Can we measure the effect of over-crowding on patient safety?

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The Story of Tipping Point 2005-2006

Century City Hospital

Olympia Medical Center

(Midway)

The Story of Tipping Point

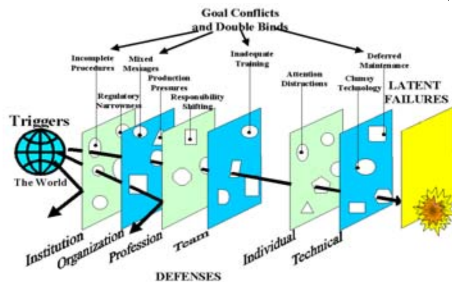
- Major incidents routinely occurred at approximately the same point in patient volume
- No increase in temporary workers
- No staff fatigue
- No difference in nurse to patient ratios
- Delays in service did occur

Observations from the Story of Tipping Point

- More mistakes occur during high volume times. We don't know how busy the system can become before errors begin.
- All departments, clinical and non-clinical, have "war stories" associated with spikes in the census.
- Leaders have different measures of volume depending on the department and the exigencies of the hospital.
- Volume increases that occur simultaneously have an exponential effect especially on the support services.
- The relationship between volume and error is non-linear. It feels like one more patient in the ED or one additional laboring woman and chaos ensues.

Swiss Cheese Model

Source: Reason, J.T., Managing the risks of organizational accidents.



Current Theoretical Approaches

<u>Smaller Holes</u>

- NPSG's
- Reliability Science
- Handoffs
- VAP bundle
- Patient identifiers
- RCA's

<u>More Screens</u>

- Licensing & Accreditation
- Organizational Policies and Procedures
- Culture of Safety
- Legislative Channeling

Methodology

- Quantify the intuitive – launch surge policies
- Each day had:
  - volume measures (census, surgery add-ons, behavioral health admits)
  - measure of harm – incident reports weighted for injury
  - # of high volume measures on that day where high volume defined as $z \geq 1.5$
- Comparison – number of high volume measures against the percentage of high error days

Findings

# of High Volume Measures/ day	*Total Days*	*# of High Error Days*	*Percent*
0	265	0	0%
1	197	27	14%
2	42	16	38%
3	8	4	50%
4	3	2	67%
Total	515	49	

Patient Harm Related to Volume (2007 Findings*)

- Harm to patients is related to the number of high volume areas in the hospital.
- As the number of high volume areas increases, so does the likelihood of patient harm.
- Systems capacity explanations hold where support services are overwhelmed as the number of high volume areas increases.

*Pedroja, A. T. "The Tipping Point: The Relationship between Volume and Patient Harm" American Journal of Medical Quality, 23 no. 5 (Sep/Oct 2008): 336-341.

Moore Grant (2008-2009) Phase I: Measurement

- Hospital Systems Load
  - Is there a short list?
  - Are the indicators ubiquitous or idiosyncratic?
  - How do they relate to patient harm?
- Error
  - Can we replicate use of incident reports against capacity indicators
  - Will the Global Trigger Tool be a better measure of harm?
- Tipping Point
  - Is there a mathematical model to find a tipping point?
  - Can this be generalized to all hospitals?

Error

- Global Trigger Tool
  - no correlations with Hospital Systems Load
  - sample was very small
  - what does it measure?
- Incident Reports weighted for injury to patients
  - less than 10% of the errors are reported
  - less reliability at the low end of the scale

Patient Harm

The incidence of errors and the level of injury from those errors obtained from voluntary adverse event reports.

Measuring Patient Harm

1. De-identified incident reports were weighted according to the level of harm to the patient.
2. A level of patient harm was assigned a numeric value on a geometric scale (1^2, 2^2, 3^2 . . .)
3. Each day had a measure of harm which was the sum of the injuries on that day.
4. The Daily Harm Score was the sum of the daily harm adjusted for census.
5. Harm assignment differed across the two hospitals but the methodology used was the same.

Harm Score Calculation for December 15, 2007

Incident harm level	# Incidents	Harm multiplier	Calculation	Harm score
No harm: did not reach patient	2	1^2	2*1	2
No harm: reached patient	9	2^2	9*4	36
Minimal harm or impact	5	3^2	5*9	45
Moderate harm or impact	4	4^2	4*16	64
Serious harm or impact	0	5^2	0*25	0
Patient death	0	6^2	0*36	0
			SUM	147
Patient Census 452			Daily Harm Score	.325

Hospital Systems Load

The stress placed on hospital systems as a function of the volume and intensity of care needs of the patients in the hospital.

Measuring Hospital Systems Load

1. Hospital leaders brainstormed a potential list of system load indicators.
2. IT created a database consisting of daily information for a one-year period using the customized set of system load indicators established during the brainstorm and a de-identified list of incidents weighted for patient injury.
3. A short list of system load indicators was developed using empirical and conceptual analysis ending in a factor solution that best fit the data for that facility, one for weekdays and a separate analysis for weekends/holidays.
4. The resulting set of system load indicators made up the measure of Hospital Systems Load for that facility.
5. Each system load indicator on each day had a percentile ranking based on its value compared to the entire year.
6. A count of the number of indicators at or above the 75th percentile was the Hospital System Load for that day.

Types of System Load Indicators

- Volume
  - quantity of patients or services
- Adjustments
  - changes caused by external forces
  - changes due to fluctuations in patient condition
  - prioritization is often required
- Bottlenecks
  - constraints causing the system to come to a halt
  - little predictive use

System Load Indicators

The Short Lists

System Load Indicators Hospital A

Weekday	Weekend	System Load Indicators	Volume	Adj.	Bottlenecks
✓	✓	Midnight Patient Census	✓		
✓	✓	# minutes in OR	✓		
	✓	ED average length of stay	✓		
✓	✓	Total Transfers In		✓	
✓	✓	Total Discharges - All Units		✓	
✓		ED, # of ambulances by day		✓	
✓		# minutes in OR-neck/back surgeries		✓	
✓	✓	ED Diversion Hours			✓
✓		Total overnighters in the PACU			✓
	✓	ED, left without being seen			✓
		TOTAL	3	4	3

System Load Indicators Hospital B

Weekdays	Weekends	System Load Indicators	Volume	Adj.	Bottlenecks
✓		Census at 1900 hours	✓		
	✓	Maximum Occupancy-Med/Surg	✓		
	✓	# OP Test Patients*	✓		
	✓	ED Arrivals at 1900hrs	✓		
✓	✓	Transfers In & Out		✓	
✓	✓	Census for Overflow Unit		✓	
✓		# PRN Medications		✓	
✓		Maximum Occupancy-Critical Care		✓	
✓		Maximum Occupancy-DCU		✓	
✓		Overflow Unit Admissions		✓	
✓		# OB Drop-Ins		✓	
	✓	# Transferred In & Out Of Overflow Unit		✓	
	✓	% Of Add On Surgeries		✓	
	✓	# Late-Administered Medications			✓
		TOTAL	4	9	1

Performance Improvement Implications

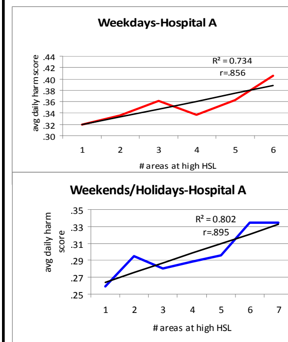
- Volume is not a likely target for improvement
- Eliminate bottlenecks
  - turn bottlenecks into adjustments
  - determine the antecedents to bottlenecks
  - act before the system comes to a halt
- Insure efficiencies re adjustments
  - staffing
  - process improvement

Improving the Adjustments

- Process Improvements
  - crash sections
  - on-call processes
  - use of overflow units
  - patient flow initiatives
- Staffing
  - SWAT RN's for admissions and discharges
  - Additional CNA's for high acuity
  - Unit Secretaries during the off hours

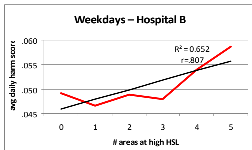
Relationship Between Hospital Systems Load & Patient Harm

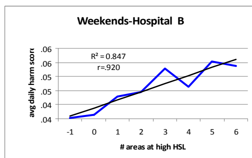
Average Daily Harm Score by Hospital Systems Load



- Strong positive correlations were found for hospitals on weekdays and on weekends/holidays. Correlations ranged from .856 to .895 explaining from 73% to 80%, respectively, of the variance in patient harm.
- As Hospital System Load (the number of high volume/intensity indicators at/above the 75th percentile) increased, the average daily harm score increased.

Average Daily Harm Score by Hospital Systems Load





- Strong positive correlations were found for hospitals on weekdays and on weekends/holidays. Correlations ranged from .807 to .920 explaining from 65% to 85% of the variance in patient harm.
- As Hospital System Load (the number of high volume/intensity indicators at/above the 75th percentile) increased, the average daily harm score increased.

Harm During The Week vs. Weekends/Holidays

Hospital Systems Load on Weekdays Compared to Weekends/Holidays

- Systems Load Indicators such as Average Daily Census and Transfers in and out were higher on weekdays than weekends/holidays for both hospitals (significant at .05 level)
- All non-ED indicators except percent add-ons in Surgery were higher on weekdays than weekends/holidays significant at .05 level for both hospitals.

Mean Midnight Census

	Hosp A	Hosp B
Weekdays	464*	270*
Weekends/Holidays	425	248
All days combined	452	264

Total Transfers

	Hosp A	Hosp B
Weekdays	253*	14.3*
Weekends/Holidays	116	11.5
All days combined	211	13.5

*Significantly higher at the 95% level of confidence.

Patient Harm on Weekdays compared to Weekends/Holidays

- Harm is lower on weekends/holidays than during the week for both hospitals significant at the .05 level.

Mean Per Capita Harm

	Hosp A	Hosp B
Weekdays	.34*	.049*
Weekends/Holidays	.28	.042
All days combined	.32	.047

*Significantly higher at the 95% level of confidence.

Patient Harm on Weekdays compared to Weekends/Holidays

- Harm/incident is higher on weekends/holidays than on weekdays.
- There are fewer incidents/patient on weekends/holidays which may be a function of patient safety or an artifact of self-reporting.

Mean Harm Per Incident.

	Hosp A	Hosp B
Weekdays	.014	.013
Weekends/Holidays	.015*	.016*
All days combined	.014	.014

Mean # Incidents Per Patient

	Hosp A	Hosp B
Weekdays	.055*	.016*
Weekends/Holidays	.046	.013
All days combined	.052	.015

Summary of Findings

- As the number of system load indicators increases so, too, does the likelihood of patient harm replicating the earlier study.
- Hospital Systems Load is routinely lower on weekends/holidays.
- Weekends/holidays are safer than the weekdays.
- Harm/incident is higher on the weekend which may account for our belief that it is less safe on the weekends.
- Incident/patient is lower on the weekend which may be due to comparatively less harm or under-reporting of incidents where harm did not reach the patient.

Implications

- Making hospitals safer requires that we calibrate Hospital Systems Load and take steps to protect patients when the load reaches a critical point.
- Incident/patient is lower on the weekend which may be due to comparatively less harm or under-reporting of incidents where harm did not reach the patient.
- Extra precautions are needed on the weekends/holidays when Hospital Systems Load reaches critical levels because --even though it is generally safer on weekends/holidays, errors are more likely to cause harm when they do occur.
- Process Improvement activities can ease hospital systems load.

Questions for Further Consideration

- How well do we consider the adjustments needed every day/every hour in a hospital?
- What steps can a hospital take to ease Hospital Systems Load?
- How will we know when to implement HSL protections?
  - Who will do it?
  - What will we do?

Hospital Profitability

Is it this? **Or this?**