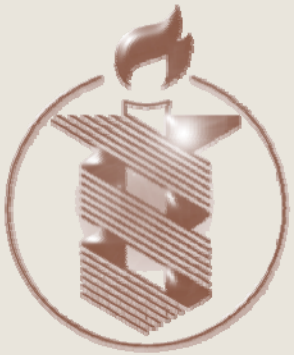
High Risk Operations in Healthcare

System Dynamics Modeling and Analytic Strategies

MIT Conference on Systems
Thinking for Contemporary Challenges
October 22-23, 2009



Contributors to This Work

- Meghan Dierks, MD – Harvard Medical School/Beth Israel Deaconess Medical Center, Division of Clinical Informatics
- Margaret Stringfellow – MIT's Complex Systems Research Laboratory
- Nancy Leveson, PhD– MIT's Complex Systems Research Laboratory

Funders of This Work

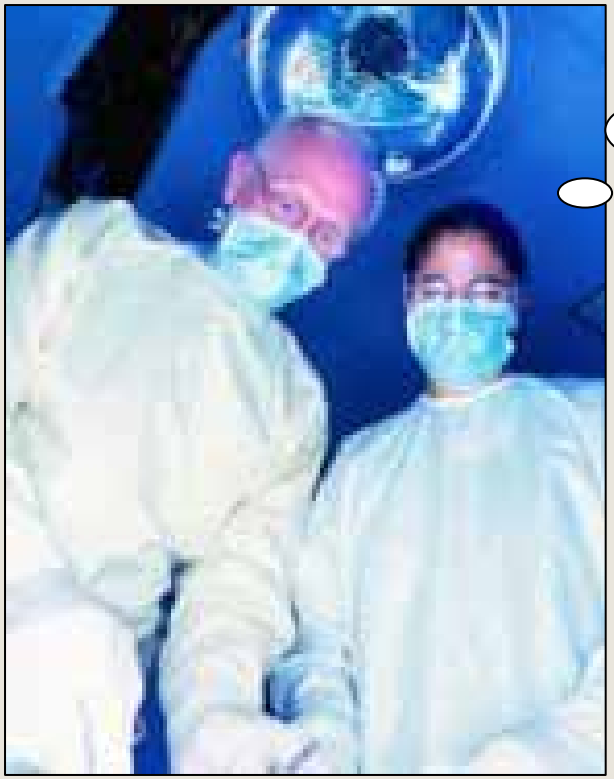
- AHRQ: Agency for Healthcare Research and Quality
- CIMIT: Center for Integration of Medicine and Innovative Technology

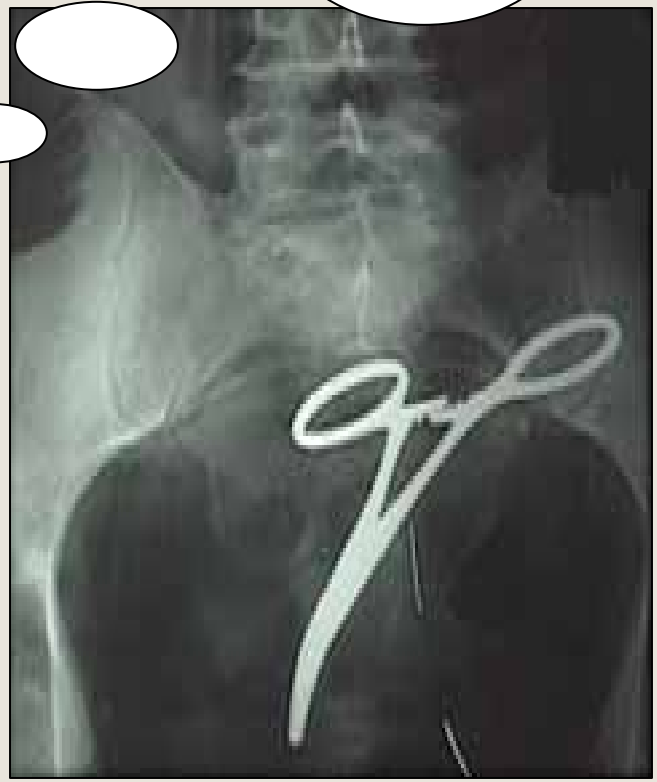
Symposium Objectives

- The imperative for adopting systems thinking, what it is, and how to apply it
- Specific examples of how systems thinking is being applied in the domain of health care
- Lessons learned and how attendees can apply them in their own domains

What's the Imperative?

How can this have happened ?!?!?





What's the Imperative?

Focus of Today's Talk

- RISK
  - Risk of adverse event or injury as a result of treatment
  - Risk of disease/illness progression as a result of no treatment
- How we have failed in terms of:
  - Current assessment techniques
  - Efforts to control
  - Tolerance
- Little or no systems thinking
- How we can change this

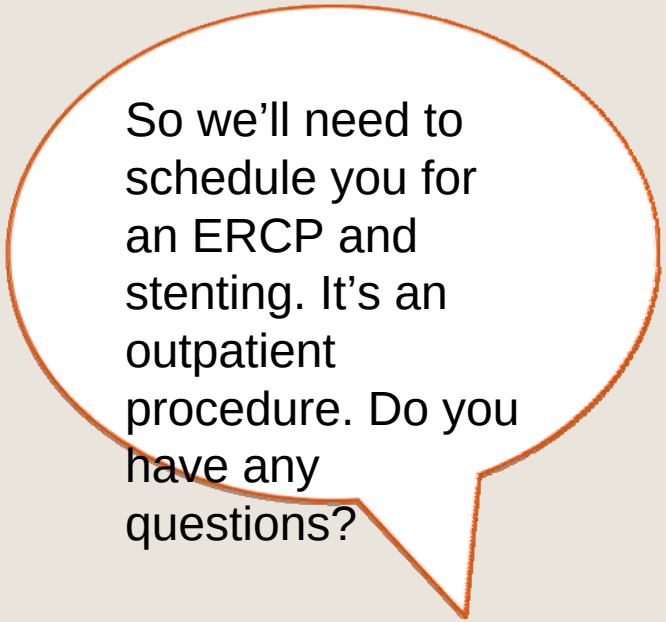
Some Assumptions

- Risk is an inherent part of healthcare
- While risk cannot be eliminated from clinical activities, it can be shaped and modified

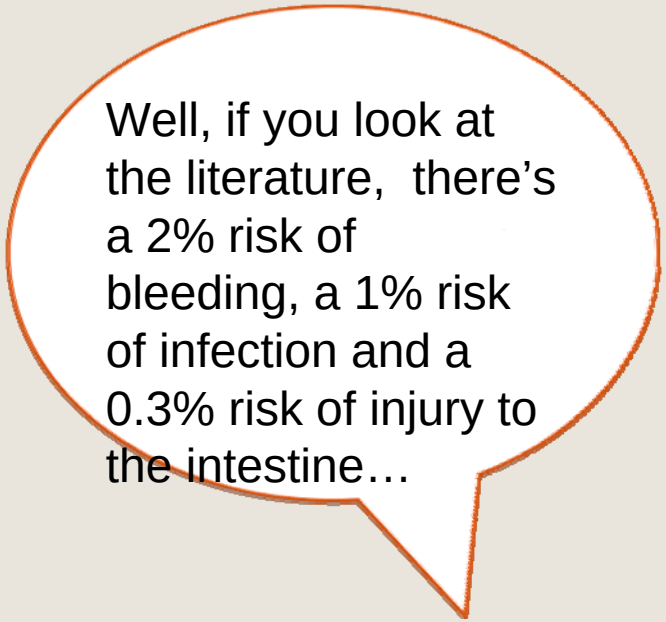
- Decisions or policies about *system operations* can
  - strongly influence *individual provider* capabilities and performance
  - shift an *individual patient's* position on the continuum of low-to-high risk during their hospitalization

Current State

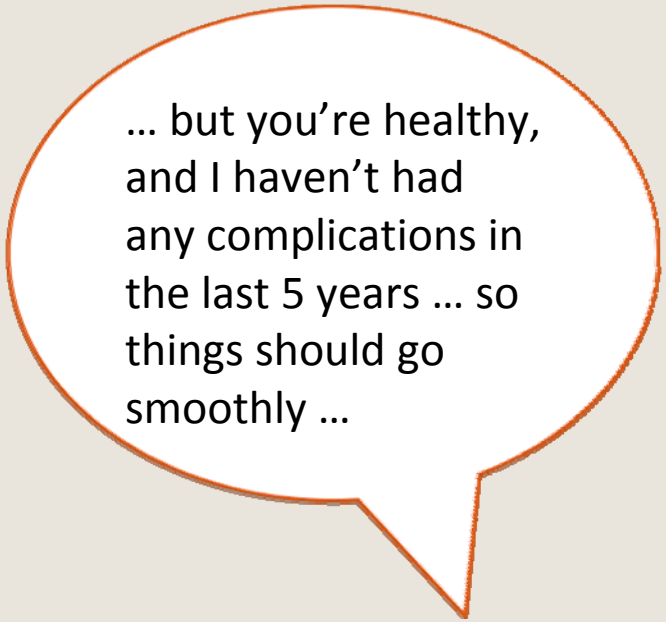
- How do we currently assess risk at an organizational level?
- How do we measure it?
- How do we characterize and analyze it in terms of:
  - Cause
  - Controllability
  - Tolerance

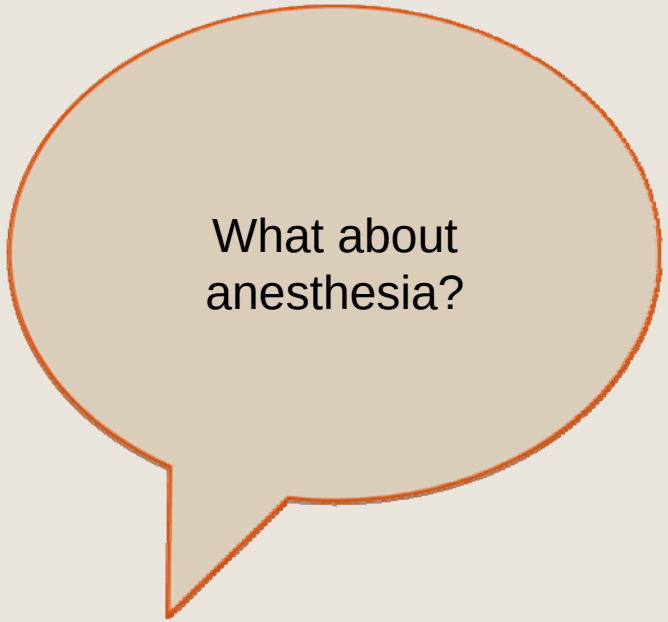

So we'll need to schedule you for an ERCP and stenting. It's an outpatient procedure. Do you have any questions?

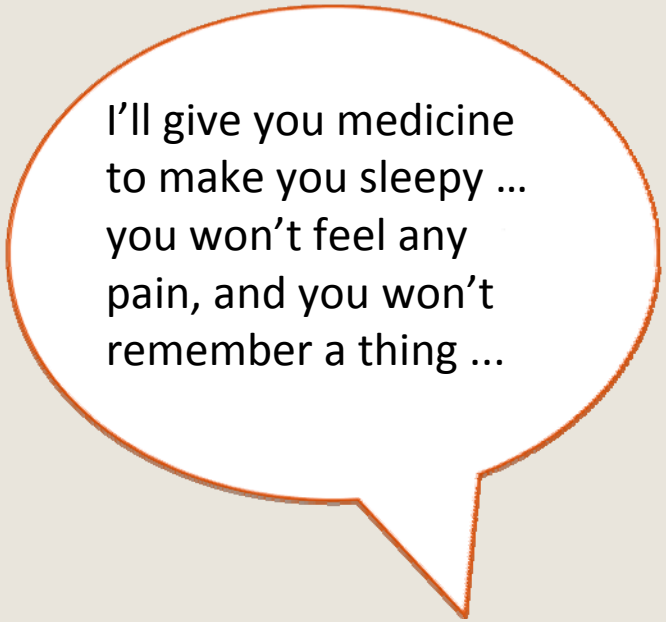

OK. Is this a safe procedure? Are there any complications?

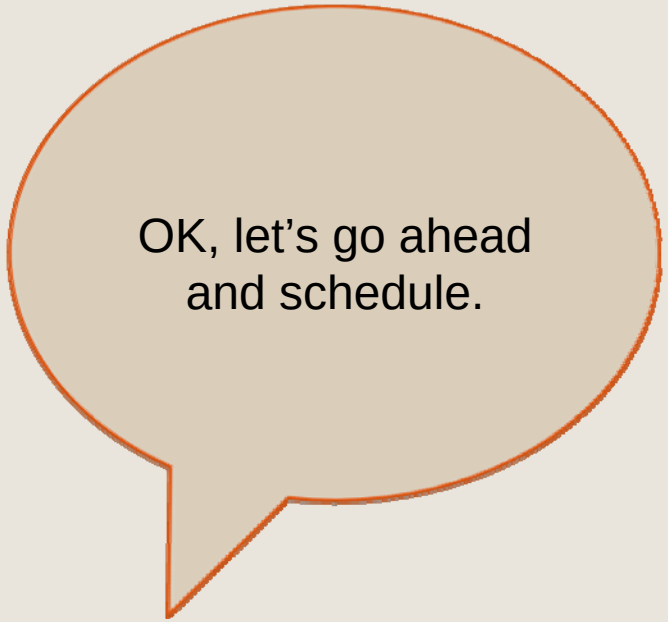

Well, if you look at the literature, there's a 2% risk of bleeding, a 1% risk of infection and a 0.3% risk of injury to the intestine…

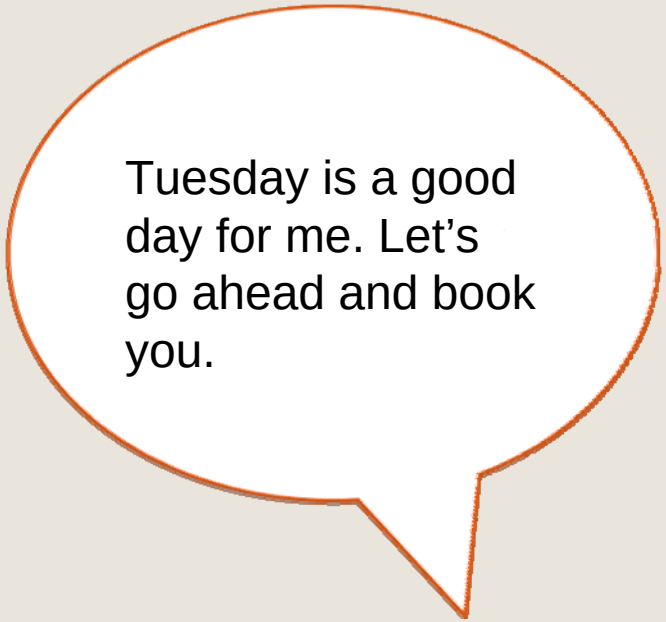

… uh huh …


… but you're healthy, and I haven't had any complications in the last 5 years … so things should go smoothly …


What about
anesthesia?


I'll give you medicine to make you sleepy … you won't feel any pain, and you won't remember a thing ...


OK, let’s go ahead
and schedule.


Tuesday is a good day for me. Let’s go ahead and book you.

One Week Later …

One Week Later …

Tuesday is historically the busiest day for the entire hospital system:

- ≥ 25% increase in volume and acuity across all units is typical.

Adding to this, several urgent ‘just say yes’ cases had been added to the schedule, requiring postponement of our patient’s from the morning until the late afternoon.

One Week Later …

During the procedure, patient is very uncomfortable, requiring use of moderate to high dosages of medication for sedation and pain control.

At times, patient is actually requiring general anesthesia, but because the one Anesthesiologist available is shared across all other procedural areas, not immediately available.

One Week Later …

Procedural MD could stop the procedure, reschedule for a later date, but . . .

- Has already made significant progress in the case
- Has previously 'pushed the envelope' and managed both sets of tasks without problems
- Concerned about the risks posed to the patient if he delays treatment – subsequent contingency
- Also concerned that rescheduling would requiring 'bumping' another patient into an already tight procedural schedule

One Week Later …

Forges on, and eventually finishes the case

Unaware that the patient has had episodes of under-ventilation

Transfers patient to the post-procedure recovery area

One Week Later …

Patient slowly is recovering in the post-procedure area, but as 6:00 PM approaches - the time at which unit staffing ends - it becomes clear that the patient is not yet ready to go home.

No arrangements had previously been made for an inpatient admission and currently, no inpatient beds are available.

One Week Later …

The patient is temporarily transferred to an observation floor that lacks adequate post-anesthesia monitoring capabilities.

The patient experiences a respiratory arrest due to prolonged effects and reduced metabolism of the sedatives, and other secondary effects.

One Week Later …

‘CODE BLUE’ is called, patient resuscitated

Transferred to the ICU (after urgently moving a ‘less sick’ patient out to the floor)

Prolonged ICU stay

Eventual discharge and rehabilitation

Current State

- How do we currently assess risk at an organizational level?
- How do we measure it?
- How do we characterize and analyze it in terms of:
  - Cause
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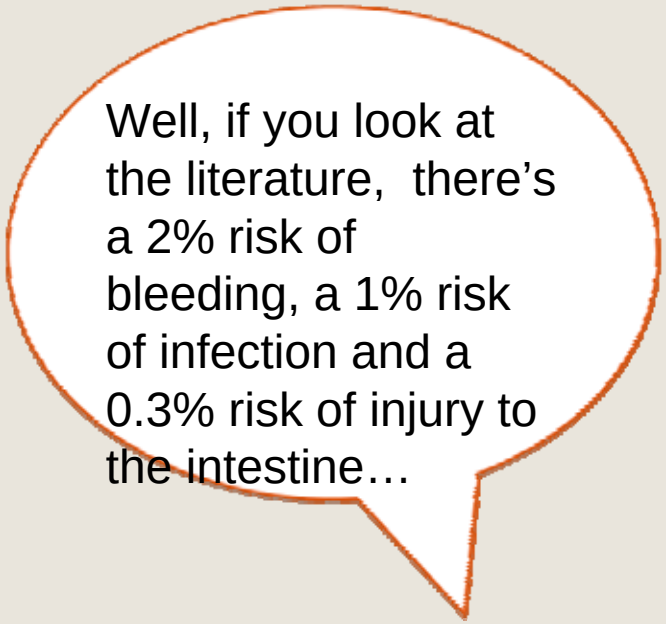
  - Tolerability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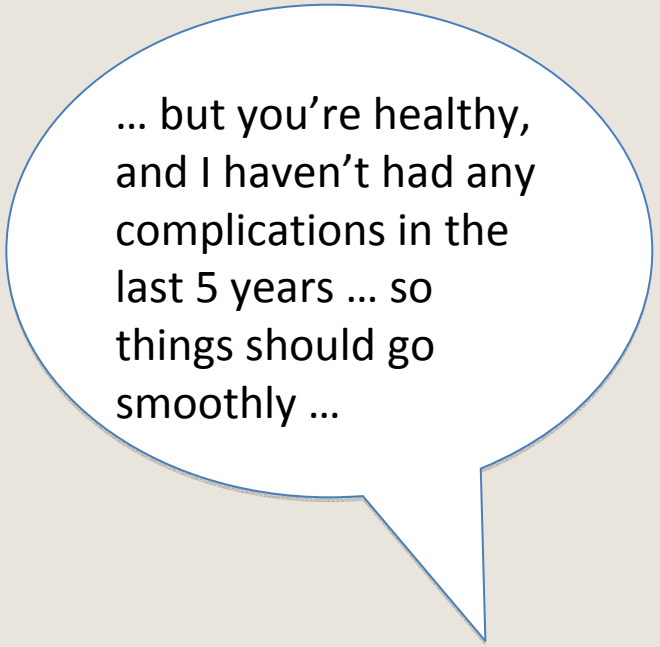
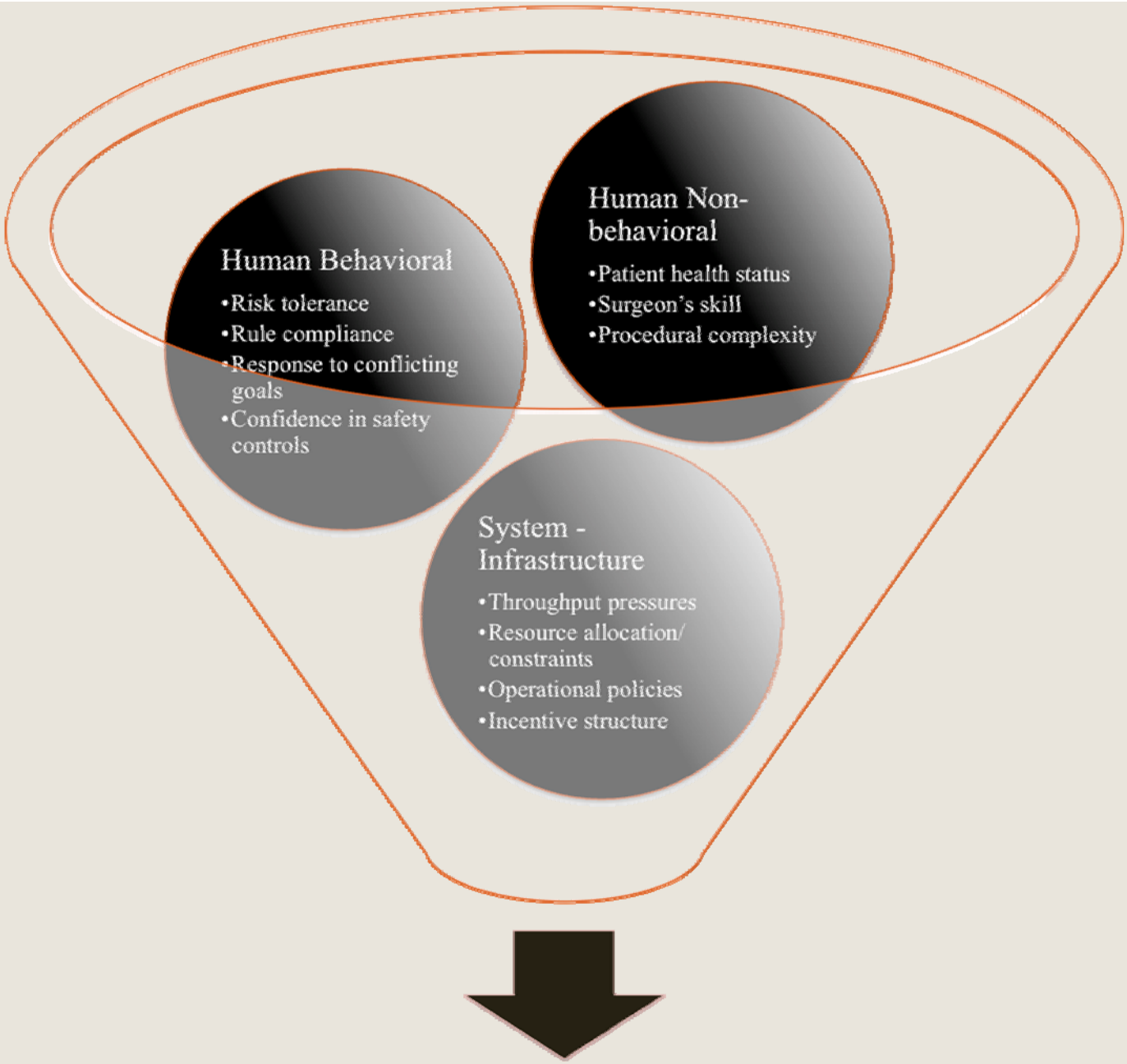

… but you're healthy, and I haven't had any complications in the last 5 years … so things should go smoothly …

Problems-Limitations

- Measurement-Representation of Risk
  - Counting and point estimates
  - Notion of uniformity across time and phase of care
  - Influenced only by:
    - patient co-morbidity
    - procedure type
    - provider experience


Human Behavioral
•Risk tolerance
•Rule compliance
•Response to conflicting goals
•Confidence in safety controls
Human Non-behavioral
•Patient health status
•Surgeon's skill
•Procedural complexity
System - Infrastructure
•Throughput pressures
•Resource allocation/ constraints
•Operational policies
•Incentive structure
Risk of Adverse Event

Problems-Limitations

- Analytic approach:
  - Retrospective review of adverse events (AEs)
  - Assumption of single ‘common’ failure within a linear chain of events

The Complexity Factor

- Multiple components, multiple agencies
  - Functioning within the context of inconsistent ‘local’ objectives
- Multiple simultaneous causal strands or multiple alternative causal strands
- Recursive causality - with reinforcing loops
- Disproportionate relationships
  - At critical times/states, small change can make a big difference
  - Notion of 'tipping point‘

Adapted from: Patricia J. Rogers, Evaluation, Vol. 14, No. 1, 29-48 (2008)

The Complexity Factor

- “Not easily analyzed”
- Never fully knowable

Goals

- Develop a more realistic representation of risk
- Dynamic changes as a function:
  - system constraints and interactions between system components
  - human decision making under uncertainty, and in the face of conflicting goals
  - feedback influences

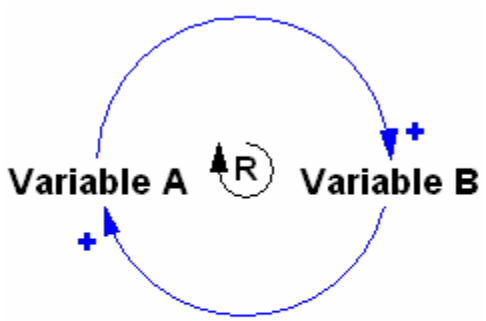
Goals

- No longer trying to calculate the probability of a specific adverse event
- Instead, focusing on:
  - Interrelationship between safety goals and productivity goals
  - Factors that drive the system to operate in a high risk state
  - Previously undetected risk exposure
  - Percentage of time that system is functioning in an 'unacceptably' high risk state

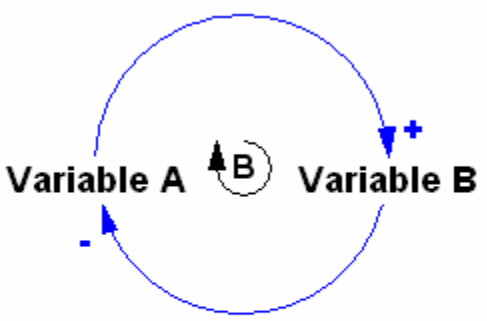
Approach

- System Dynamics Framework

Causal Influence

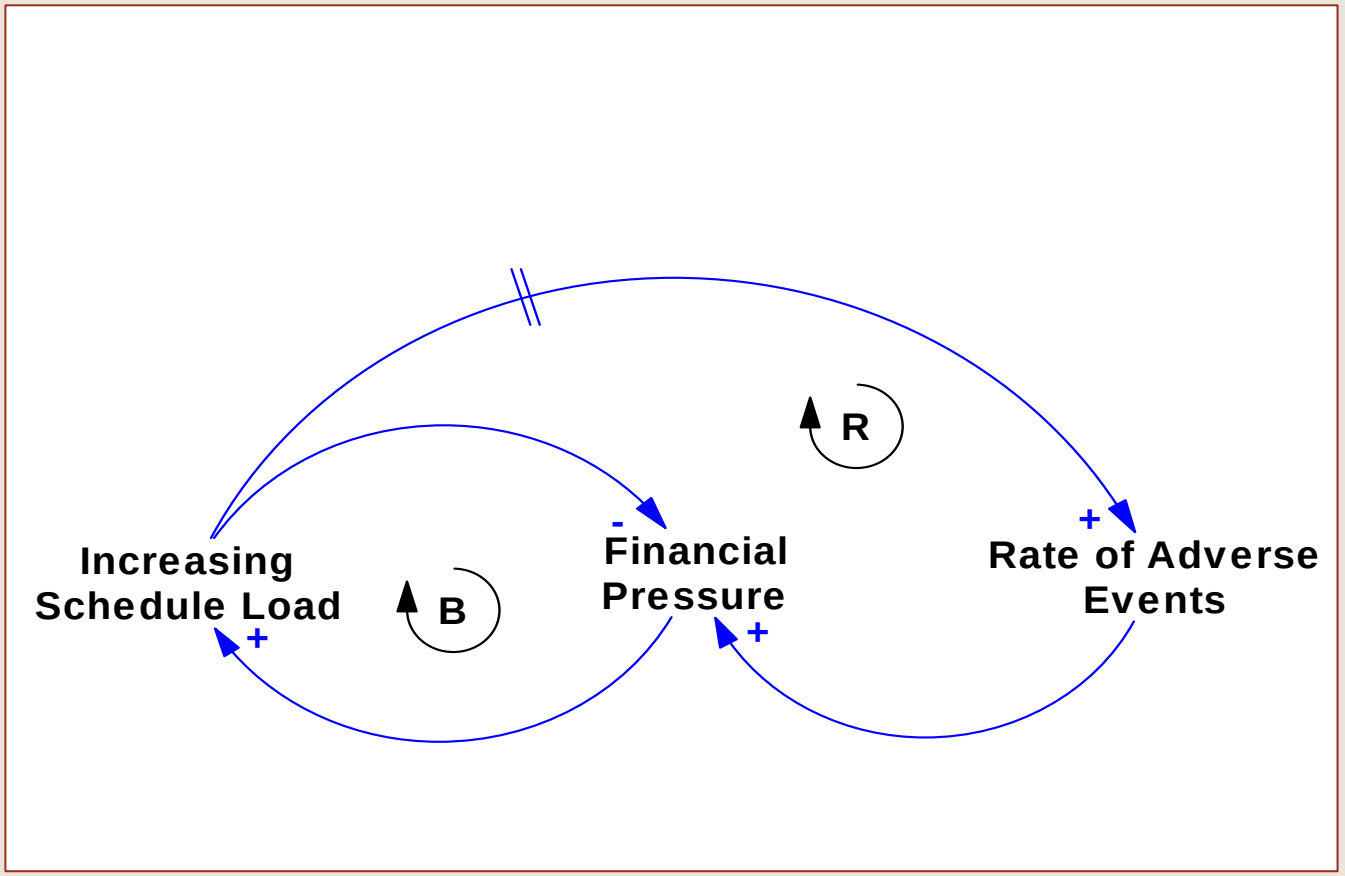


Positive Feedback or Reinforcing Loop

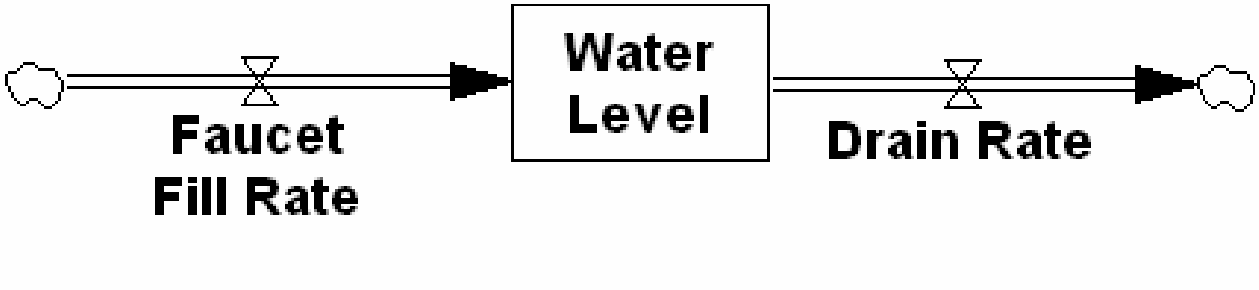


Negative Feedback or Balancing Loop

Causal Influence Loop

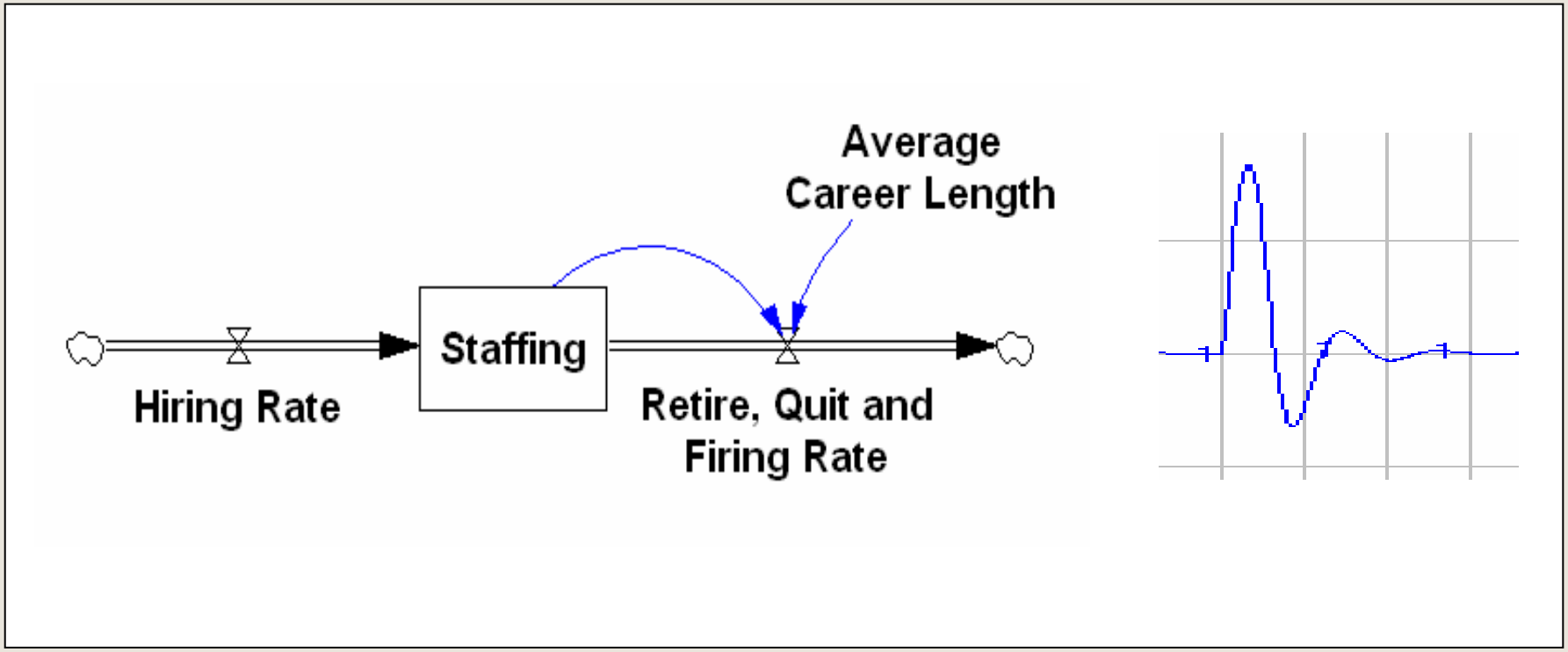


Stocks and Flows



Bathtub

Stocks and Flows



Test Bed

- Ambulatory procedural care

Ambulatory Procedural Care

- What is special about surgery in an ambulatory setting?
  - Considerably less expensive model of care
  - Potentially more efficient
  - This drives a trended effort to perform increasingly complex procedures in an ambulatory (outpatient) setting

Ambulatory Procedural Care

- What is special about surgery in an ambulatory setting?
  - Can be less fully equipped for contingencies
  - Often are 'remote' from inpatient crisis management teams
  - Pre-procedure patient preparation can be considerably less formal

Ambulatory Procedural Care

- What is special about surgery in an ambulatory setting?
  - Little or no overt or pre-planned backup by specialists (e.g. Anesthesiologists) for management of complications
  - Fixed operational hours leading to ‘sundown' issues: shut-down of these units at a specific time
    - increasing potential for premature patient discharge or rushed execution of procedures towards the end of the day
    - heavy reliance on patient and family to manage post-procedure recovery

Safeguards – ‘Safety Controls’

- Day-of-procedure screening checklist to assess need for other specialist involvement
- ‘Readiness for discharge’ checklist

‘Safety Control’ Conflict

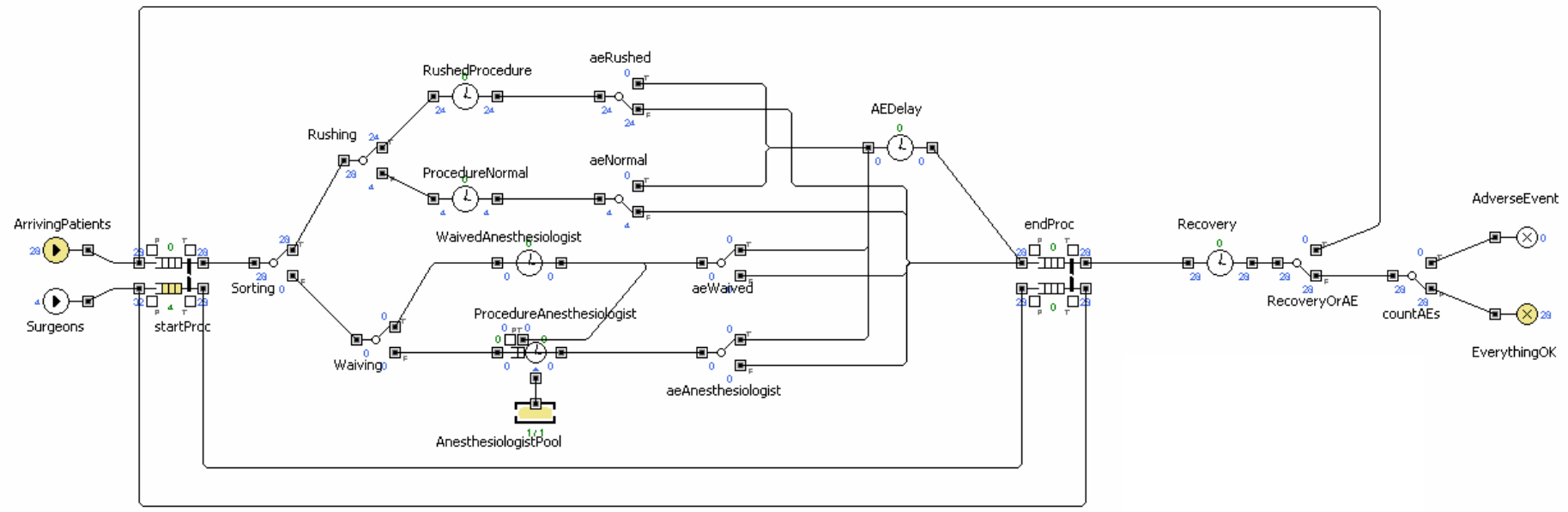
- Have the potential to:
  - Add to the overall cost
  - Slow or delay the process of care (thus undermining the dominant economic objective for this particular delivery model)
- Result:
  - Often are ‘disengaged’ or waived in the interest of maximizing the productivity and efficiency outcome objectives.

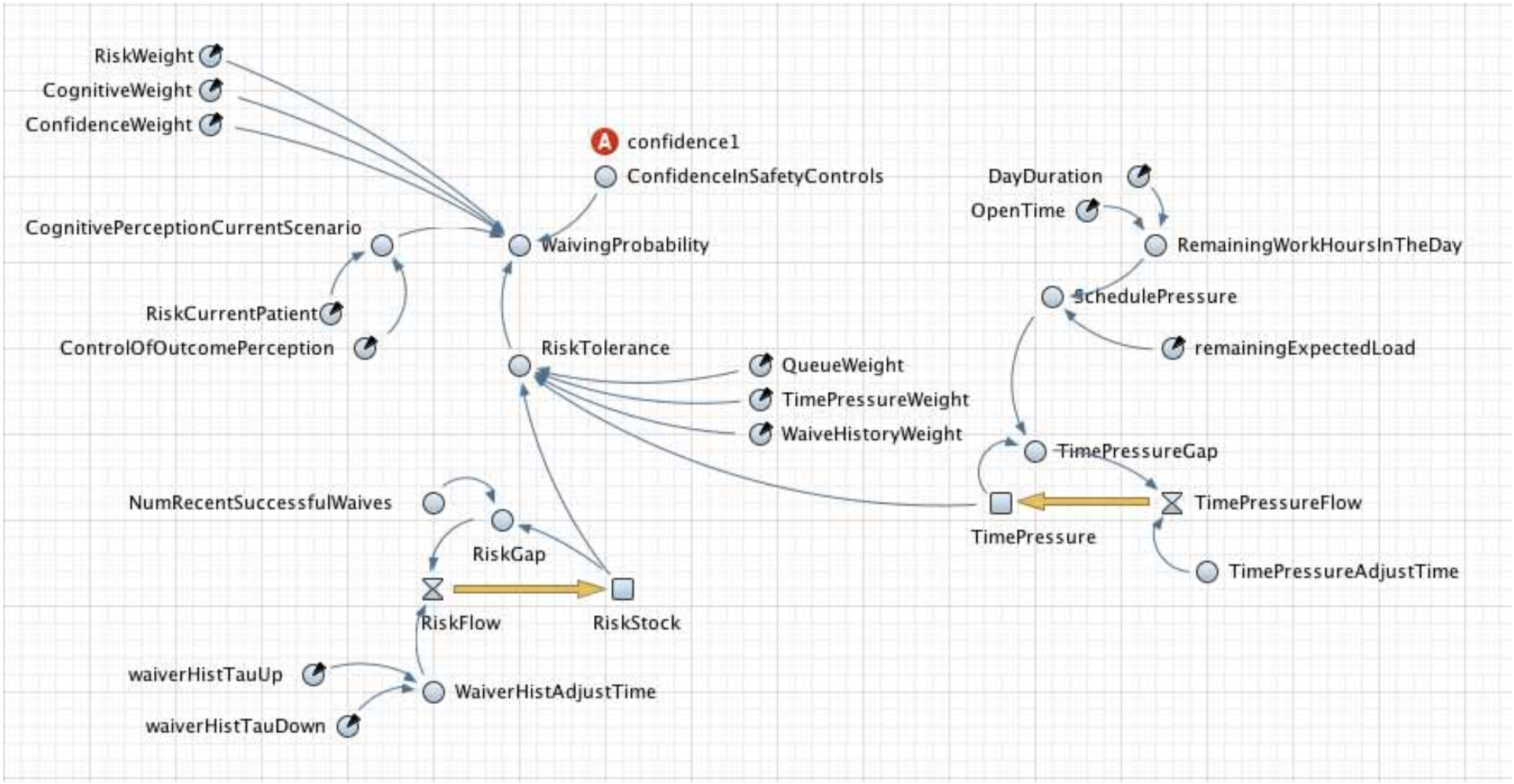
Paradox

- High volume units
  - 28,000 cases/year
  - 2-3 adverse events
- At the same time, relatively high rates of engaging in ‘risky’ behavior … operating at the thresholds of safety

Questions We Will Try to Answer with SD

- How decision makers at all levels respond to:
  - Conflicting/interacting goals
  - Feedback
  - Dynamic interactions between organizational and social
- How organizational structures and priorities
  - Shape behavior, decision making of individuals
  - May disproportionately favor productivity goals over safety goals
  - Migration over time to high risk operational states


ArrivingPatients
Surgeons
startProc
Sorting
Rushing
RushedProcedure
aeRushed
ProcedureNormal
aeNormal
Waiving
WaivedAnesthesiologist
aeWaived
ProcedureAnesthesiologist
aeAnesthesiologist
AnesthesiologistPool
AEDelay
endProc
Recovery
RecoveryOrAE
countAEs
AdverseEvent
EverythingOK


RiskWeight
CognitiveWeight
ConfidenceWeight
confidence1
ConfidenceInSafetyControls
DayDuration
OpenTime
CognitivePerceptionCurrentScenario
WaivingProbability
RemainingWorkHoursInTheDay
SchedulePressure
RiskCurrentPatient
ControlOfOutcomePerception
RiskTolerance
remainingExpectedLoad
QueueWeight
TimePressureWeight
WaiveHistoryWeight
TimePressureGap
NumRecentSuccessfulWaives
TimePressureFlow
TimePressure
RiskGap
TimePressureAdjustTime
RiskFlow
RiskStock
waiverHistTauUp
WaiverHistAdjustTime
waiverHistTauDown

Modeling and Simulation Results

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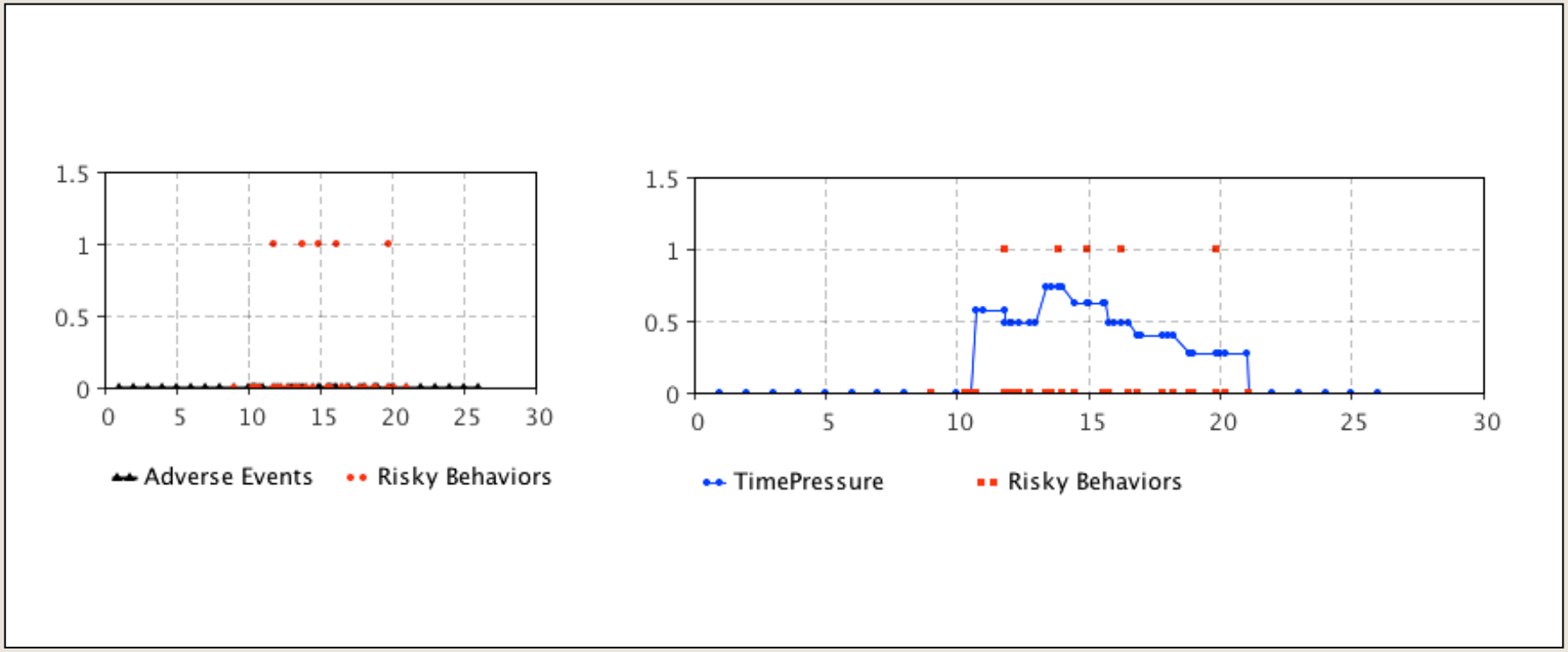
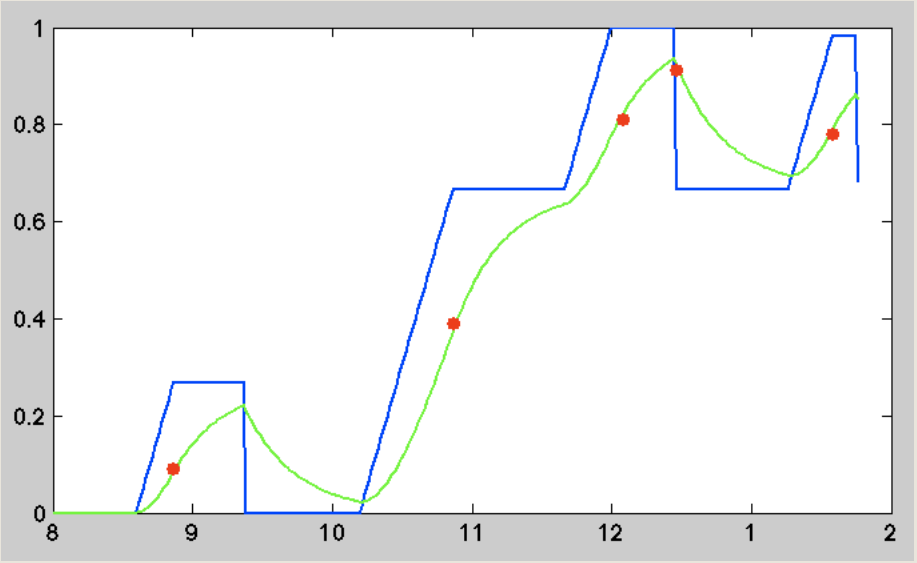
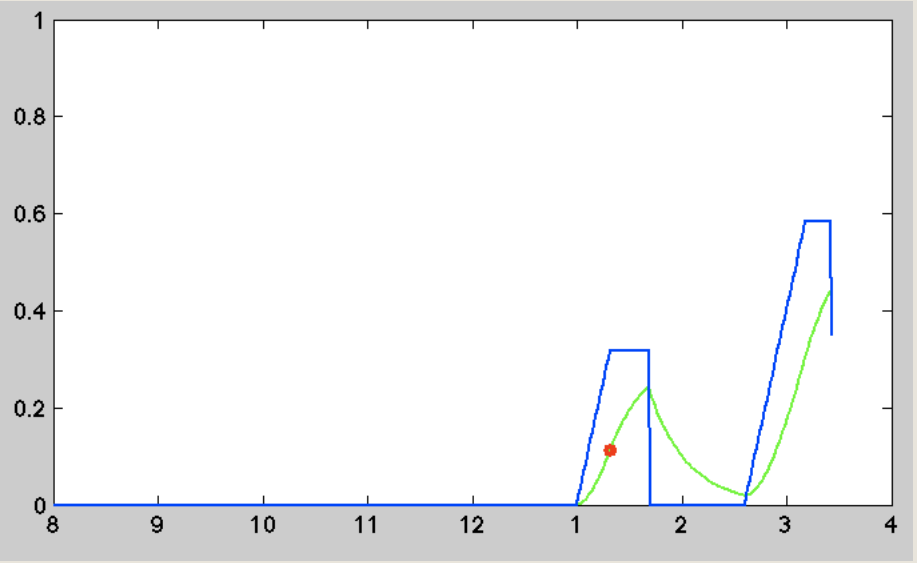


Modeling and Simulation Results



Time →



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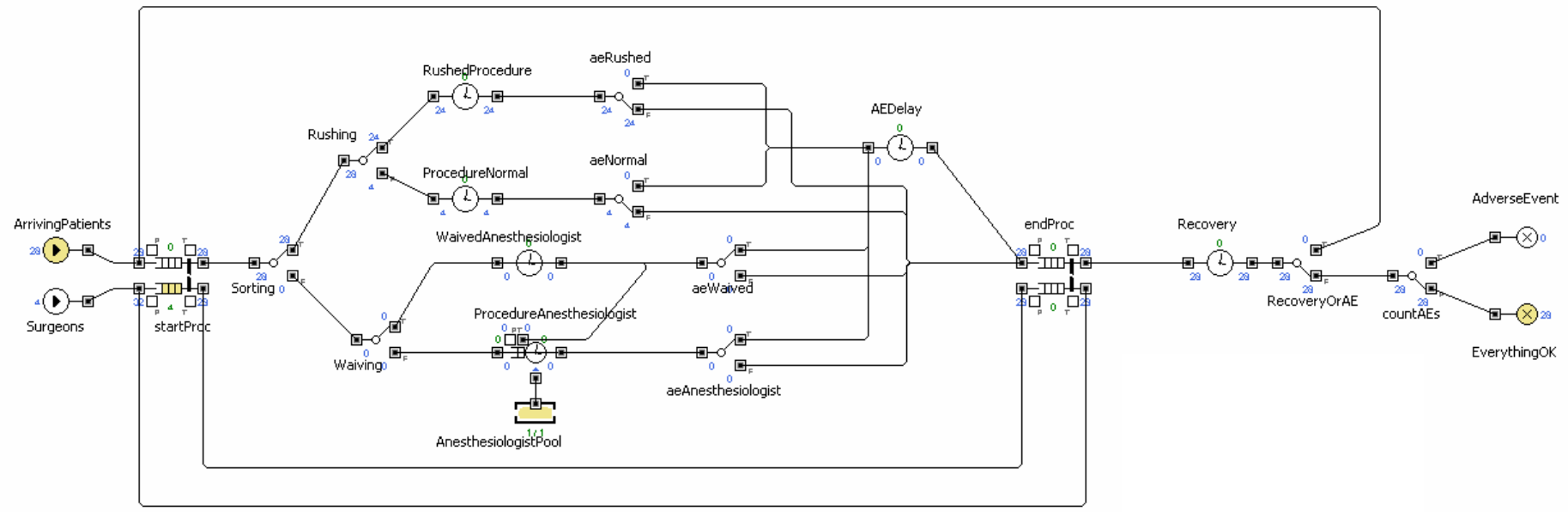
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ProcedureAnesthesiologist
aeAnesthesiologist
AnesthesiologistPool
AEDelay
endProc
Recovery
RecoveryOrAE
countAEs
AdverseEvent
EverythingOK

Summary

- One Testbed
- Exploration of three policies
- Going forward -> Make a strong case for applying this approach to study and monitor risk in an increasingly complex healthcare setting.

So What Does This Mean to You?

- Imperative for adopting systems thinking, what it is, and how to apply it
- Specific examples of how systems thinking is being applied in the domains of health care
- Lessons learned and how attendees can apply them in their own domains ... or,
  - to your own role as a component of the healthcare system
  - to your role in current and future efforts to redesign the healthcare system

Thank You!

Questions and Discussion