurate determination of capacity growth need (Additional Med/Surg bed requires ≈ $1 million in capital cost + over $.25 million annual operational cost)

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**Cincinnati Children’s Hospital Medical Center**

- **Weekend waiting times:**
  Despite a 37% increase in the case volume in July-August as compared to January-March the waiting times for unscheduled procedures has been reduced by 34%.

- **Weekday waiting times:**
  Despite a 24% increase in the case volume during September-early October, as compared to January-March, the waiting times for unscheduled procedures has been reduced by 28%.
Case Study: Cincinnati Children’s

- Weekend waiting time (for urgent/emergent surgeries) down 34% despite 37% volume increase, Weekday waiting time down 28% despite 24% volume increase (results for the first three months after implementation)
- Surgery volume has sustained 7% growth per year for the last two years
- Initially an equivalent of 1 OR capacity freed up
- OR overtime down by 57% (approx. $559K saved annually)
- Inpatient occupancy increased from 76% to 91% resulting in $137 million/year plus 100 new beds avoided capital cost (over $100 million)
- Substantially improved provider satisfaction

Source: Frederic Ryckman, MD, Cincinnati Children’s Hospital Medical Center

Case Study: Cincinnati Children’s Survey

- “We have not had anywhere near the patient complaints or physician complaints. Physician and Family satisfaction has skyrocketed…” - Orthopedic Surgeon, Division Director
- “The family satisfaction with their experience is better than it used to be.” – ENT Surgeon, Attending
- “As a general observation, nursing staff ‘on call’ are not staying as late due to add-ons remaining at change of shift.” - OR Nurse
- “…We get our case done early, and patients don’t have to wait NPO until the evenings to have their surgery. This has made call much less stressful for my surgeons and myself…” - Orthopedic Surgeon, Division Director
Case Study: Boston Medical Center

- Surgical throughput up 10%
- Bumped surgeries down 99.5%
- Reduced nurse stress; 1/2 hour reduction (6%) in nurse hours per patient day in one unit ($130,000 annual saving)
- ED waiting time down 33%
- 2.8 hour wait in one of state’s busiest EDs vs. 4 to 5+ hours for most of the academic hospitals in Boston

Source: John Chessare, MD, then Chief Medical Officer at Boston Medical Center

Case Study: Palmetto Health Richland

- Waiting time for urgent / emergent surgical cases decreased 38% while overall surgical volume grew about 3%
- Annual margin growth opportunity of $8M per year, $2.5M of which has been realized
- Results achieved in less than 1 year

Source: Ellis Knight, MD, MBA, then Chief Medical Officer at Palmetto Health Richland, now Sr. VP for Ambulatory Services for the Palmetto Health System
**Case Study: Mayo Clinic (Fl)**

### CHANGES IN OPERATIONAL PERFORMANCE OF OPERATING ROOMS

<table>
<thead>
<tr>
<th>Change</th>
<th>Pre-Re-Design</th>
<th>Post-Re-Design</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical Cases (count)</td>
<td>11,874</td>
<td>12,367</td>
<td>4%</td>
</tr>
<tr>
<td>Surgical Minutes</td>
<td>1,757,008</td>
<td>1,844,479</td>
<td>5%</td>
</tr>
<tr>
<td>Prime Time OR Utilization</td>
<td>61%</td>
<td>64%</td>
<td>5%</td>
</tr>
<tr>
<td>Number of Overtime FTE’s (average)</td>
<td>7.4</td>
<td>5.4</td>
<td>-27%</td>
</tr>
<tr>
<td>Staff Turnover Rate</td>
<td>20.3%</td>
<td>11.5%</td>
<td>-43%</td>
</tr>
<tr>
<td>Daily Elective Room Changes (Average/Mon)</td>
<td>80</td>
<td>25</td>
<td>-69%</td>
</tr>
<tr>
<td>Daily Elective Room Changes (%)</td>
<td>8%</td>
<td>2%</td>
<td>-70%</td>
</tr>
<tr>
<td>Cost/Case (added 15 OR Staff FTEs)</td>
<td>$1,062</td>
<td>$1,070</td>
<td>0%</td>
</tr>
<tr>
<td>Cost/Minute of Surgery (added 15 OR Staff FTEs)</td>
<td>$7.18</td>
<td>$7.26</td>
<td>1%</td>
</tr>
<tr>
<td>Staff Turnover Cost (millions)</td>
<td>$2.47</td>
<td>$1.40</td>
<td>-43%</td>
</tr>
<tr>
<td>Overtime Cost Savings</td>
<td></td>
<td>$111,488</td>
<td></td>
</tr>
<tr>
<td>Total OR Net Revenue (fee increase adjusted)</td>
<td>$93,929,569</td>
<td>$98,686,693</td>
<td>5%</td>
</tr>
<tr>
<td>Net Operating Income</td>
<td>$15,877,986</td>
<td>$21,957,708</td>
<td>38%</td>
</tr>
<tr>
<td>Operating margin</td>
<td>17%</td>
<td>22%</td>
<td>28%</td>
</tr>
</tbody>
</table>


**Case Study: Johns Hopkins Hospital**

### Relative to Assessment (Mar-Jun 2010) vs. Relative to Pre-Implementation (Sep-Nov 2011)

<table>
<thead>
<tr>
<th></th>
<th>Relative to Assessment (Mar-Jun 2010)</th>
<th>Relative to Pre-Implementation (Sep-Nov 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous Cases/ NHW</td>
<td>87</td>
<td>89</td>
</tr>
<tr>
<td>Current Cases/ NHW</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td>Incremental Cases/ NHW</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Incremental Margin/ Year*</td>
<td>$6,350,000</td>
<td>$3,810,000</td>
</tr>
</tbody>
</table>

*Assumes $5,000 margin per case x 254 Non-Holiday Weekdays per Year

Source: Dr. Jackie Martin, Medical Director of Perioperative Services for the Johns Hopkins Hospital; Professor, Anesthesiology and Critical Care Medicine
Elliot Hospital (Maternity ward)

- Eliminated morning chaos
- Reduced the demand for additional staffed beds by 6 positions (50%)
- Improved quality of care

IHO State-wide collaborative to improve patient safety and quality of care while reducing its cost

**Partnership for Patients - New Jersey**

News

On January 30, NJHA in collaboration with The Institute for Healthcare Optimization kicked off Partnership for Patients-NJ, part of a national initiative from the U.S. Department of Health and Human Services to improve the quality, safety and affordability of healthcare. [Learn more](#)

**Patient Flow/Throughput**

The New Jersey Hospital Association has provided IHO Variability Methodology™ to NJ hospitals to help them improve patient safety and flow/throughput. Some of these resources and the list of the NJ Patient Flow Collaborative Members have been publicly disseminated, [Learn more](#)

U.S. Senator Robert Menendez (Senate Finance Committee) at the Partnership for Patients New Jersey kick-off on January 30, 2012
IHO State-wide collaborative to improve patient safety and quality of care while reducing its cost

- "The following results were achieved in a 15-month collaborative between our hospitals and the Boston-based Institute for Healthcare Optimization.
- The results show great promise for both improving patient care and reducing long-term healthcare costs. Data from our 14 participating hospitals showed projected summary results of:
  - 11,800 to 17,300 additional patients that could be treated without adding inpatient beds or operating rooms
  - Roughly 20,000 additional patients that could be accommodated in hospital emergency departments
  - 21 percent to 85 percent decrease in wait times for emergency department patients to be admitted to a hospital bed
  - Reductions in the length of hospital stays ranging from 3 percent to 47 percent for certain groups of patients."

*New Jersey Hospital Association

Three alternatives:

- Provide the resources (e.g., staffing) sufficient to meet current patient peaks in demand - historical scenario
- Staff below the peaks and tolerate ED diversions, nursing overloading and medical errors - current scenario
- **Smooth artificial variability and provide the resources to meet patient (vs. schedule) driven peaks in demand. Variability methodology can quantify and justify such additional resources**
What would be national return on investment from applying these concepts?


---

**OECD Acute Care Bed Occupancy**

**Acute Care Bed Occupancy 2009**

<table>
<thead>
<tr>
<th>Country</th>
<th>2009 Bed Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>90%</td>
</tr>
<tr>
<td>Norway</td>
<td>88%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>86%</td>
</tr>
<tr>
<td>Ireland</td>
<td>86%</td>
</tr>
<tr>
<td>UK</td>
<td>84%</td>
</tr>
<tr>
<td>Japan</td>
<td>70%</td>
</tr>
<tr>
<td>Austria</td>
<td>79%</td>
</tr>
<tr>
<td>Spain</td>
<td>79%</td>
</tr>
<tr>
<td>Germany</td>
<td>76%</td>
</tr>
<tr>
<td>Italy</td>
<td>76%</td>
</tr>
<tr>
<td>France</td>
<td>76%</td>
</tr>
<tr>
<td>U.S.</td>
<td>67%</td>
</tr>
</tbody>
</table>
US hospitals are 1/3 empty and overcrowded!!!

National Opportunity – An Example

- Based on AHA 2010 data, overall nationwide hospital inpatient occupancy was about 66%
- Even if one were to assume that all admissions are urgent in nature (statistically random arrivals), 80% occupancy should be achievable (based on queuing methodology) without compromising access or quality of care¹
- Potential savings of tens of billions of dollars annually²

¹ From Front Office to Front Line- Joint Commission Resources, chapter 4: Optimizing Patient Flow by Managing its Variability


National Opportunity – An Example

“Early hospital adopters such as Cincinnati Children’s Hospital (CCH) have been able to increase hospital throughput capability by more than 15%¹. If the experience of early hospital adopters proves generalizable, it will reduce U.S. hospital cost per admission by ~15 percent. Since hospitalizations, including outpatient procedures, consume over 30 percent of U.S. healthcare spending, this single improvement would reduce the cost of U.S. health insurance by roughly 4-5 percent if hospitals pass savings through to insurers and insurers, in turn, to insurance buyers. It is also likely to reduce hospital mortality by sparing hospital nursing units preventable bulges in the number of new patients they must admit in a single day.” ²

These 4%-5% mean over $1 trillion in 10 years.

¹ http://www.ihi.org/IHI/Files/WIHI/WIHI_20091202_Patient_Flow.mp3

² E. Litvak, A. Milstein, M. Smith. “Engineering Science And Episode-Based Hospital Payment”

Variability Methodology® Endorsements

- **Institute of Medicine ED report**: The Institute of Medicine has embraced Variability Methodology’s role in addressing the problem of ED overcrowding in its 2006 report.

- **American Hospital Association’s Hospitals in Pursuit of Excellence**: The Institute for Healthcare Optimization’s approach is recognized by the American Hospital Association as a key principle for achieving IOM’s Six Aims for Improvement: care that is safe, timely, effective, efficient, equitable, and patient-centered.


- **Government Accountability Office**: The Government Accountability Office recognizes variability in elective admissions as one of the key drivers of ED overcrowding (see page 23).
Recent quote

“...rely on systems engineering and operations research to smooth the flow of patients through the health care system. Backups in emergency rooms, periodic crowding in hospitals, and the lack of specialty postoperative beds are often symptoms of uneven scheduling of admissions, suboptimal scheduling of operating rooms, and inadequate discharge planning. Hospitals that apply systems engineering to scheduling and resource use can save many millions of dollars individually and billions in the aggregate, reduce overcrowding, and improve staff satisfaction and performance. Organizations such as the Institute for Healthcare Optimization are showing the way.”


Variability, Quality of Care, Safety and Economy

The New England Journal of Medicine

**Perspective**
Smoothing the Way to High Quality, Safety, and Economy, October 24, 2013 | E. Litvak and H.V. Fineberg

“Direct and indirect savings from smoother patient flow could give Medicare a new lease on life, underwrite biomedical research, reduce the national debt, support schools, and serve many other private and public purposes. At the same time, properly managed patient flow can reduce medical errors and enhance the quality of care. We owe these improvements to our patients, to the health care community, and to the next generation.”

Mortality, Readmissions, Medical Errors, High Cost vs. Health Care “Culture”: What Will Prevail?

You decide!
The systems approach to flow at GOSH

Great Ormond Street

- Analysed our data to see variability
- Then developed programmes to implement change
- The following data is from one of the workstreams
Great Ormond Street

- Tertiary and quaternary hospital
- No Emergency Room
- However variability is still a problem
- How do we deal with this
  - Analysis of data
  - Understand the problem
  - Develop the model for system wide change

Where is the problem?

- Inpatient beds
- Diagnostic procedures
- Operating room
- Outpatients
ANALYSIS 2008

Program for Management of Variability in Health Care Delivery. Boston University Health Policy Institute

GOSH Admissions By Date

Program for Management of Variability in Health Care Delivery. Boston University Health Policy Institute
Admissions By Urgency and Date

Elective Inpatient Admissions by Use of Theatres
Non-holiday Weekdays
Inpatient vs. Day Case Admissions: Non-holiday Weekdays Only

Theatre Cases by Date: Non-holiday Weekdays Only
Summary

- While day case patients comprise majority of admissions, true inpatients have most impact

- Substantial variability in elective admissions
  - Theatre cases comprise large majority

- Wasted bed & theatre capacity

- Improved scheduling of elective admissions, especially theatre cases, needed
# Recommendations to GOSH

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central management of admissions</td>
<td>Yes ...starting</td>
</tr>
<tr>
<td>Establishment of a central ‘patient flow team’</td>
<td>Yes</td>
</tr>
<tr>
<td>Central management of operationally-relevant information systems</td>
<td>Yes</td>
</tr>
<tr>
<td>Improve collection and reporting of flow data</td>
<td>Yes</td>
</tr>
<tr>
<td>Separate emergency and elective beds</td>
<td>No</td>
</tr>
<tr>
<td>Separate resources for day case and inpatients</td>
<td>+/-</td>
</tr>
<tr>
<td>Determine best management strategies for ‘high utiliser’ patients</td>
<td>+/-</td>
</tr>
<tr>
<td>Reconfigure wards into larger units</td>
<td>+/-</td>
</tr>
</tbody>
</table>

## GOSH WORK 2009 -2010

CARDIO RESPIRATORY
Cardiac VFM Pilot: Weekly Theatre Throughput and Critical Flow Failures

Increasing NHS + IPP throughput

Decreasing critical flow failures (cancellations, emergency refusals and nursing shifts lost to sickness)

New solution go live

PDCA: flow management taken on by operational manager

Reduced variability process more predictable

High variability process unpredictable

Copyright Great Ormond Street
Cardiac VFM Pilot: Weekly Theatre Throughput and Critical Flow Failures

- New solution go live
- PDSA: flow management taken on by operational manager
- Increasing NHS X IP through put
- Reduced variability - process failures better managed
- Decreasing critical flow failures (cancellation and emergency refusal)

Weekly theatre throughput
Weekly theatre critical flow failures
Linear (Weekly theatre throughput)

Date

Copyright Great Ormond Street

Theatre Cancellations

The percentage of cancelled cardiac theatre cases

The percentage of cardiac theatre cases cancelled each week that were not performed on the day, or on the day after the initial cancellation.

Pre go-live average 13%
Target 10%
Current 6.3%
### Emergency Booking Summary (VCB only)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Total</th>
<th>Hit Target</th>
<th>Missing Booking Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency A ≤ 30 Minutes</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Emergency B ≤ 2 Hours</td>
<td>8</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Emergency C ≤ 4 Hours</td>
<td>20</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Emergency D ≤ 8 Hours</td>
<td>9</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Emergency E ≤ 24 Hours</td>
<td>17</td>
<td>13</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average Wait (mins)</th>
<th>Percent Hit Target</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>100.0%</td>
<td>30</td>
</tr>
<tr>
<td>565</td>
<td>62.5%</td>
<td>120</td>
</tr>
<tr>
<td>339</td>
<td>50.0%</td>
<td>240</td>
</tr>
<tr>
<td>713</td>
<td>66.7%</td>
<td>480</td>
</tr>
<tr>
<td>870</td>
<td>76.5%</td>
<td>1440</td>
</tr>
</tbody>
</table>

#### Emergency C ≤ 4 Hours

![Chart showing Emergency C ≤ 4 Hours](chart1)

#### Emergency theatre cases for VCB theatres - past month

**Emergency D ≤ 8 Hours**

![Chart showing Emergency D ≤ 8 Hours](chart2)
Utilisation

U4 (H4/H1) - End utilisation of original planned theatre hours: All Main Theatres, ENT

% patient operations hours utilised (UK)

Week start date

U4 (H4/H1) - End utilisation of original planned theatre hours: All Main Theatres, Cleft

% patient operations hours utilised (UK)

Week start date
Increase in operations

Decrease in lost time
And to late finishes

Decease in cancellations
Decrease cancellations

The future

- Good foundation to address underlying variation
- Good data set available
- Now looking at case by case variation
Patients:
• Reduced waiting time and improved access to care
• Reduced mortality and medical errors

Nurses:
• Reduced overtime
• Reduced workload

Conclusion- What is here for me?

Physicians:
• Reduced waste of time
• Increased patient throughput
• Reduced overtime

Hospital:
• Better utilization of resources
• Reduced hours of ED overcrowding
• Staff and patient satisfaction
• More staffing resources: better tolerating peak loads
• Reduced mortality and medical errors
• Reduced length of stay
• Increased hospital throughput and revenue
Readings


http://www.ihoptimize.org
http://www.ihoptimize.org/knowledge-center-publications.htm

WWW.IHOPTIMIZE.ORG

Quality and Safety Corner

The Institute for Healthcare Optimization’s approach to managing variability in healthcare delivery addresses some of the most intractable quality and safety issues such as readmissions, ED boarding and others. Learn more »

Healthcare Cost Corner

Hospital costs can be decreased by millions of dollars annually by adopting the Institute for Healthcare Optimization’s approach to managing variability in healthcare delivery. Learn more »

A Case Study

How one hospital increased annual revenue by $137M, and avoided $100M in cost, while improving quality of care Learn more »

ROI Estimator

Estimate your hospital's ROI. Read More »
Some helpful links:

http://www.rwjf.org/pr/product.jsp?id=50488

Summary

- **Scientific** managing variability in patient flow is absolutely necessary to increase overall hospital patient throughput while improving quality of care, patient safety and reducing nursing workload.

- It requires *rigorous data analysis, scientific management of operations, clinical and organizational behavior expertise.*
What is next?

Three alternatives:

1. Provide the resources (e.g., staffing) sufficient to meet current patient peaks in demand - historical scenario

2. Staff below the peaks and tolerate ED diversions, nursing overloading and medical errors - current scenario

3. Smooth artificial variability and provide the resources to meet patient (vs. schedule) driven peaks in demand. Variability methodology can quantify and justify such additional resources