Center for Management Science in Health

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Towards a Science of Health Care Quality: Notes From the Field

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What We All Know

- …$.30 to $.40 of every dollar spent on health care…is spent on costs associated with "overuse, underuse, misuse, duplication, system failures, unnecessary repetition, poor communication, and inefficiency."

  IOM 2008

- 3/4 of patients surveyed described their medical encounter as "a nightmare to navigate"

  American Hospital Assoc 2008

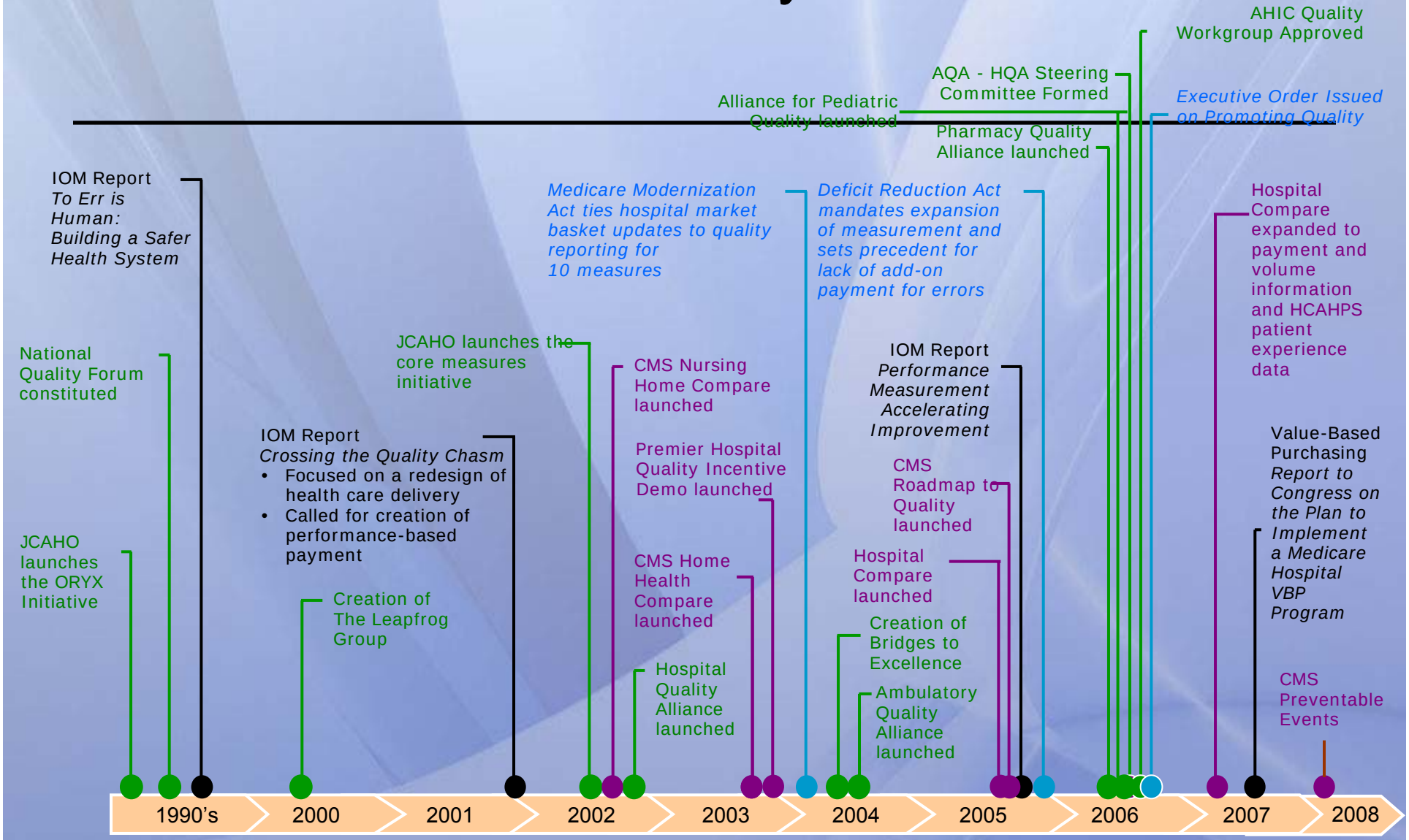
- 80,000 hospital deaths and 150,000 ambulatory deaths occur annually from Error

  IOM 2006, 2008

O/R Techniques Have Little Impact

- Demand Forecasting has not reduced ED overcrowding, diversions, “sentinel” events or “boarding”
- Scheduling optimization has not reduced OR under-utilization or staff overtime
- EMR’s have nether reduced error (though they’ve changed the pattern), improved data analysis or improved patient –provider communication

Numerous National Quality Initiatives



…Adopting a Number of Quality Improvement Techniques

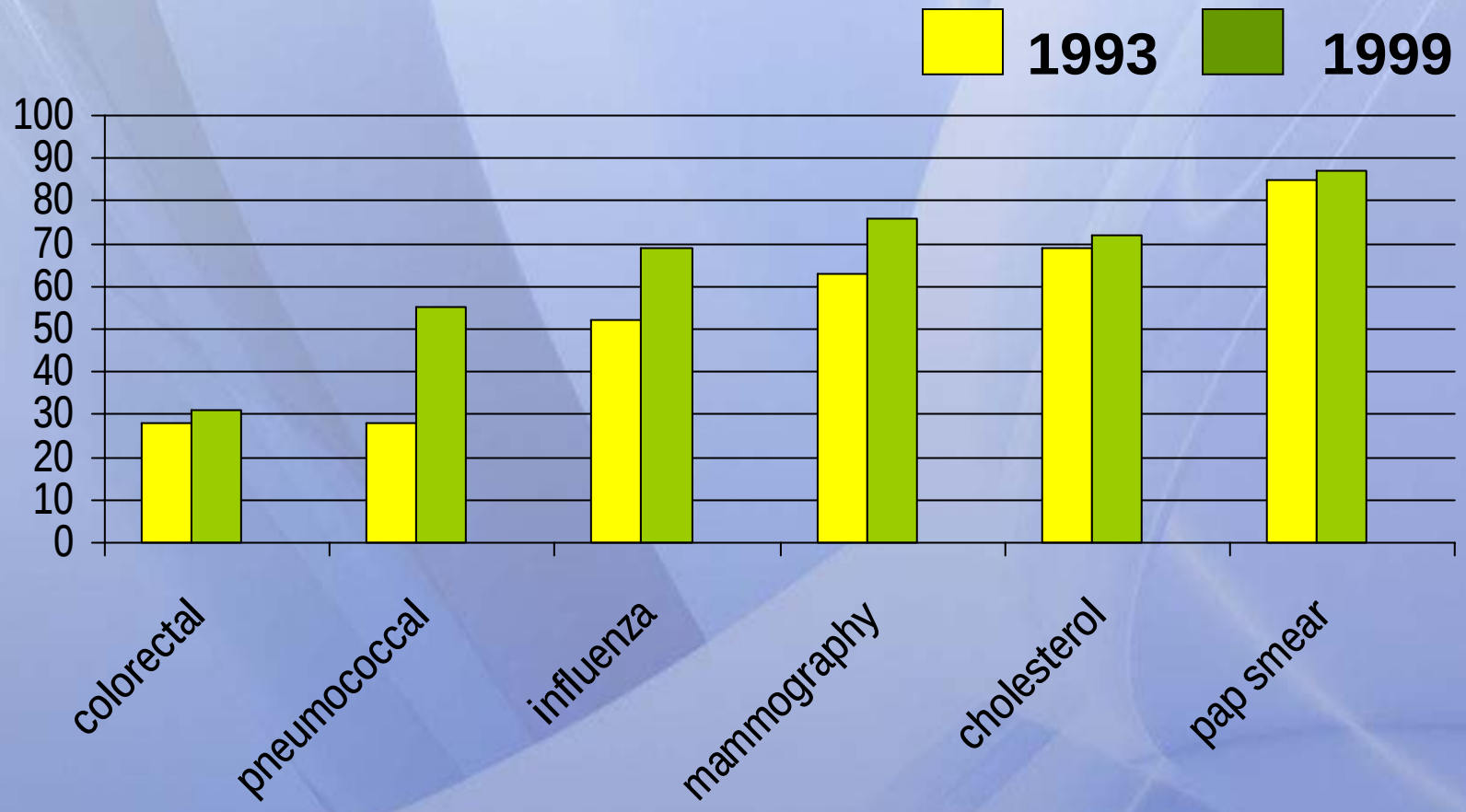
- Total Quality Management
- Continuous Quality Improvement
- Benchmarking
- Evidence-based Medicine
- Clinical Practice Guidelines
- Sigma Six
- Toyota Lean
- Pay-for-Performance

…Using "Rearview Mirror" Quality Measures

- % of 2 years olds fully vaccinated
- % of diabetics with Ha1c screenings
- % of depressed patients on medications
- Joint Commission LD 3.10 and MM series
- Press-Ganey Patient Satisfaction Scores

ALL SYSTEM OUTPUTS RATHER THEN DETERMINANTS OF QUALITY

…Yielding



Nelson DE et al. JAMA 2002;287:2659-67

…Begs The Question

- How can a national system that leads the world in technological and biological innovation be so much less then the parts?

The Answer

Medicine lacks a *science* of health care quality

- Incoherent Health Service Research Agenda
- Initiatives treat quality as a black box
- Unable to describe the relationship between satisfaction, outcomes and efficiency

Science of Health Care Quality Requires…

- Theory
- Axioms
- Testable Hypothesis
- Field Observations
- Methodologies
- Identification of Key Constraints

The Phenomenon to be Understood

- Patients arrive with
  - Biologic conditions
  - Health beliefs
  - Health experience
  - Health goals/desires
- Providers Arrive with
  - Knowledge of human biological systems
  - Knowledge of treatment options
  - Knowledge of legal and ethical constraints
  - A sense of what is possible

Characteristics Shared with Other Service Industries

- Co-production of value
- perishable, heterogeneous, and intangible (but measurable)
- Inputs are human capital and knowledge
- Production and consumption are inseparable (but the value derived have different temporal gradients)
- Requires significant levels of mass customization and service provider judgment

Characteristics Unique to Health Care

- Consumer has little choice
- Consumer has little ability to objectively judge the quality of the service provided
- Timing of service can be critical
- Consumer satisfaction *NOT* meaningfully defined the same as in other industries
- Severe step-wise cost functions

This Dialectic Process:

(Axioms or First Principles)

1. Is dynamic and transformative
2. information intensive
3. often time-sensitive
4. Predicting and matching service demand to service capacity is critical
5. “outputs “are a customized (but categorical) patient and provider *mutual understanding* of what is possible.

Implications

- A core Service Science tenet posits that clients must take an active role as co-producers of the knowledge based solution to achieve a successful outcome
  - Technically correct care that is either not wanted or not understood erodes the "value" of clinical encounter
- Difficult to specify the terms of the interaction a priori
- Must agree on the expectations and scope of the consultation

– Which will be dynamic and evolutionary

– knowledge transfers will be "sticky"

Service Science Challenges

- Enabling technologies for smarter information use
- Reducing and managing uncertainty
- Quality assurance in real time
- When should variability be reduced-and would should it *not*
- Meaningful measurement systems
- Modeling and predicting processes
- Satisfization of resource use

Mutual Understanding Theory of Health Care Quality Frontiers

- The state of what is possible is defined as the health care quality *potential*
- This *potential* must be dynamic to meet changes in medical knowledge, the health system, and patient resources
- The dialectic process is *evolutionary*, as beliefs, knowledge and perceptions are altered by the process
- The interactions amongst the variables in this system are knowable and quantifiable and produce the quality potential *frontier*

Developing Objective Functions for:

Provider Variables

- Practice Setting
- Arrival Patterns
- Informational Needs
- Provider Personality

Patient Variables

- Patient Health Status
- Patient Health Beliefs
- Patient Circumstances
- Patient Personality

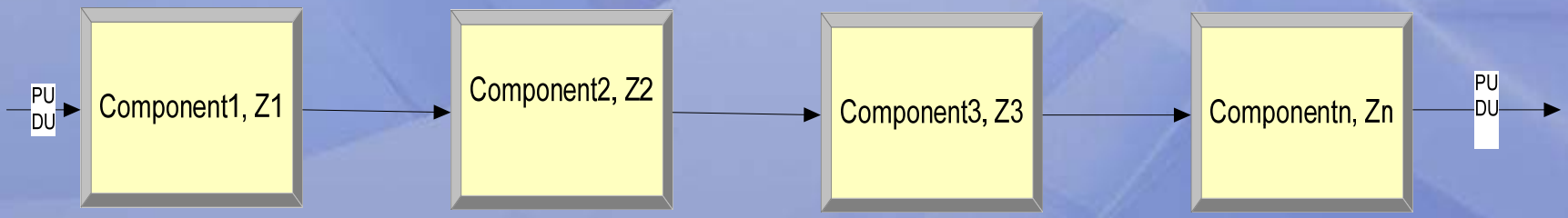
Provider-Patient Interaction

=

Individualized Desired Outcomes

Beginning the Mathematical Model

- Definition patient understanding array ***PU***, and provider understanding array ***DU***.
- Definition of element variables within understanding array ***A***.
- Definition of component transfer function vector $Z_{C_i}^{p}(PU)$ *and* $Z_{C_i}^{d}(PU)$
- Definition of component inequality constraints (Potential/Frontier) $PV_{C_i}(A)$
- Definition of component current value $CV_{C_i}(A)$



Key Determinants or Inputs

Ratio of Patient-Provider time to all other time in Service

- Internal Parameters
  - (Service Capacity = staffing, exam rooms, scheduling schemas)
- External Parameters
  - (Service Demand = stochastic for ED, deterministic for Specialty, mixed for Primary)
- Information Parameters
  - (External for Specialty, Internal for ED mixed for Primary)

Developing a Mathematical Model

- Principle Component Analysis
  - Outcomes *(the Gap between what is possible and what has occurred for individual patients)*
  - Patient satisfaction *(rooted in liklehood of compliance with agreed-to treatment recommendations)*
  - Efficiency *(ratio of patient-provider time to all other time in clinic)*

Examples form the Field

Field Tests

- Direct Observations in
  - Primary care (Pediatric, Emergency Departments, Family and GIM clinics)
  - Rural and Urban
  - Specialty care (e.g. Nephrology, Orthopedics, Cardiology, HIV)
  - Large (V.A. and Kaiser), Medium (15-60 providers) and small (>3 providers) clinics

Field Study 1: Matching Service Demand to Service Capacity in an Emergency Department

- Nearly half of U.S. hospitals report ED crowding on a daily basis
- Seriously ill and injured ED patients can wait 12-48 hours for an inpatient bed
- > ½ million inbound ambulances diverted in 2007
- "Crowding" / imbalance in patient/staff ratio responsible for 35% of "sentinel events

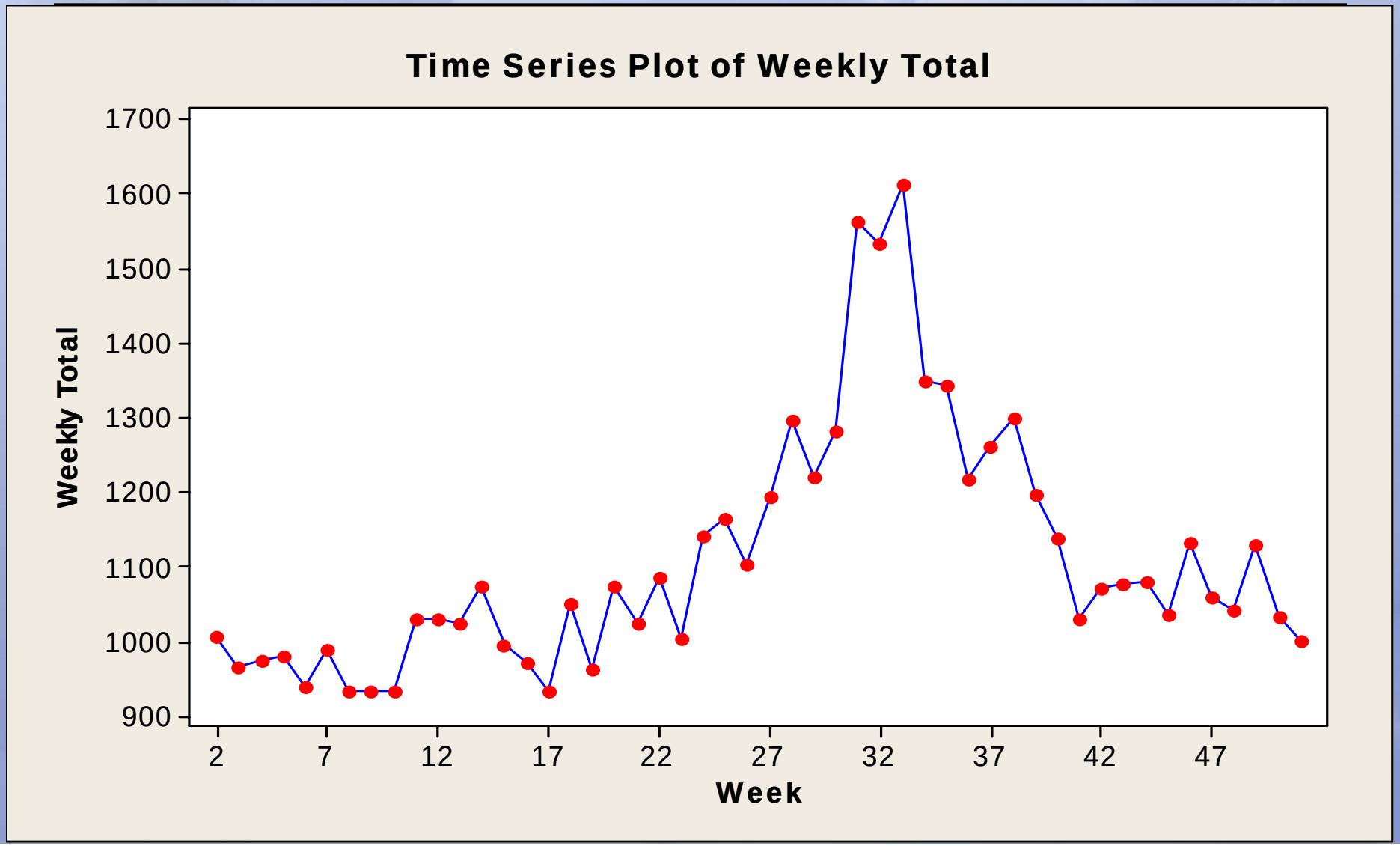
Emergency Department Constraints

- Must accept all takers
- Legal mandates (with financial penalties) on staffing
  - 1 RN per 3 low acuity
  - 1 RN per 2 medium acuity
  - 1 RN per 1 high acuity
- Joint Commission Requires ED's to examine Patient flow (JCAHO LD.3.15 leadership standard)
- Severe Step-wise cost functions

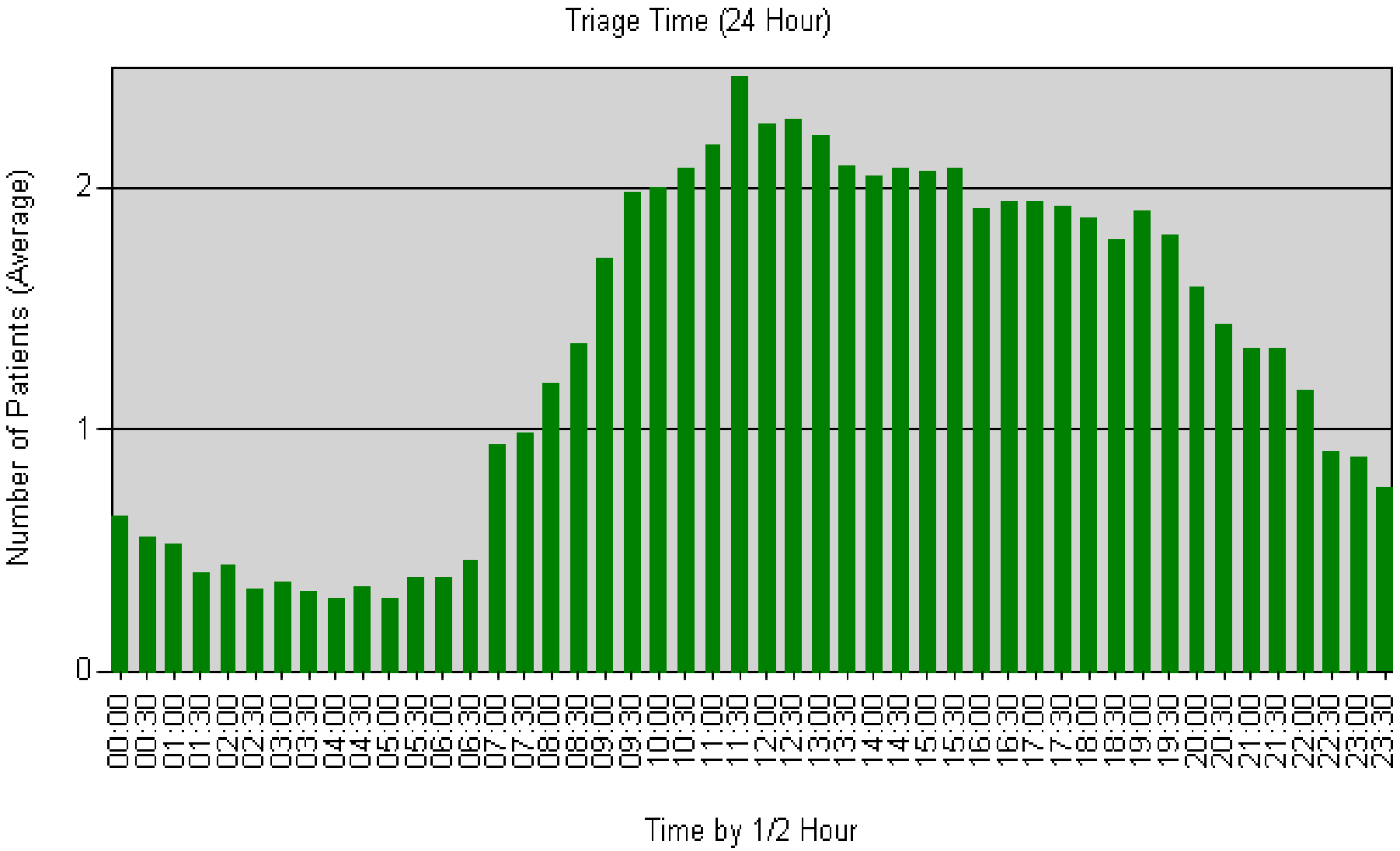
ED Benchmarks

Arrival to triage	6 min
Triage to room	23 min
Arrival to MD	53 min
Arrival to admit	253 min
Arrival to discharge	139 min
Lab turnaround	49 min
Radiograph turnaround	47 min
LWOT	2.3%
Pts per MD hour	2.25 pts/hr

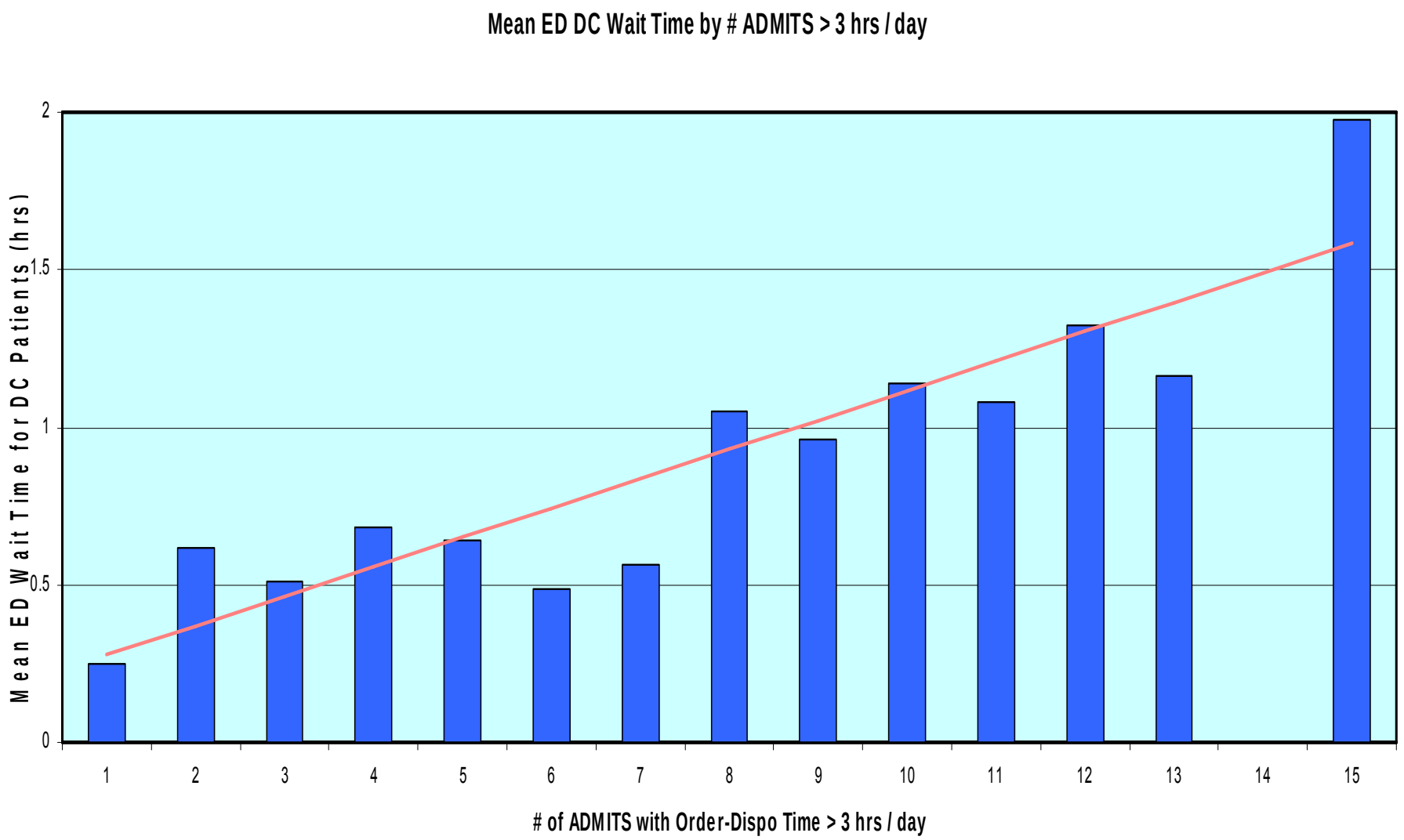
Annual Service Demand Mapped to Week of Year



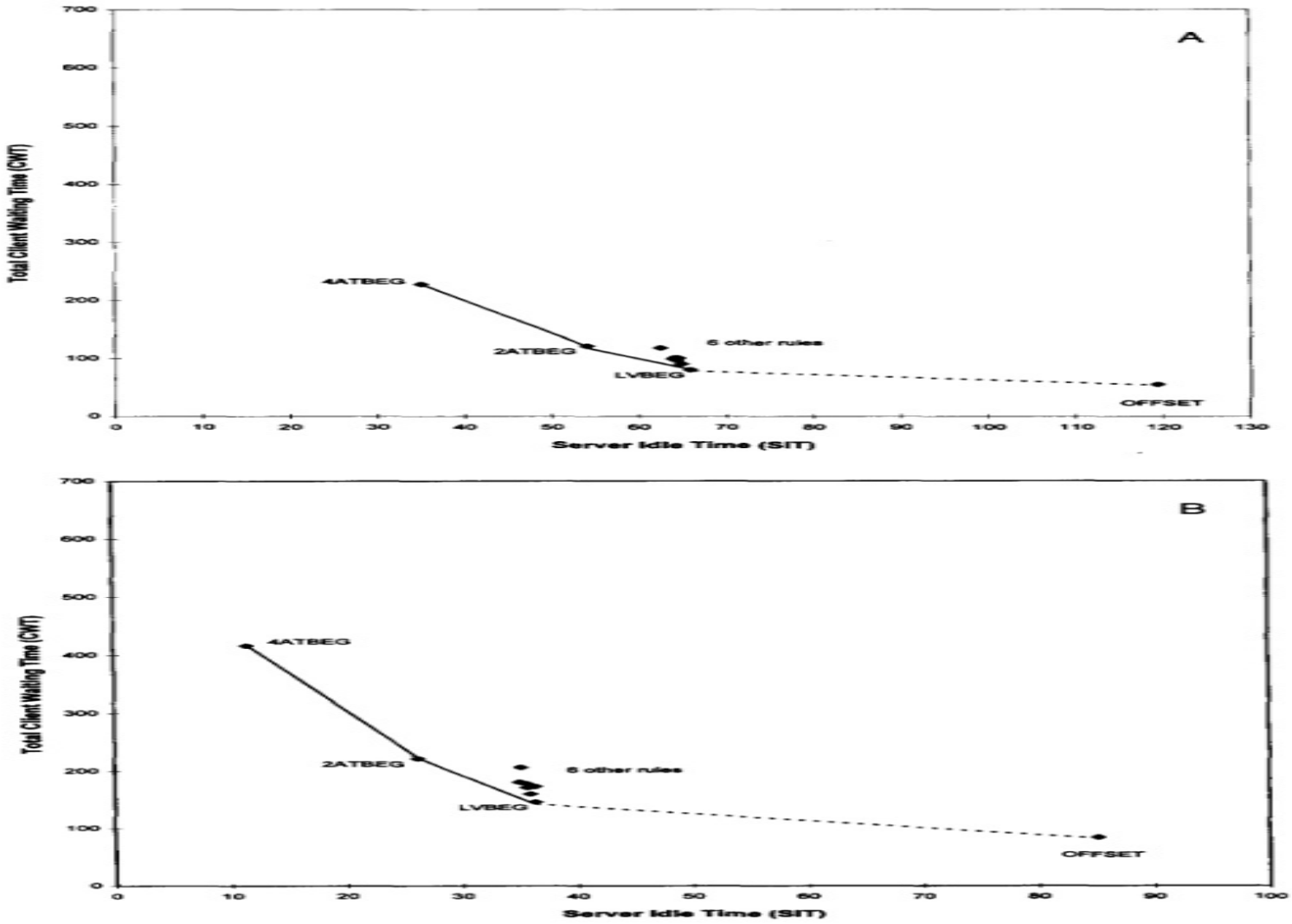
Average Hourly Demand



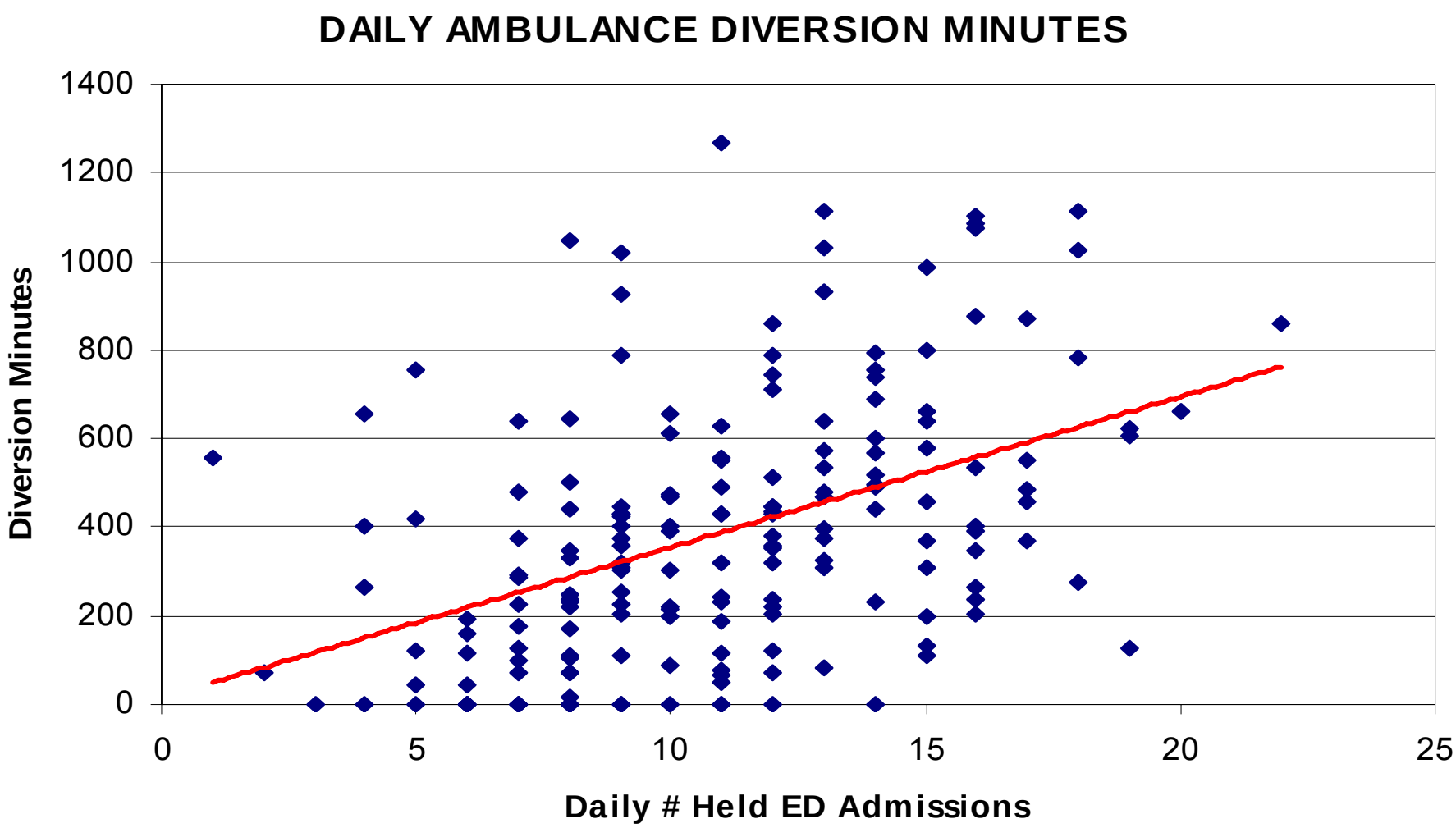
Mean ED Wait Times by # of Admits



Patient's Waiting Time vs. Doctor's Idle Time



Ambulance Diversion – Impact of Delayed Admits



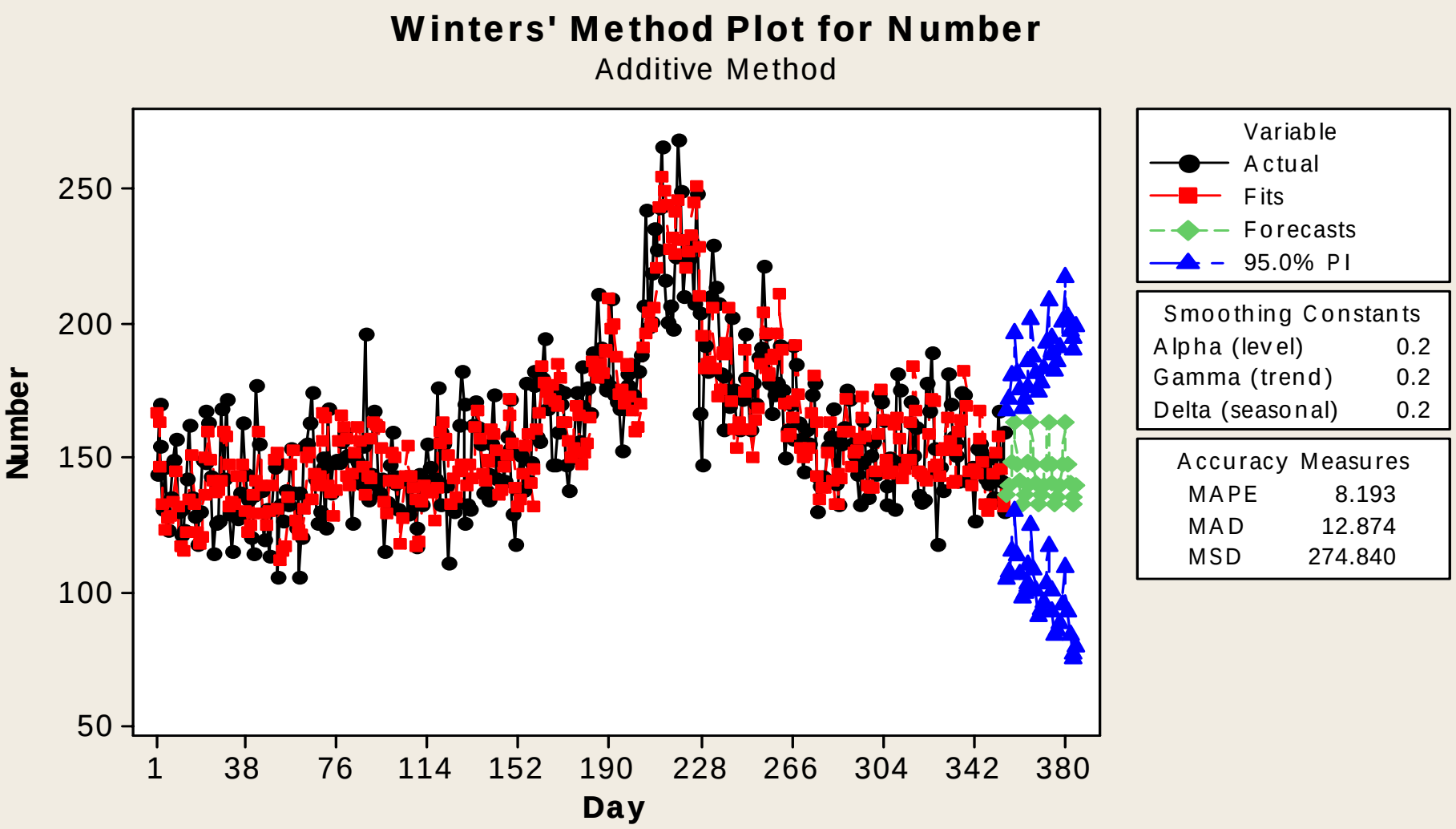
Predictive Modeling

- AutoRegressive Moving Average (ARIMA)
- Exponential Smoothing Models
- Poisson regression Models
  - All assume Gaussian Process
  - But there is obvious interaction in ED Demand

Modeling Inputs

- Data Mining 24 months of patient demand by:
  - DX
  - Patient Characteristics
  - Were patients idled within ED
  - Were staff idled within ED
  - "Feeder" institution data (e.g. County Mental Health discharges)
  - ***Readmission within 24 hours of discharge***

Bending Light: Winters Methods Added to an ARIMA Model



When Staffed to Predicted Demand

- Reduction of 24 hour readmits reduced by32%
- Non-compliance staffing ratio reduced from 16% to 0%
- Diversions reduced from 16% to 3%
- Non-Emergent patients referred to FDQC's

Field Study 2: Service Demand Modeling and Primary Care Screening Ordering

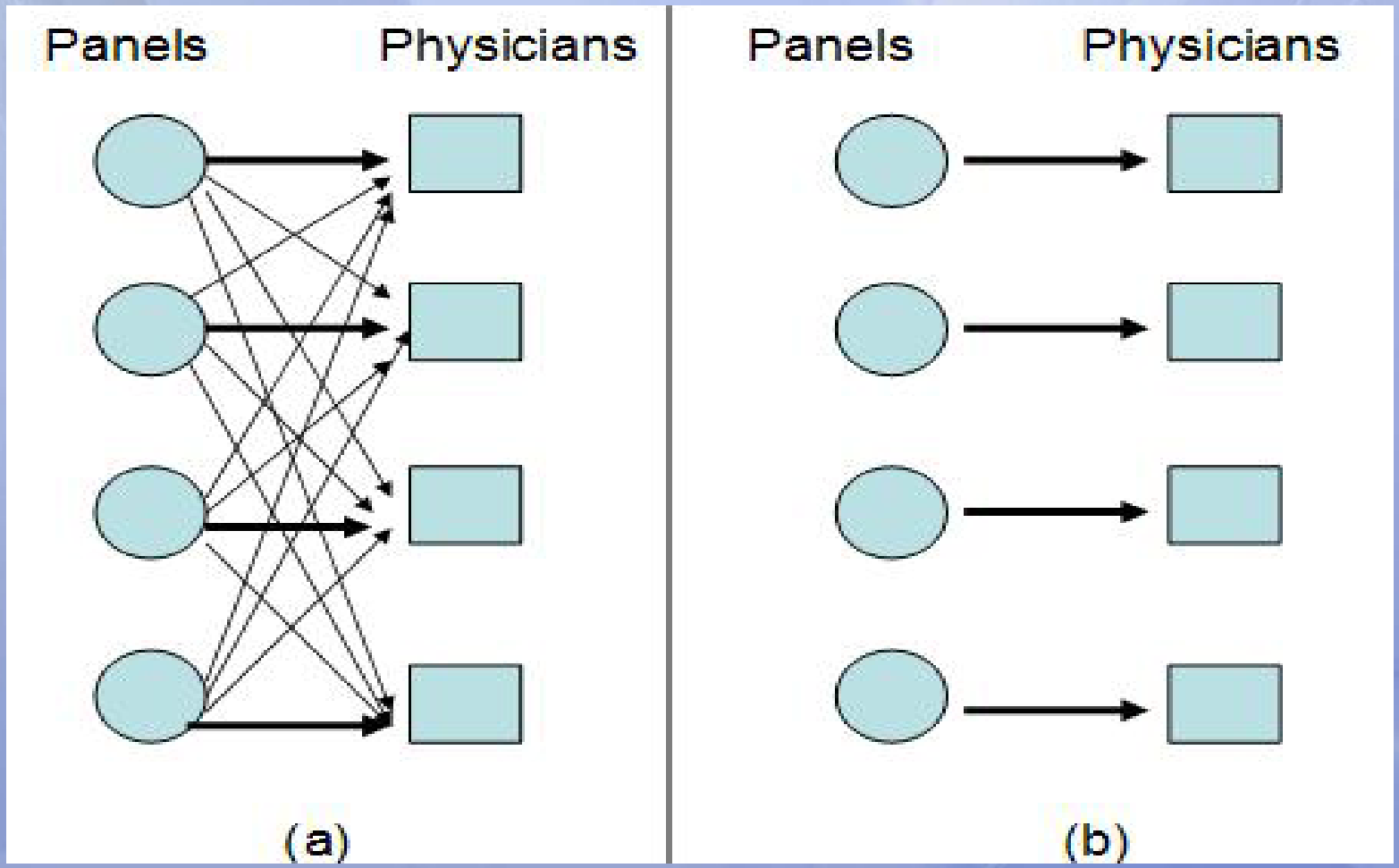
- It is standard of Care to Provide Diabetic Pt's routine, scheduled screening tests
  - Eye Exam
  - Ha1C
  - Lipid Screening
  - Foot Exam
- National Average is about 73% for any 1 item- less then 45% for all items
- Significant impact on Patient Health
- Major Pay-for-Performance Measure

The Moving Parts

Finite appointment slots and fixed individual provider times

- Permitting indiscriminate visits with any GIM physician is expensive
  - takes longer
  - May not identify unique characteristics of patient-e.g. antibiotic response
- Requiring Urgent visits with PCP *only* is not feasible
- GIM exists within a larger Medical Group
  - There is an ED

The Two Common Models



The Moving Parts: Capacity Allocation for Two Stream Demand

Scheduled and Urgent

- Each has different patient requirements for timeliness and continuity
  - Scheduled is Deterministic
  - Urgent is Stochastic
- Each has different cost-structures and revenue

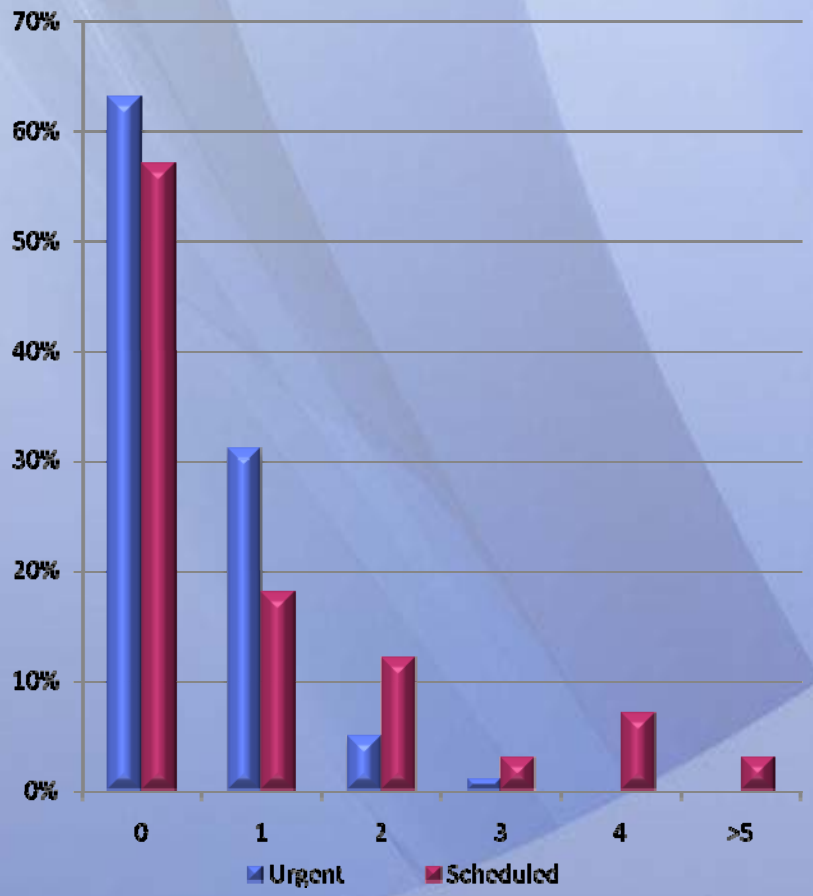
Analyzing Demand-Urgent Care

- Size of provider panel
- Complexity of panel
  - Age
  - Chronic condition
  - Health Expectations
  - Copay structure
- Sub-set Patient demand Characteristics

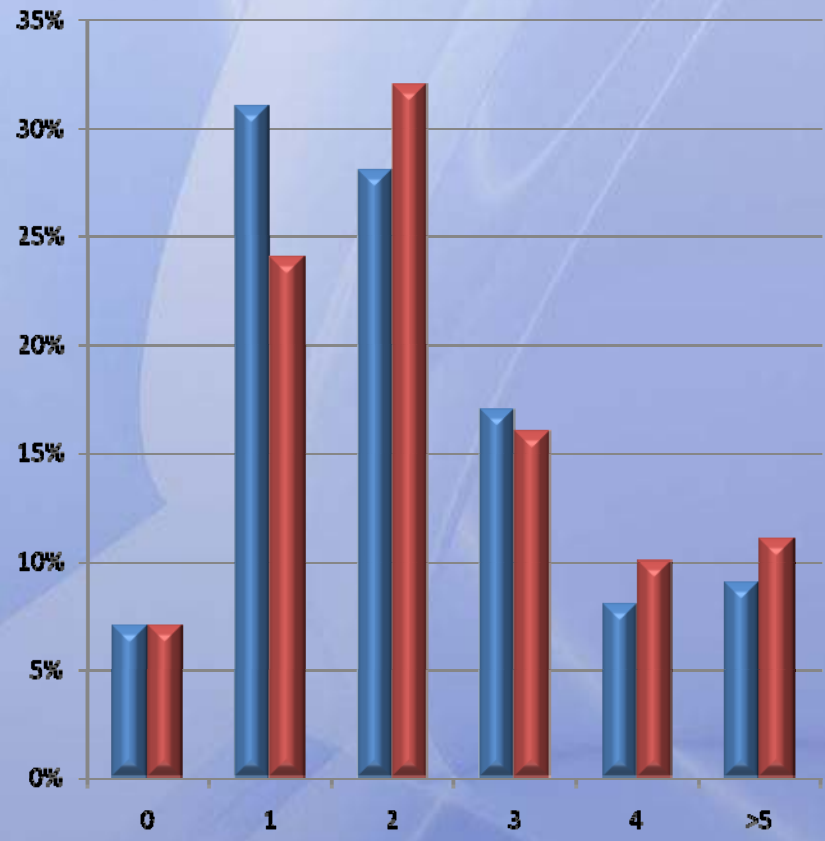
An Example from an Academic Medical Center in Dan Diego

- Group1:Women < 50 yrs of age with no chronic condition
  - Low demand and mostly for urgent care appointments –
- Group 2: Anyone over 69 with chronic heart disease
  - High demand -mostly for scheduled appointments with a seasonal spike in

Type and Volume of Visits-2009



Healthy Women < 50

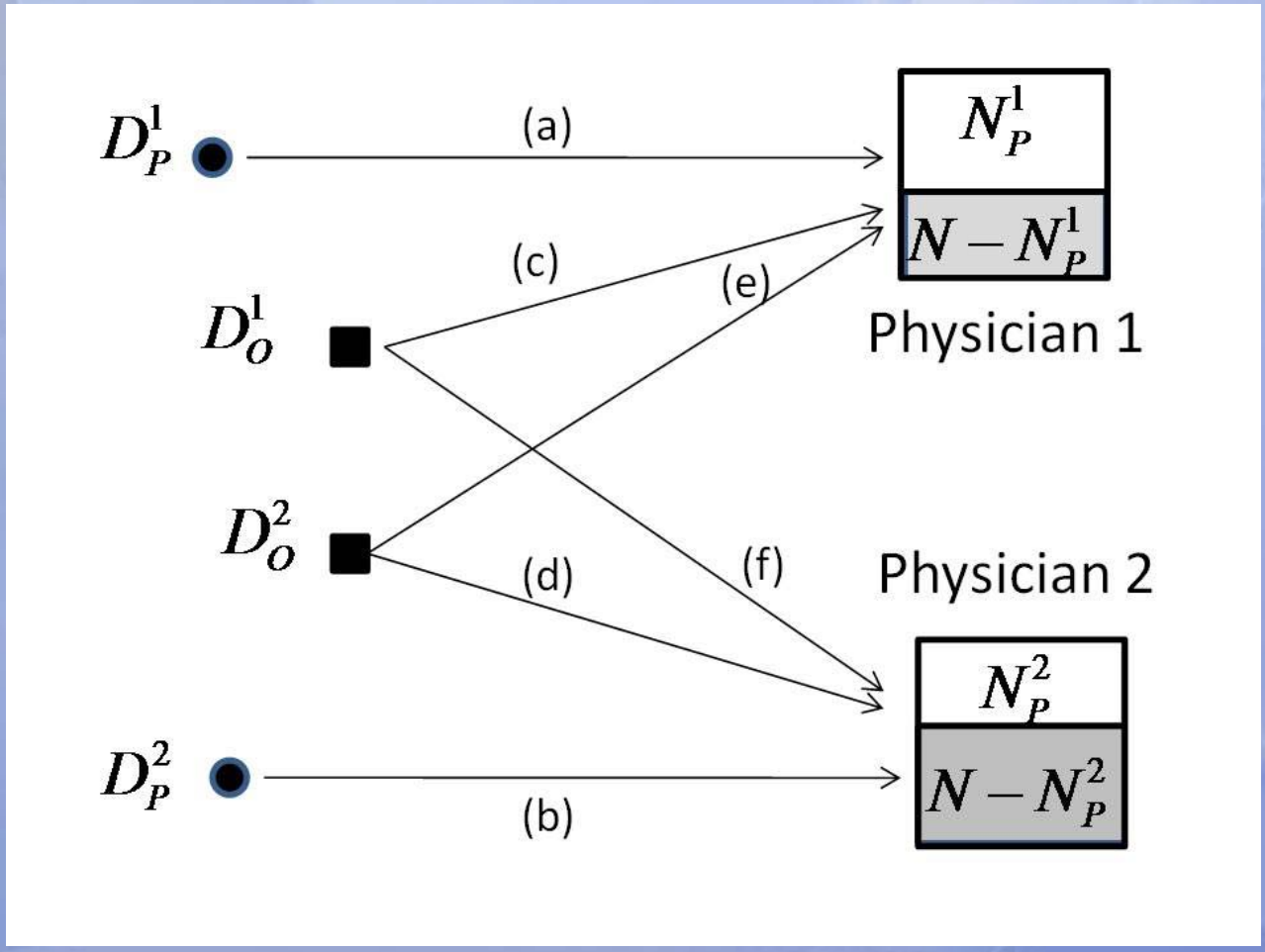


Chronic Illness > 69

Decision Process: Appointment Booking Policies

1) Strategic - Build the Patient-Physician relationship through access
2) Tactical, reserve XX daily slots for open access patients and anticipate future appointments up to the remaining slots
3) Operational level, appointments for daily open access demand given dynamically

Third Model: Partial Flexibility Chained Scheduling



Mathematical Modeling

- N is the total daily capacity
- Np, decision variables (aka performance and philosophical constraints
- Dp demand for scheduled
- Do demand for urgent care

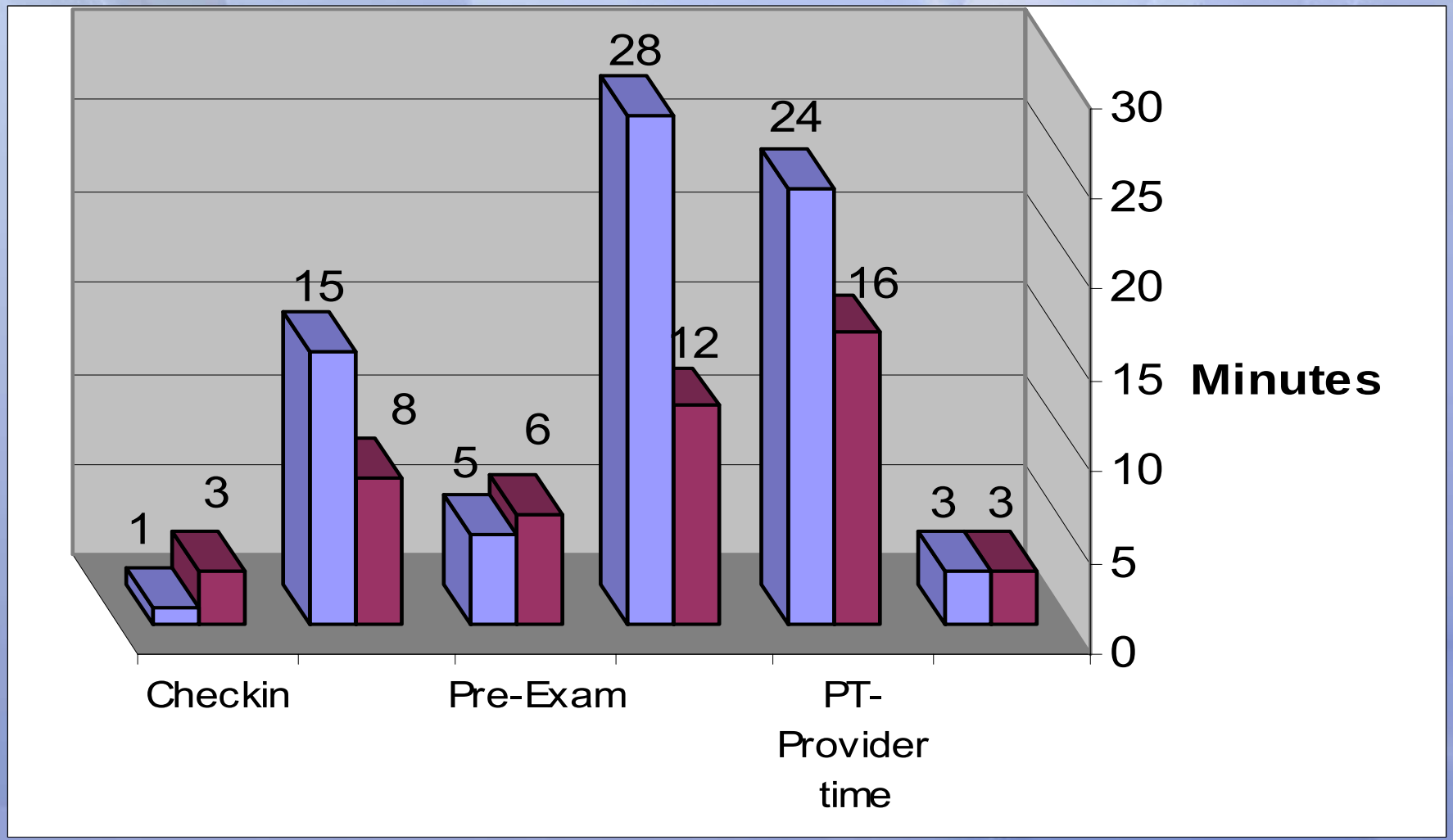
Creates

- MinNp cpE[Dp − Np]+ + coE[Do − (N − min(Np, Dp))]+

Results of Improved Scheduling: Adherence to Policy

	Baseline	Follow-up
Activity	**Frequency**	**Frequency**
Patient reports having been reminded of appt	31%	85%
Contact information verified at check-in	74%	92%
Patient visit terminated before seeing a Provider	3%	0%
Patient chart “pulled” by check-in/pre-exam	60%	86%
Health history taken	26%	86%
Influenza vaccination rate	43%	68%

Results of Improved Scheduling : Patient Throughput



Results of Improved Scheduling: Rate of Screenings

	Baseline	Follow-up
Ha1c	67%	93%
Lipid screening	63%	91%
Eye Exam	43%	84%
Foot Exam	37%	89%

Results of Improved Scheduling: Patient Satisfaction

	Baseline	Follow-up
Registration	3.0	4.2
Waiting Room	3.0	4.4
Waiting for Provider	3.0	4.2
Doc	4.0	5.0

Field Study 3:Operational Conditions Affecting Patient Understandings of Treatment

- 13% of Pediatric Transplant "fail" annually
  - failure to comply with treatment recommendations
- Traditional Studies of Non-Compliance Focus on difficult to change factors
  - Patient SES
  - Provider practice type
  - Patient-Provider communication style
- Little analysis of the structural determinants of "understanding"

Input: Uncontrolled Patient Arrival Patterns Determine Wait Times

- Traditionally assume patients arrive randomly (bell shaped curve peaking at appointment time)
  - Each patient's "timeliness" is independent of the other's
  - "Timeliness" is within patient control
  - Consistent arrival patterns throughout the day

Tardiness(GM): Johnson S_U fits well

Method: Moment matching

γ = -0.3099 δ = 1.432

λ 24.5789 ξ

= 25.03 = -19.02

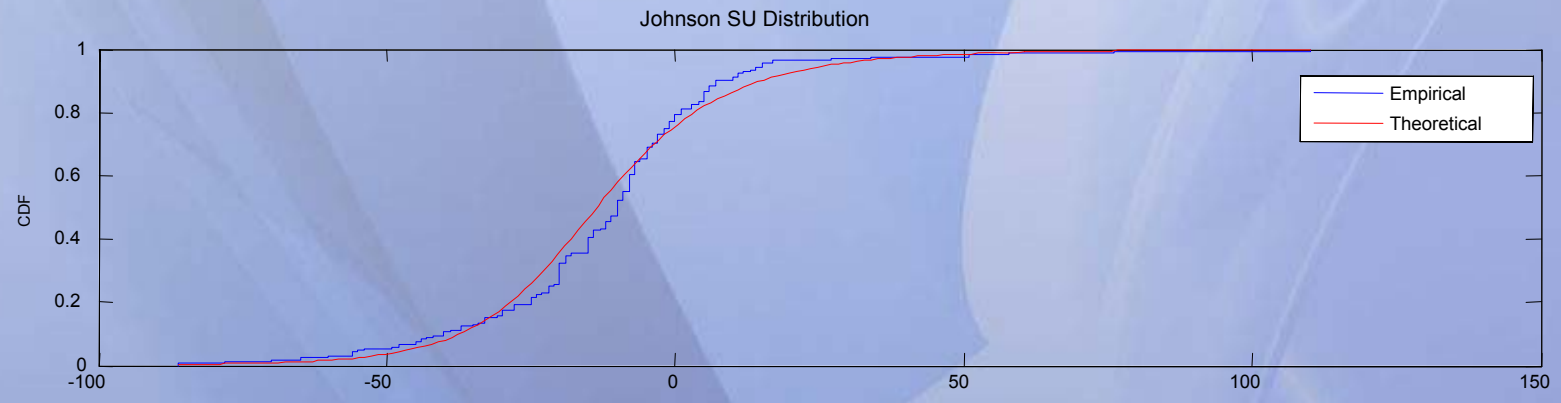
Goodness-of-fit tests

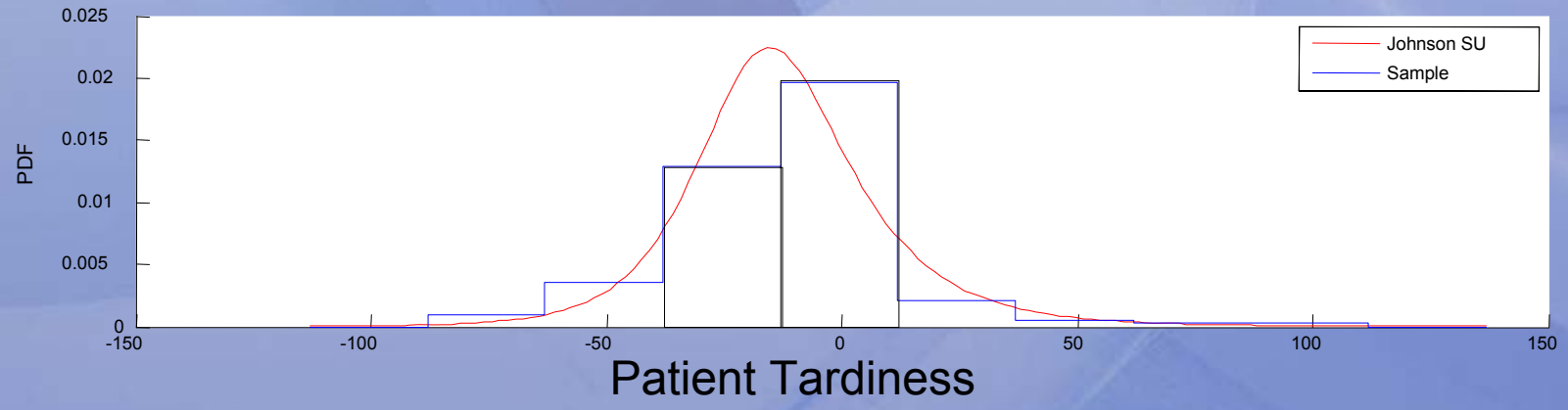
K-S statistic 0.1110

Significance probability 0.0296

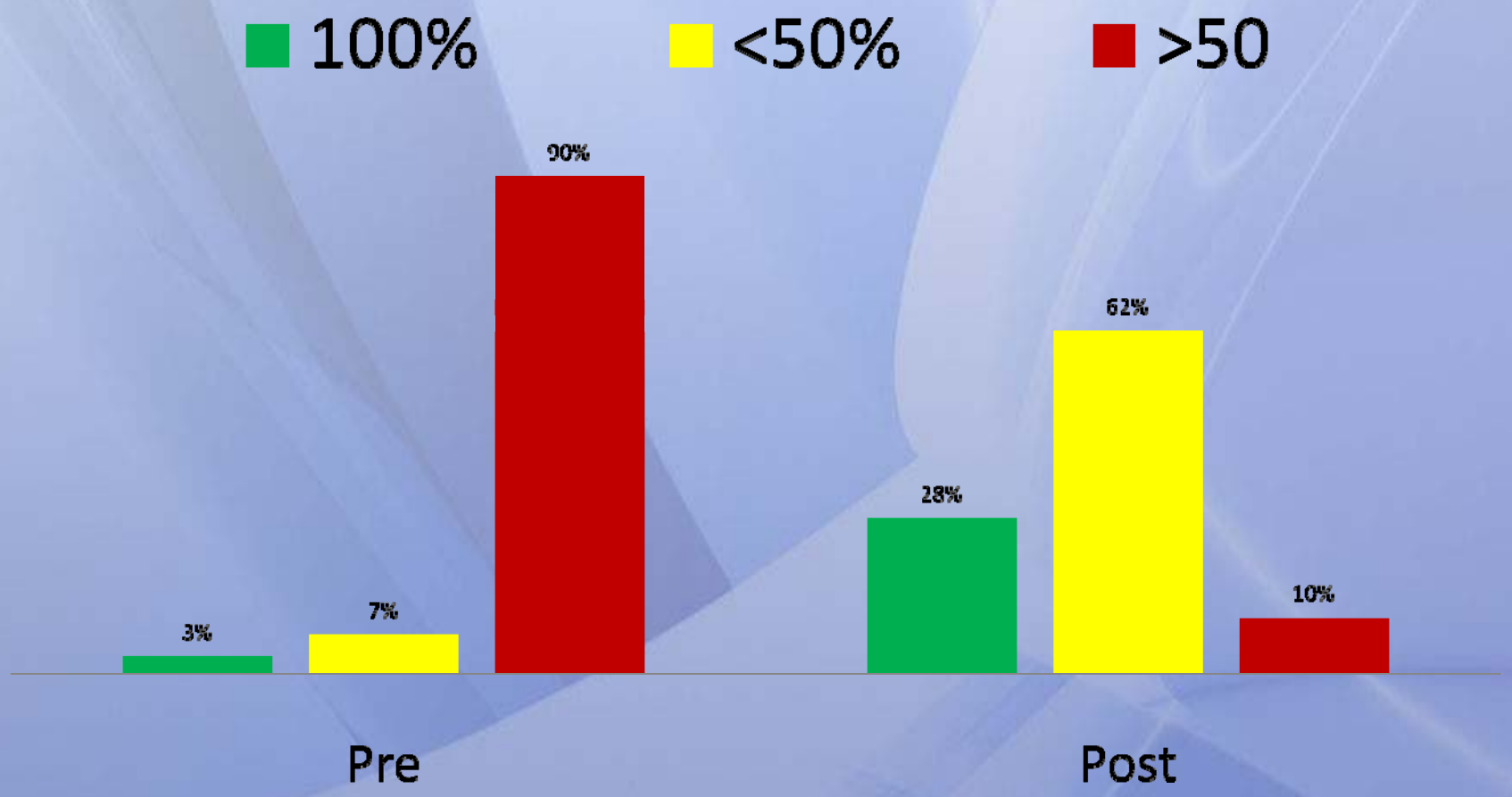
χ^2_{GOF} statistic

Significance probability 0.0009





Change in Patient Understanding of Provider Recommendations



Scheduling Optimization goals

1. Revenue
2. Patient throughput
3. Patient access
4. ***Fairness***

Results of Naïve Modeling

- Schedule using *Easy* First Five rule gives 10.8% decrease in total cost over present scheduling system
- If classification of patients into easy and hard is implemented, it can reduce total cost by more than 10% on average.