

# Operating Room Staffing and Allocation

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# Operating Room Staffing and Allocation



Franklin Dexter, M.D., Ph.D.

Director, Division of Management Consulting

Professor, Department of Anesthesia

University of Iowa

Franklin-Dexter@UIowa.edu

[www.FranklinDexter.net](http://www.FranklinDexter.net)

# Financial Disclosure

- I am employed by the University of Iowa, in part, to consult and analyze data for hospitals, anesthesia groups, and companies
- Department of Anesthesia bills for my time, and the income is used to fund our research
  - I receive no funds personally other than my salary and allowable expense reimbursements from the University of Iowa, and have tenure with no incentive program
  - I own no healthcare stocks (other than indirectly through mutual funds)

# Sequence of the Talk Based on Review Article

- What precisely is OR efficiency?
- OR efficiency applies to existing workload
- Review principles using scenarios
- Service-specific staffing based on OR efficiency
  - Important to use the statistical methods
  - How to use the statistical methods



# Sequence of the Talk Based on Review Article

- McIntosh C, Dexter F, Epstein RH. Impact of service-specific staffing, case scheduling, turnovers, and first case starts on anesthesia group and operating room productivity: tutorial using data from an Australian hospital.  
Anesthesia & Analgesia 103: 1499-1516, 2006



# Sequence of the Talk

- What precisely is OR efficiency?
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# Example of a Decision on Operating Room Staffing

- How many operating room teams should we plan in the Fall, on Mondays, in the “main surgical suite,” for orthopedics between 7 AM and 5 PM?



# Example of a Decision on Operating Room Staffing

- How many operating room teams should we plan in the Fall, on Mondays, in the "main surgical suite," for orthopedics between 7 AM and 5 PM?

Focus in on these words





# Example of a Decision on Operating Room Allocation

- How many operating room teams should we plan in the Fall, on Mondays, in the “main surgical suite,” for orthopedics between 7 AM and 5 PM?

All of the other words are the same for OR allocation



# ***Staffing and OR Allocation*** **are Synonymous**

- If staff are present to do a case in an OR, then the OR time has been allocated
  - OR time that is staffed but not allocated to a service has effectively been allocated to the open, first-come, first-served OTHER service
    - Different names at different facilities



# *Staffing and OR Allocation* are **Synonymous**

- If staff are present to do a case in an OR, then the OR time has been allocated
  - OR time that is staffed but not allocated to a **service** has effectively been allocated to the open, first-come, first-served OTHER service

Next definition



# *Service* Is the Unit of Operating Room Allocation

- *Service* can represent a ...
  - Surgical group
  - Department
  - Specialty
  - Surgeon
  - Any combination of the above
- If one or more surgeons is allocated OR time, he, she, or they is (are) a service



# *Service* Is the Unit of Operating Room Allocation

- *Service* can represent a ...
  - Surgical group
  - Department
  - Specialty
  - Surgeon
  - Any combination of the above
- If one or more surgeons is allocated OR time, he, she, or they is (are) a service
- Focus of talk is service-specific staffing



# Example of *Under-Utilized OR Time*

- Staffing is planned from 7 AM to 3 PM
- An OR's last case of the day ends at 1 PM
- There are 2 hr of *under-utilized OR time*
  - Under-utilized time is from 1 PM to 3 PM





# Under-Utilized OR Time Affects Adjusted Utilization

- Adjusted utilization =  $100\% - \frac{(\text{hours of under-utilized OR time})}{(\text{staffed hours of OR time})}$
- Just as adjusted utilization cannot exceed 100%, average hours of under-utilized OR time does not equal the OR allocation minus the average hours of cases



# Example of *Over-Utilized OR Time*

- OR staffing is planned from 7 AM to 3 PM
- OR's last case of the day ends at 6 PM
- There are 3 hr of *over-utilized OR time*
  - Over-utilized OR time is from 3 PM to 6 PM

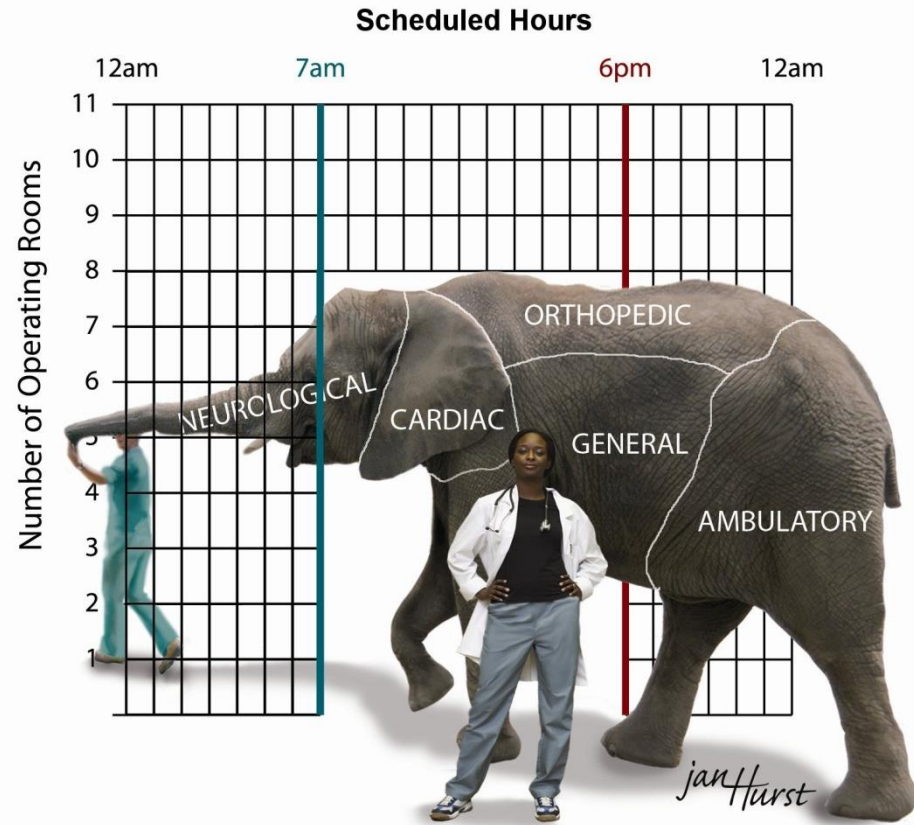
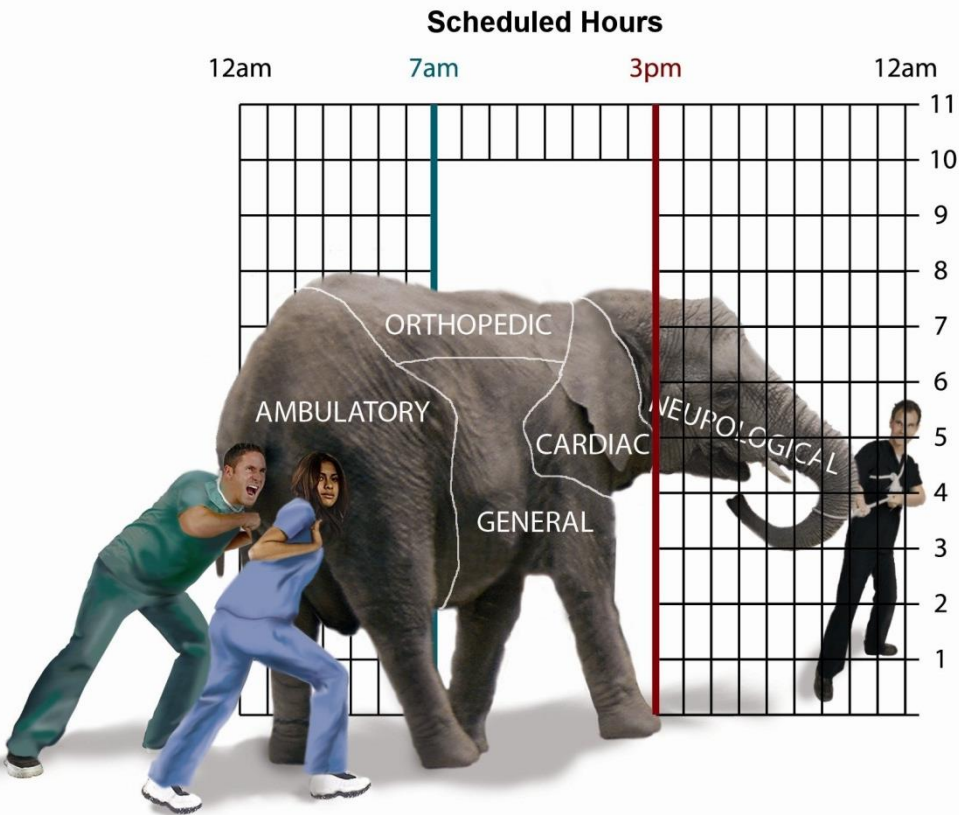


# Precise Meaning of *Maximize OR Efficiency*

Inefficiency of use of OR time (\$) =  
(Cost per hour of under-utilized OR time)  
× (hours of under-utilized OR time)  
+ (Cost per hour of over-utilized OR time)  
× (hours of over-utilized OR time)

Strum DP et al. J Med Syst 1997





“You are not going to get the elephant to shrink or change its size. You need to face the fact that the elephant is 8 OR tall and 11 hr wide.”

Steven Shafer, MD

# Sequence of the Talk

- What precisely is OR efficiency?
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# Allocating OR Time is a Two-Stage Process

- Tactical decisions determine initial increases in OR time allocations for each subspecialty
  - Rarely reductions, just increases or no changes
- Operational decisions based on OR efficiency fill the OR time once actual workload known
  - Adjust service-specific staffing
  - Schedule cases based on OR efficiency
  - Release allocated but unused OR time

Dexter F et al. Anesth Analg 2005





# OR Efficiency Applies to Operational Decision Making

- Operational decision making
  - How to get the existing cases done
  - Making decisions on the day of surgery
  - Scheduling cases
  - Planning staffing and OR allocations
- Operational decision making is almost never made based on financial criteria



# OR Efficiency Does Not Apply to Tactical Decision Making

- Tactical decision making
  - Decisions over many months to years
  - Invariably includes financial criteria
  - That is a different talk



# Planning Fixed “Blocks” of OR Time and Resources

- Based on total hours of cases (i.e., utilization)
- Based on revenue and variable costs
- Conceptual model for tactical decision making
- Very rarely used in practice for operational OR management decision making
  - Reason: Fixed hours means *literally* fixed
  - This does not and should not match the reality of operational decision making

Dexter F et al. Anesthesiology 1999



# OR Staffing, OR Allocation, and OR Efficiency

- Service has  $9.5 \pm 3$  hr (SD) of elective cases including turnover times on Mondays
- Why the cases are done is irrelevant, as OR allocation problem is whether to staff for 8 hr, 10 hr, 13 hr, or 16 hr
- OR efficiency differs depending on the OR staffing and allocation, not the workload
  - OR efficiency is an operational concept, not related to tactical decision making



# Surgeons Have Open Access to OR Time on Any Future Workday

- From an operational perspective, surgeons schedule cases on any future workday
- Major limitation is what can be done safely
- Future slides will show that *in practice* this is what is used almost everywhere for *operational* OR management decisions





# Open Access Case Scheduling Is Current Practice (Example 1)

- Dr. Jones has been allocated 8 hours of OR time every Friday for the past decade
  - Staffed hours are 7 AM to 3 PM
- Dr. Jones always underestimates the durations of his cases
- Dr. Jones never finishes before 5 PM and usually ends between 6 PM and 7 PM





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- Make a list of services at your facility who schedule cases like Dr. Jones



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- Dr. Jones always underestimates the durations of his cases
- Dr. Jones never finishes before 5 PM and usually ends between 6 PM and 7 PM
- Dr. Jones is, in practice, scheduling his cases on any future workday



# Open Access Case Scheduling Is Current Practice (Example 1)

- Planning staffing from 7 AM – 7 PM, instead of 7 AM – 3 PM, increases OR efficiency
  - Reduction in hours of over-utilized OR time
- This is not providing increased OR resources (OR time) to Dr. Jones
  - Doing so would be tactical, not operational



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- Planning staffing from 7 AM – 7 PM, instead of 7 AM – 3 PM, increases OR efficiency
  - Reduction in hours of over-utilized OR time
- This is not providing increased OR resources (OR time) to Dr. Jones
  - Doing so would be tactical, not operational
- If not applying Open Access, on day of surgery would often cancel Dr. Jones' last case



# Open Access Case Scheduling Is Current Practice (Example 2)

- University Hospital's staffing for General Surgery is 2 ORs, 7 AM to 5 PM Mon-Fri
- No case is scheduled unless it will fit into the 10 hr based on historical case duration data
- General Surgery schedules 20% of its cases as add-on or urgent
  - Yet, patients could safely wait days for surgery





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- Make a list of services at your facility who schedule cases like General Surgery





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  - Yet, patients could safely wait days for surgery
- General Surgery is, in practice, scheduling its cases on any future workday



# Open Access Case Scheduling Is Current Practice (Example 2)

- Increase OR allocations (staffing) to match the reality of existing OR workload
  - Reduces over-utilized OR time with minimal or no increase in under-utilized OR time
  - Increases OR efficiency
- Operational change, not tactical
  - Open Access changes *when* a case gets done, not total workload



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- Increase OR allocations (staffing) to match the reality of existing OR workload
  - Reduces over-utilized OR time with minimal or no increase in under-utilized OR time
  - Increases OR efficiency
- Operational change, not tactical
  - Open Access changes *when* a case gets done, not total workload
  - Without Open Access, many inpatients (preoperatively) would wait days for surgery

# Open Access Case Scheduling Is Current Practice (Example 3)

- Physicians at a hospital are salaried employees of the health care system
- Staffing is planned from 8 AM to 5 PM
- As per official policy, surgeons schedule almost all cases for 8 AM to 5 PM
  - Unlike General Surgery of Example 2, most of the add-on cases are added day of surgery



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- Make a list of services at your facility who schedule cases like these physicians





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- Physicians at a hospital are salaried employees of the health care system
- Staffing is planned from 8 AM to 5 PM
- As per official policy, surgeons schedule almost all cases for 8 AM to 5 PM
  - Unlike General Surgery of Example 2, most of the add-on cases are added day of surgery
- The surgeons are, in practice, scheduling their elective cases on any future workday



# Open Access Case Scheduling Is Current Practice

- Functional meaning of Open Access
  - Cancel case on day of surgery only for safety
  - Schedule cases for patients in hospital preoperatively on working day before surgery
  - Schedule add-on cases also on day of surgery



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- Principle applies only to how anesthesia & nursing handle case scheduling from late 2 workdays before surgery to day of surgery



# Open Access Case Scheduling Is Current Practice

- Functional meaning of Open Access
  - Cancel case on day of surgery only for safety
  - Schedule cases for patients in hospital preoperatively on working day before surgery
  - Schedule add-on cases also on day of surgery
- Principle applies only to how anesthesia & nursing handle case scheduling from late 2 workdays before surgery to day of surgery
- Applies even at facilities that only do elective cases during limited hours



# Open Access Case Scheduling Makes Economic Sense in US

- Average hospital in Iowa had the majority of its growth in inpatient and outpatient cases from one year to next among surgeons who performed  $N \leq 2$  cases per *week* in the baseline year ( $77.0\% \pm 2.5\%$  [SE])
- Majority of the growth in outpatient surgery Relative Value Units was among those surgeons ( $81.9\% \pm 2.2\%$ )

Dexter et al. J Clin Anesth 2018





# Open Access Case Scheduling Makes Economic Sense in US

- Hospital 1 with annual loss \$114 million
- Hospital 2 with positive operating margin

Macario A et al. Anesth Analg 2001

Dexter F et al. Anesth Analg 2002

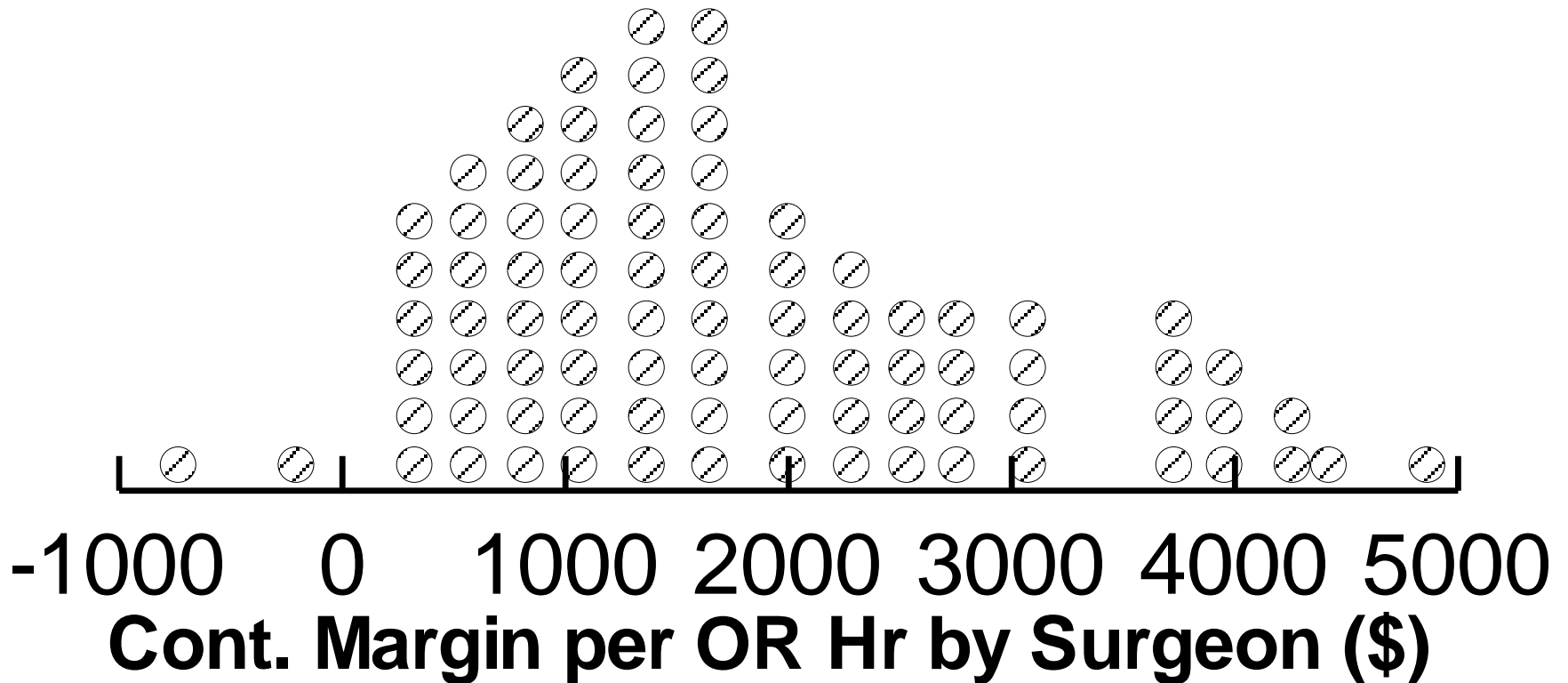


# Open Access Case Scheduling Makes Economic Sense in US

- Methodology
  - Limit to outpatient and same day admit cases, since once patient is admitted want no delay
  - Operating room time used by each surgeon from operating room information system
  - Overall contribution margin for each surgeon from hospital accounting information system
  - Make a graph with one circle for each surgeon

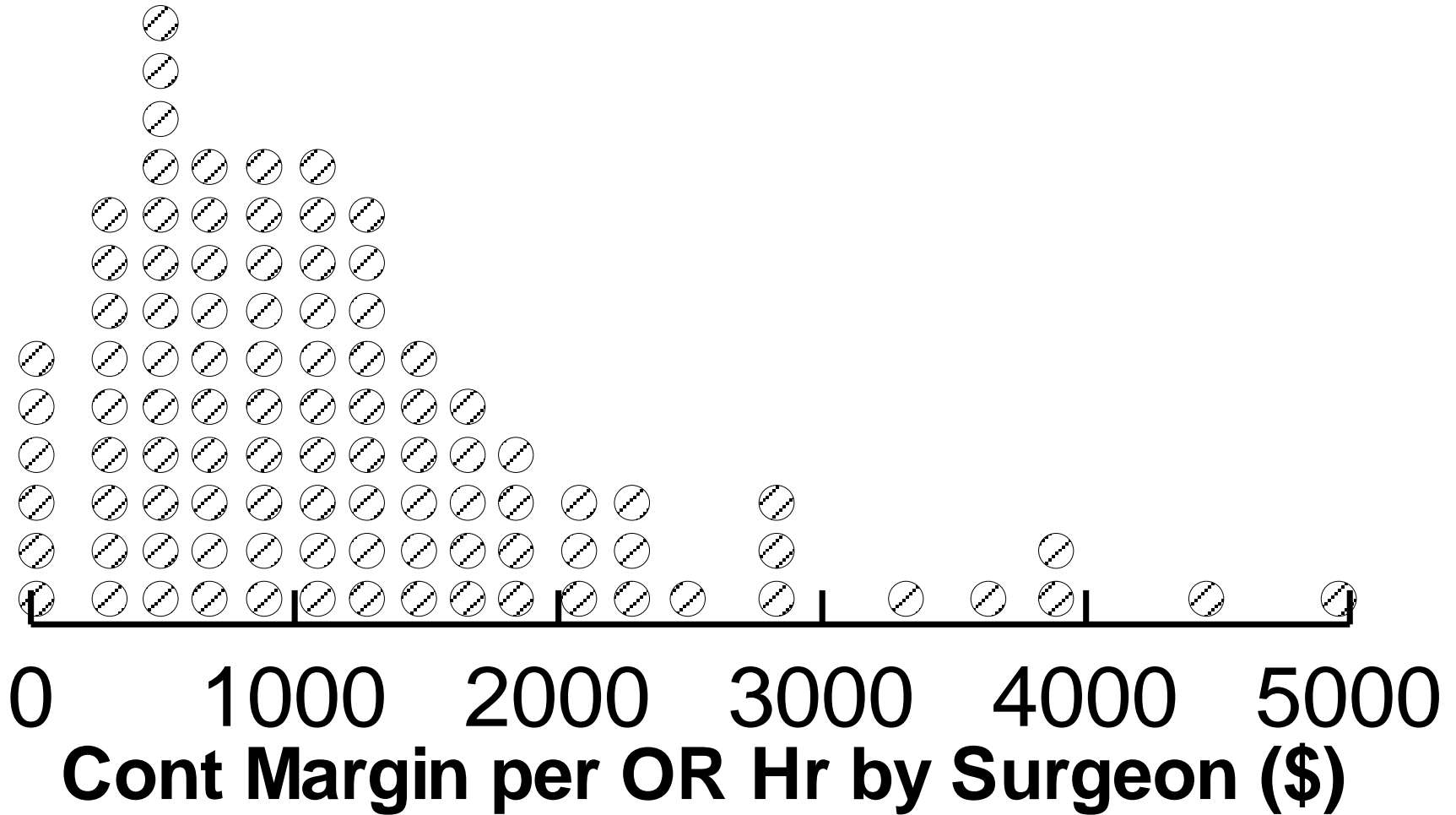


# Hospital Losing Money Has + Cont. Margin For 97% Surgeons



**Cont. Margin = Revenue - Variable Costs**

# Other Hospital Positive Contribution Margin all Surgeons



# There Are Exceptions For Some Procedures

- At some hospitals, for some surgeons, contribution margin is consistently negative for some procedures because of implants
- Time and the place to address this is not at the OR nursing desk when Mrs. Yu is being scheduled as an add-on case
  - Since operational decision-making is not based on financial criteria, it needs to be economically rationale for the average case





# Interpretation of Finding for Operational Decision-Making

- Since contribution margin is positive, it makes economic sense to do cases
  - If you can do the case safely, do the case



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- However, safety is a large practical limit



# Interpretation of Finding for Operational Decision-Making

- Since contribution margin is positive, it makes economic sense to do cases
  - If you can do the case safely, do the case
- However, safety is a large practical limit
  - Safety includes limited ICU beds, hospital ward beds, PACU beds, fluoroscopy equipment, non-fatigued staff, implants, ...
  - ***Tactical planning*** sets these and other capital planning (capacity) constraints



# Allocating OR Time 1<sup>st</sup> Tactically and 2<sup>nd</sup> Operationally

- Tactical – next lecture
  - Dr. Jones (Example 1), with 1 OR every Friday
  - Has financial implications (do by surgeon)
  - Affects surgical practices' schedules and growth
- Operational – this lecture
  - Nursing and anesthesia staffing planned to 7 PM to match Dr. Jones' workload
- If operational decisions were affecting Dr. Jones, he would usually be done by 3 PM



# Understanding Operational Decision Making Is Important

- Implication for operations research is that staffing is appropriately planned separately for each combination of surgical suite, service, and day of the week
  - At most outpatient facilities and smaller hospitals, the staffing decision involves only 1 to 3 choices
    - Staff an OR for 8 hr, 10 hr, or 12 hr





# Understanding Operational Decision Making Is Important

- Most of the surgeons in a department are away at their national conference
- There is substantial under-utilized OR time
- Who is responsible for the poor OR efficiency?
  - Is this an example of the surgeons' lack of responsibility for hospital resources?
  - Is this an example of bad management?



# Understanding Operational Decision Making Is Important

- Fixed hours of OR time (tactical perspective)
  - Surgeons are responsible for increasing OR efficiency by *scheduling* their cases into their block time
- Maximizing OR efficiency (operational)
  - Managers are responsible for increasing OR efficiency by adjusting *staffing* to match the surgeons' and patients' hours (e.g., 8 or 13 hr)
  - Managers have responsibility and authority



# Understanding Operational Decision Making Is Important

- Fixed hours of OR time
  - Surgeons are responsible for increasing OR efficiency by *scheduling* their cases into their block time
- Maximizing OR efficiency
  - Managers are responsible for increasing OR efficiency by adjusting *staffing* to match the surgeons' and patients' hours (e.g., 8 or 13 hr)
  - Managers have responsibility and authority

Rest of talk



# Sequence of the Talk

- What precisely is OR efficiency?
- OR efficiency applies to existing workload
- Review principles using scenarios
- Service-specific staffing based on OR efficiency
  - Important to use the statistical methods
  - How to use the statistical methods



# Increasing OR Efficiency Can be Applied to ...

- Staffing and OR allocations
- Scheduling elective cases
- Sequencing elective cases
- Releasing allocated OR time
- Scheduling delays between surgeons' cases
- Scheduling add-on cases
- Assigning and relieving staff
- Moving cases on the day of surgery
- Sequencing urgent cases





# ***Statement is Not Intuitively Obvious – Why do Math***

- Staffing and OR allocations
- Scheduling elective cases
- Sequencing elective cases
- Releasing allocated OR time
- Scheduling delays between surgeons' cases
- Scheduling add-on cases
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# Next Several Slides Show Over-Simplified Scenarios

- Scenarios will not seem like your facility
- Scenarios ignore uncertainty in case duration
- Lecture is not how scenarios are truly used
  - Although the concepts apply everywhere, every facility is an exception to a description
  - Adapt scenarios to provide appropriate OR names, employee types, times of the day, units of OR allocation, surgeon names, equipment limiting what cases can be scheduled, etc.



# Generate Adapted Scenarios for Organizations

## Surgical suite

Export 3-12 months  
of OR information  
system data

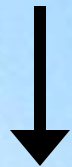
## Science

100+ scenarios, with  
explanations, showing how  
to make decisions based  
on OR efficiency

# Generate Adapted Scenarios for Organizations

## Surgical suite

Export 3-12 months of OR information system data



## Math

Pick appropriate ORs, names, blocks, & times for each scenario

## Science

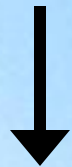
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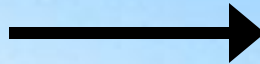
## Surgical suite

Export 3-12 months of OR information system data



## Math

Pick appropriate ORs, names, blocks, & times for each scenario



## Science

100+ scenarios, with explanations, showing how to make decisions based on OR efficiency

## Examples with cues

Adapted materials to elicit how decisions are being made



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- OR nurses, nurse anesthetists, and anesthesiologists are full-time employees
- Staffing is planned from 7 AM to 3 PM
- There is estimated to be 9 hr of cases
- Anesthesiologist gets every IV first stick, A lines and C lines first stick, and does a fiberoptic intubation in 8 minutes
- The OR finishes at 3 PM
- Has anesthesiologist increased OR efficiency?



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- OR nurses, nurse anesthetists, and anesthesiologists are full-time employees
- On the day of surgery, the cost of an hour of under-utilized OR time is negligible relative to the cost of an hour of over-utilized OR time



# Meaning of Maximizing OR Efficiency on Day of Surgery

Inefficiency of use of OR time (\$)  $\cong$   
~~(Cost per hour of under-utilized OR time)~~  
× (hours of under-utilized OR time)  
+ (Cost per hour of over-utilized OR time)  
× (hours of over-utilized OR time)

Dexter F, Traub RD. Anesth Analg 2002



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- Implication
  - Maximize OR efficiency on the day of surgery by minimizing hours of over-utilized OR time



# Meaning of Maximizing OR Efficiency on Day of Surgery

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 $\times$  (hours of over-utilized OR time)

Constant

- Implication
  - Maximize OR efficiency **on the day of surgery** by minimizing hours of over-utilized OR time



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- Scenario
  - Staffing is planned from 7 AM to 3 PM
  - Fast anesthesiologist finished cases in 8 hr instead of in the expected 9 hr
  - Fast anesthesiologist increased OR efficiency by preventing 1 hr of over-utilized OR time



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- OR nurses, nurse anesthetists, and anesthesiologists are full-time employees
- Staffing is planned from **7 AM to ~~3 PM~~ 5 PM**
- There is estimated to be 9 hr of cases
- Anesthesiologist gets every IV first stick, A lines and C lines first stick, and does a fiberoptic intubation in 8 minutes
- The OR finishes at 3 PM
- **Has anesthesiologist increased OR efficiency?**



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- Scenario

- Staffing is planned from ~~7 AM to 3 PM~~ **5 PM**
- Fast anesthesiologist finished cases in 8 hr instead of in the expected 9 hr
- Fast anesthesiologist ~~increased~~ *did not increase* OR efficiency





# Scenario 1 – Can Working Fast Increase OR Efficiency?

- Scenario

- Staffing is planned from ~~7 AM to 3 PM~~ **5 PM**
- Fast anesthesiologist finished cases in 8 hr instead of in the expected 9 hr
- Fast anesthesiologist ~~increased~~ *did not increase* OR efficiency

Value of clinician activity is very sensitive to the OR allocations. I consider each issue of clinician “motivation” to be a failure of statistical forecasting (allocations) until proven otherwise.

# Scenario 2 – Anesthesiologist Reduces Turnover Times

- Staffing is planned from 7 AM to 3 PM
- Anesthesiologist is assigned to supervise resident physicians in OR 1 and OR 2
- These ORs have just finished their first cases
- The last case of the day in OR 1 is expected to be finished at 2:30 PM
- The last case of the day in OR 2 is expected to be finished at 4:30 PM
- Which OR should anesthesiologist start next?



# Scenario 2 – Anesthesiologist Reduces Turnover Times

- *Patient safety* is unaffected by decision
- Open *access* is unaffected by the decision
- *OR efficiency*
  - OR 1 expected 0 over-utilized hours
  - OR 2 expected 1.5 over-utilized hours
- If the patient for OR 2 is ready, the anesthesiologist should start OR 2 first



# Scenario 2 – Anesthesiologist Reduces Turnover Times

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- Which OR should anesthesiologist start next?



# Scenario 2 – Anesthesiologist Reduces Turnover Times

- *Patient safety* is unaffected decision
- Open *access* is unaffected by decision
- *OR efficiency* is unaffected by decision
  - OR 1 expected 0 over-utilized hours
  - OR 2 expected ~~1.5~~ **0** over-utilized hours
- *Patient waiting* is unaffected by decision
  - Last case of the day in both ORs
- *Professional satisfaction* may be affected
  - Whatever anesthesiologist thinks best





# Scenario 2 – Anesthesiologist Reduces Turnover Times

- Moral
  - Good (rational) OR management operational decision-making is highly sensitive to the service-specific staffing, and requires knowing the service-specific staffing
  - System fails well-intentioned individuals if the OR allocations are not calculated appropriately



# Scenario 3 – Case Scheduling to Maximize OR Efficiency

- Staffing planned for Ophthalmology Associates is OR 1 and OR 2 from 7:15 AM to 3:30 PM
- Dr. Smith has scheduled cases in OR 1 that are scheduled to finish at 2 PM
- OR 2 is empty
- Dr. Reynolds wants an afternoon start
  - She asks to start an elective 3-hour case at 3 PM in OR 1
- Schedule the case into OR 1?



# Scenario 3 – Case Scheduling to Maximize OR Efficiency

- Starting the case at 3 PM would be expected to result in over-utilized OR time, thereby reducing OR efficiency
- Options available to Dr. Reynolds:
  - Take first case of the day start in OR 2
  - Choose a different workday



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# Scenario 3 – Case Scheduling to Maximize OR Efficiency

- Starting the case at 3 PM would be expected to result in over-utilized OR time, thereby reducing OR efficiency
- Options available to Dr. Reynolds:
  - Take first case of the day start in OR 2
    - Most facilities do not schedule an OR with over-utilized OR time when another allocated OR is empty
  - Choose a different workday





# Scenario 3 – Case Scheduling to Maximize OR Efficiency

- Starting the case at 3 PM would be expected to result in over-utilized OR time, thereby reducing OR efficiency
- Options available to Dr. Reynolds:
  - Take first case of the day start in OR 2
  - Choose a different workday
    - She has OR time available every workday



# Scenario 3 – Case Scheduling to Maximize OR Efficiency

- Starting the case at 3 PM would be expected to result in over-utilized OR time, thereby reducing OR efficiency
- Options available to Dr. Reynolds:
  - Take first case of the day start in OR 2
  - Choose a different workday
    - She has OR time available every workday

**Must** get OR allocation right to PREVENT this scenario. Every case scheduling conflict is failure of OR allocation until proven otherwise.

# Scenario 4 – Reduce Turnover Times to Increase OR Efficiency?

- Outpatient Surgery Center with 6 ORs, all staffed from 7 AM to 5 PM
- Mean ORs in use before intervention
  - 2 PM – 6 ORs
  - 3 PM – 5 ORs
  - 4 PM – 2 ORs
  - 5 PM – 0.2 ORs
- Mean ORs in use after intervention
  - 2 PM – 5 ORs
  - 3 PM – 4 ORs
  - 4 PM – 1 ORs
  - 5 PM – 0 ORs
- Increased OR efficiency?



# Scenario 4 – Reduce Turnover Times to Increase OR Efficiency?

- No impact on OR efficiency, because hours of over-utilized OR time are the same
- Decision making on the day of surgery has a negligible impact on OR efficiency if there are no hours of over-utilized OR time

Dexter F et al. Anesth Analg 2003



# Scenario 4 – Reduce Turnover Times to Increase OR Efficiency?

- No impact on OR efficiency, because hours of over-utilized OR time are the same
- Decision making on the day of surgery has a negligible impact on OR efficiency if there are no hours of over-utilized OR time
- Because principal determinant of OR efficiency is OR staffing, impact of other interventions is highly sensitive to the service-specific staffing





# **You Cannot Have Made These Decisions Based on Utilization**



**Utilization**

# Scenario 5 – OR Allocation

## Markedly Affects OR Efficiency

- Staffing is planned from 7 AM to 5 PM
- Anesthesiologist arrives at 6 AM, and works fast and non-stop until his list is done
- Some days he finishes at 2 PM, some days at 8 PM, average is 5 PM
- What has been the anesthesiologist's impact on OR efficiency?



# Scenario 5 – OR Allocation

## Markedly Affects OR Efficiency

- Staffing is planned from 7 AM to 5 PM
- Some days he finishes at 2 PM
  - Under-utilized OR time = 3 hours
- Some days he finishes at 8 PM
  - Over-utilized OR time = 3 hours



# Scenario 5 – OR Allocation

## Markedly Affects OR Efficiency

- Staffing is planned from 7 AM to 5 PM
- Some days he finishes at 2 PM
  - Under-utilized OR time = 3 hours
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- Valiant and noble effort, but of no substantive impact on OR efficiency

★ If OR staffing is chosen poorly, actions on day of surgery have little to no benefit ★



# Review – Summarize the Facts of the Talk So Far



# Qualitative Expectations for a Manager Based on the Talk So Far



# Qualitative Expectations for a Manager Based on the Talk So Far

1. What precisely is inefficiency of use of OR time?
  2. OR efficiency applies to existing workload
  3. Review principles using scenarios
- Service-specific staffing based on OR efficiency
    - Important to use the statistical methods
    - The non-obvious details of statistical methods



# Sequence of the Talk

- What precisely is OR efficiency?
- OR efficiency applies to existing workload
- Review principles using scenarios
- Service-specific staffing based on OR efficiency
  - Important to use the statistical methods
  - How to use the statistical methods



# Interactive Portion

## - Case Presentation -

- On Mondays, hospital currently plans 3 ORs for orthopedics, each OR for 10 hr
  - $3 \text{ ORs} \times 10 \text{ hr} = 30 \text{ hr}$
- On Mondays, total hours of orthopedic cases including turnovers follows a normal distribution with a mean of 30 hr
  - Use the mean of 30 hr to answer each of the 4 questions
- Relative cost of 1 hr over-utilized OR time =  $2.0 \times$  that of 1 hr under-utilized OR time



# Interactive Portion

## - Question #1 -

- Pretend that the standard deviation of orthopedics' workload on Mondays = 0 hr
- Using the mean of 30 hr, what staffing plan maximizes efficiency of use of OR time?
  - 1) 3 ORs: 2 × 8 hr, 1 × 10 hr
  - 2) 3 ORs: 1 × 8 hr, 2 × 10 hr
  - 3) 3 ORs: 0 × 8 hr, 3 × 10 hr
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# Interactive Portion

## - Question #1 -

- Pretend that the standard deviation of orthopedics' workload on Mondays = 0 hr
- Using the mean of 30 hr, what staffing plan maximizes efficiency of use of OR time?
- Hospital's current policy to plan 30 hr staffing for mean 30 hr of workload is effectively assuming that standard deviation equals 0 hr



# Interactive Portion

## - Question #2 -

- Consider standard deviation of orthopedics' workload on Mondays = 5 hr, a typical value
- Since workload follows a normal distribution, need inverse of normal distribution function
  - Ratio of 2.0:1.0 over-utilized: under-utilized
  - Excel "= NORMINV( 2/3, 30, 5 )"
- The 66<sup>th</sup> percentile of the normal distribution function with mean 30 hr and standard deviation 5 hr equals **32 hr**



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# Interactive Portion

## - Question #3 -

- Consider standard deviation of orthopedics' workload on Mondays = **10** hr, a large value
- Since workload follows a normal distribution, need inverse of normal distribution function
  - Ratio of 2.0:1.0 over-utilized: under-utilized
  - Excel "= NORMINV( 2/3, 30, **10** )"
- The 66<sup>th</sup> percentile of the normal distribution function with mean 30 hr and standard deviation **10** hr equals **34 hr**



# Interactive Portion

## - Question #3 -

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# Interactive Portion

## - Question #4 -

- Standard deviation = 0 hr, very small  
3) 3 ORs:  $0 \times 8 \text{ hr}$ ,  $3 \times 10 \text{ hr}$
- Standard deviation = 5 hr, typical value  
4) 4 ORs:  $4 \times 8 \text{ hr}$ ,  $0 \times 10 \text{ hr}$
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  - Standard deviation = 10 hr, large value
    - 5) 4 ORs:  $3 \times 8 \text{ hr}$ ,  $1 \times 10 \text{ hr}$
- More hours of staffing are planned for each increase in the standard deviation of workload



# Interactive Portion

## - Question #4 -

- What benefits from using the mathematics?
  - 1)** Facilitate surgeons' scheduling of more cases (i.e., grow workload)
  - 2)** Achieve more predictable work hours for OR nurses, anesthesiologists, etc.
  - 3)** Process to adjust staffing to gain from small reductions in non-surgical time
  - 4)** Process to target ORs with over-utilized OR time as reduce non-surgical time
  - 5)** All except **1)**

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- What benefits from using the mathematics?
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    - Regardless of whether good or bad, no change because mean workload is same



# Interactive Portion

## - Question #4 -

- What benefits from using the mathematics?
  - 1) Facilitate surgeons' scheduling of more cases (i.e., grow workload)
    - Regardless of whether good or bad, no change because mean workload is same
    - May facilitate growth in workload long-term, but indirectly, by having process in use to gain from the small reductions in non-surgical time





# Interactive Portion

## - Limitation -

- “Trick” in case is that the numbers happened to work out to be multiples of 8 hr and 10 hr
- For single ORs, inverse of normal distribution function actually works well in practice
  - Can use Excel for Dr. Dexter’s OR on Mondays
- For multiple ORs, I prefer instead to use “empirical method”

Pandit JJ, Dexter F. Anesth Analg 2009

McIntosh C et al. Anesth Analg 2006



# Tiny Example of Using Empirical Method for OR Allocation

- Example of the calculations
  - On three Mondays a service did 12, 7, and 15 hours of cases including turnover times
  - Staff plan an 8-hour scheduled day
  - $1.75 =$  relative cost of 1 hour of over-utilized OR time to 1 hour of under-utilized OR time



# Cost of Inefficient Use of OR Time with Different Staffing

- Weekly values: 12, 7, and 15 hours of work
- If staff 1 OR for 8 hours for the service
  - $20.25 \text{ hr} = (0 + 1 + 0) + 1.75 \times (4 + 0 + 7)$
- If staff 2 OR for 8 hours for the service
  - $14.00 \text{ hr} = (4 + 9 + 1) + 1.75 \times (0 + 0 + 0)$
- If staff 3 OR for 8 hours for the service
  - $38.00 \text{ hr} = (12 + 17 + 9) + 1.75 \times (0 + 0 + 0)$



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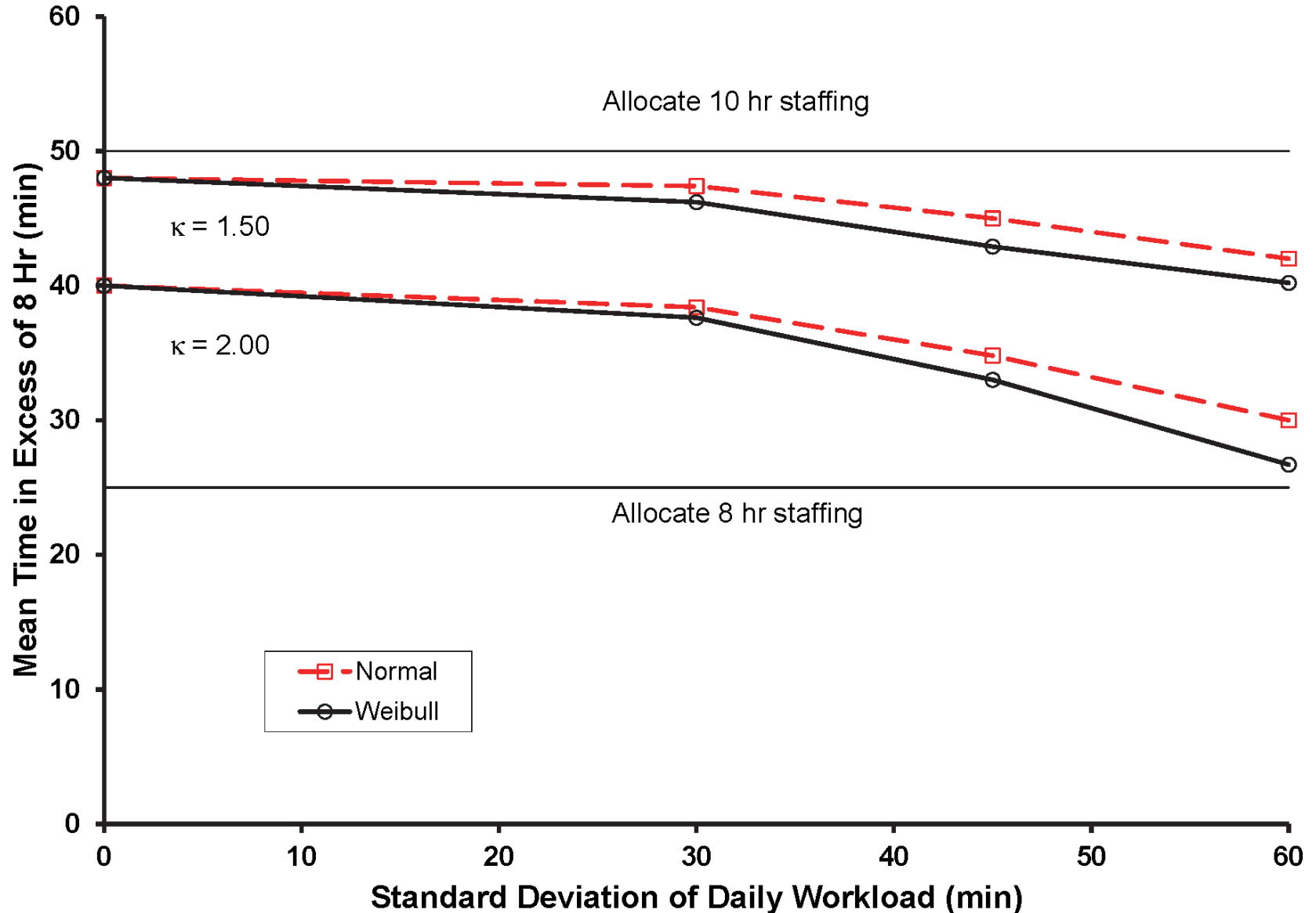


# Not Same Process to Allocate Based on OR Utilization

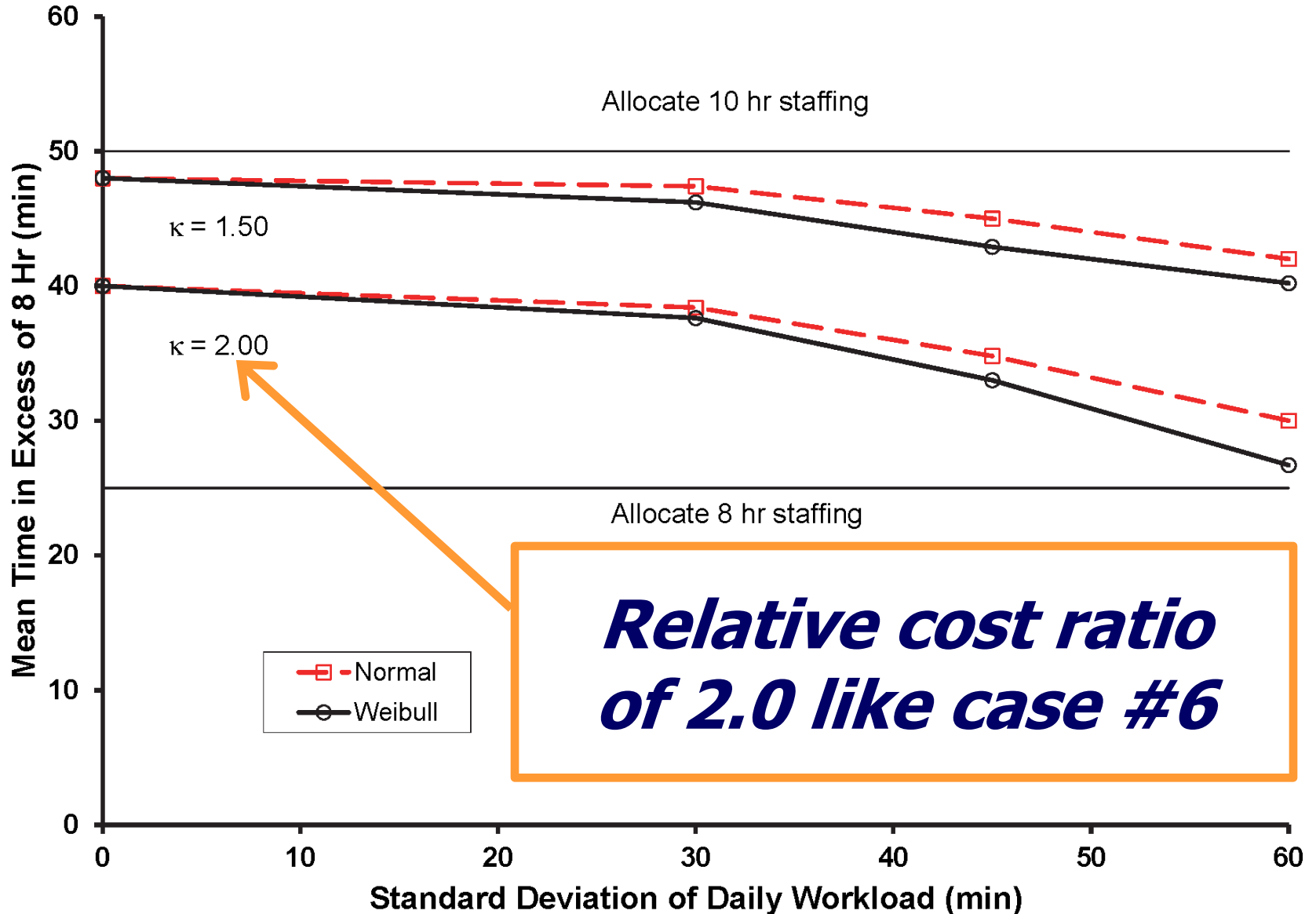
- Allocation based on OR utilization:
  - Starts with a goal OR utilization
    - OR efficiency gives the answer based on the existing OR workload
  - Considers just the under-utilized OR time
    - Larger concern is over-utilized OR time
  - Ignores variation among weeks in workload
    - Average workload not used to calculate under-utilized and over-utilized OR time



# Allocated Times for Single ORs From Pandit & Dexter 2009

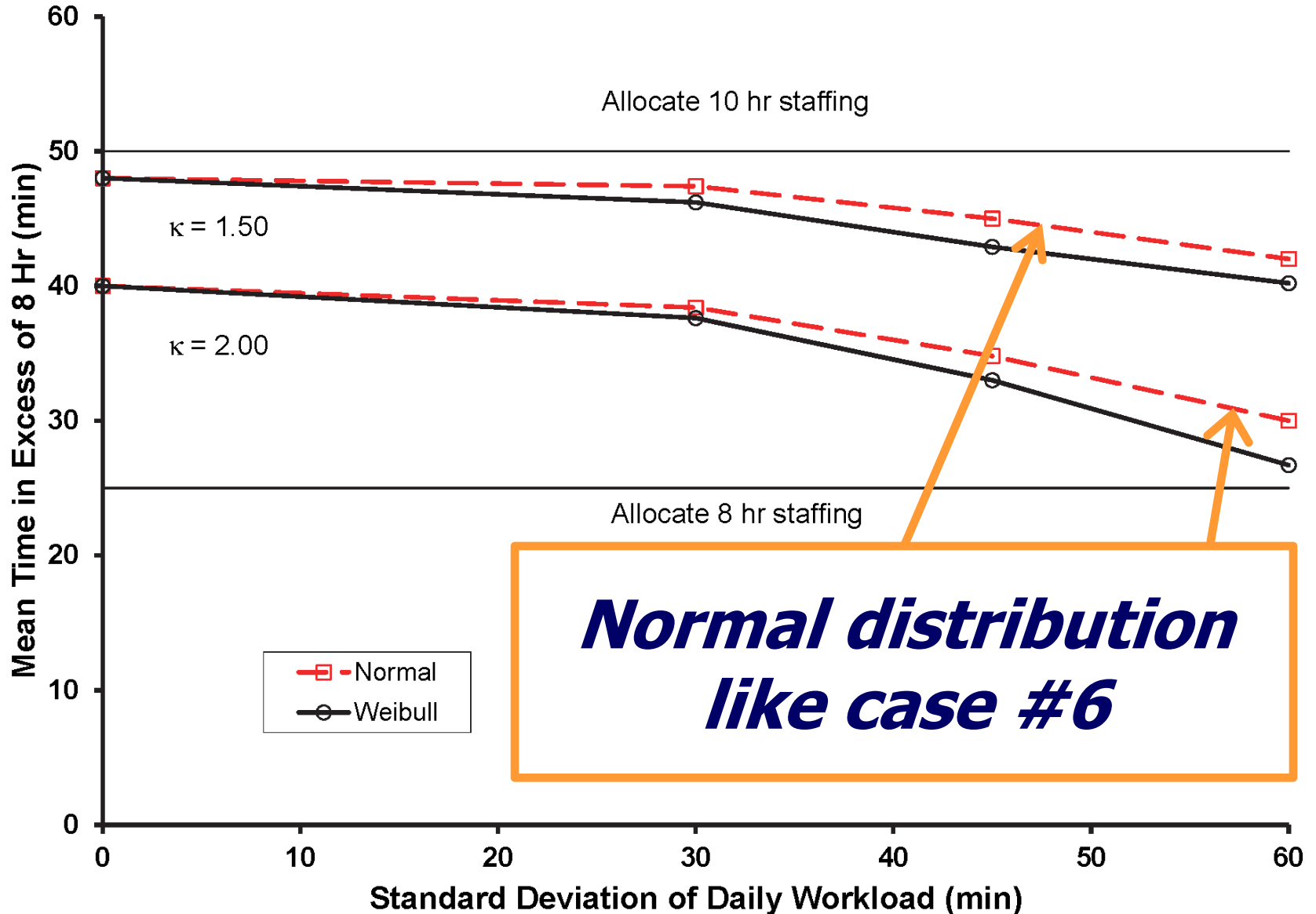


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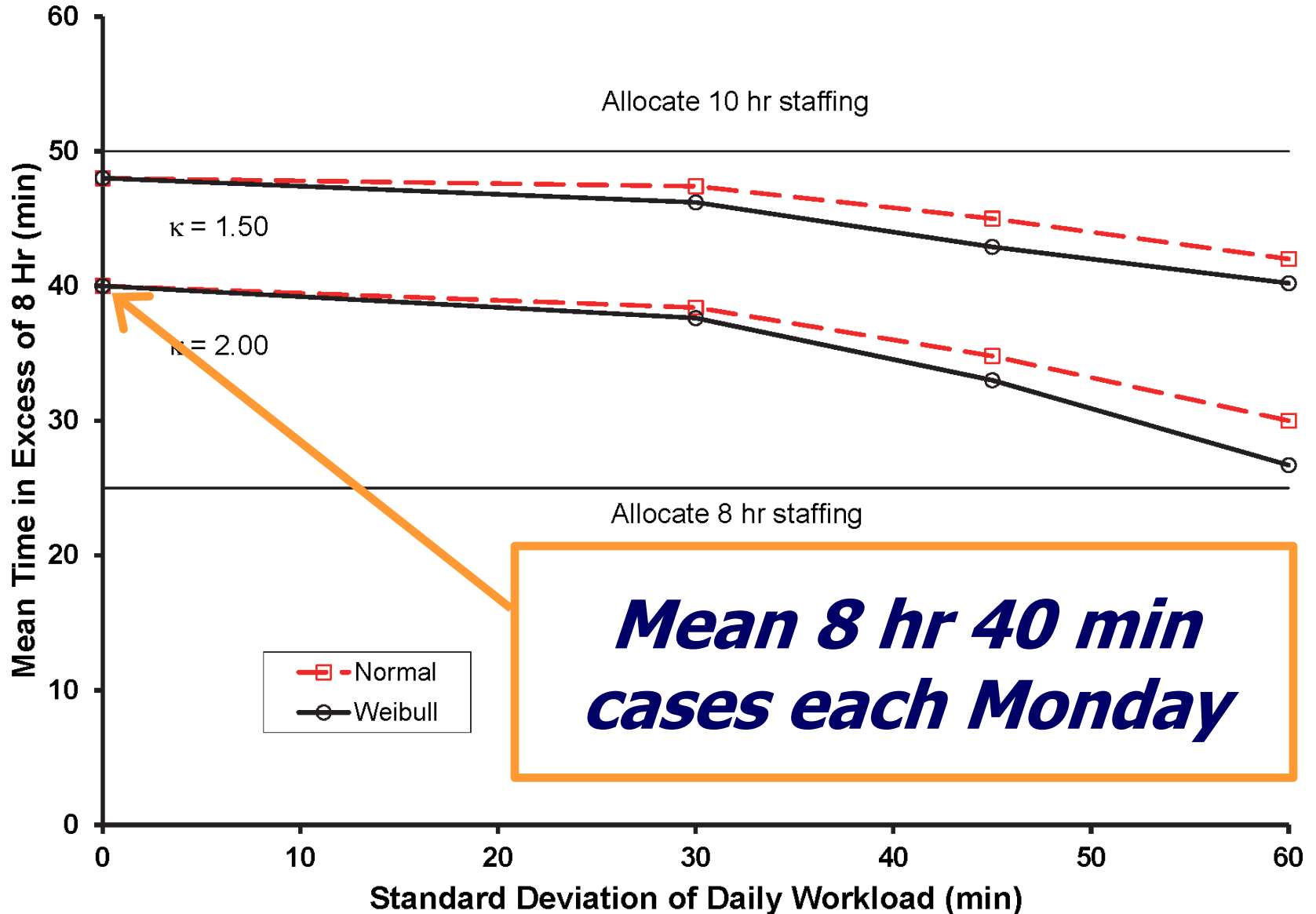




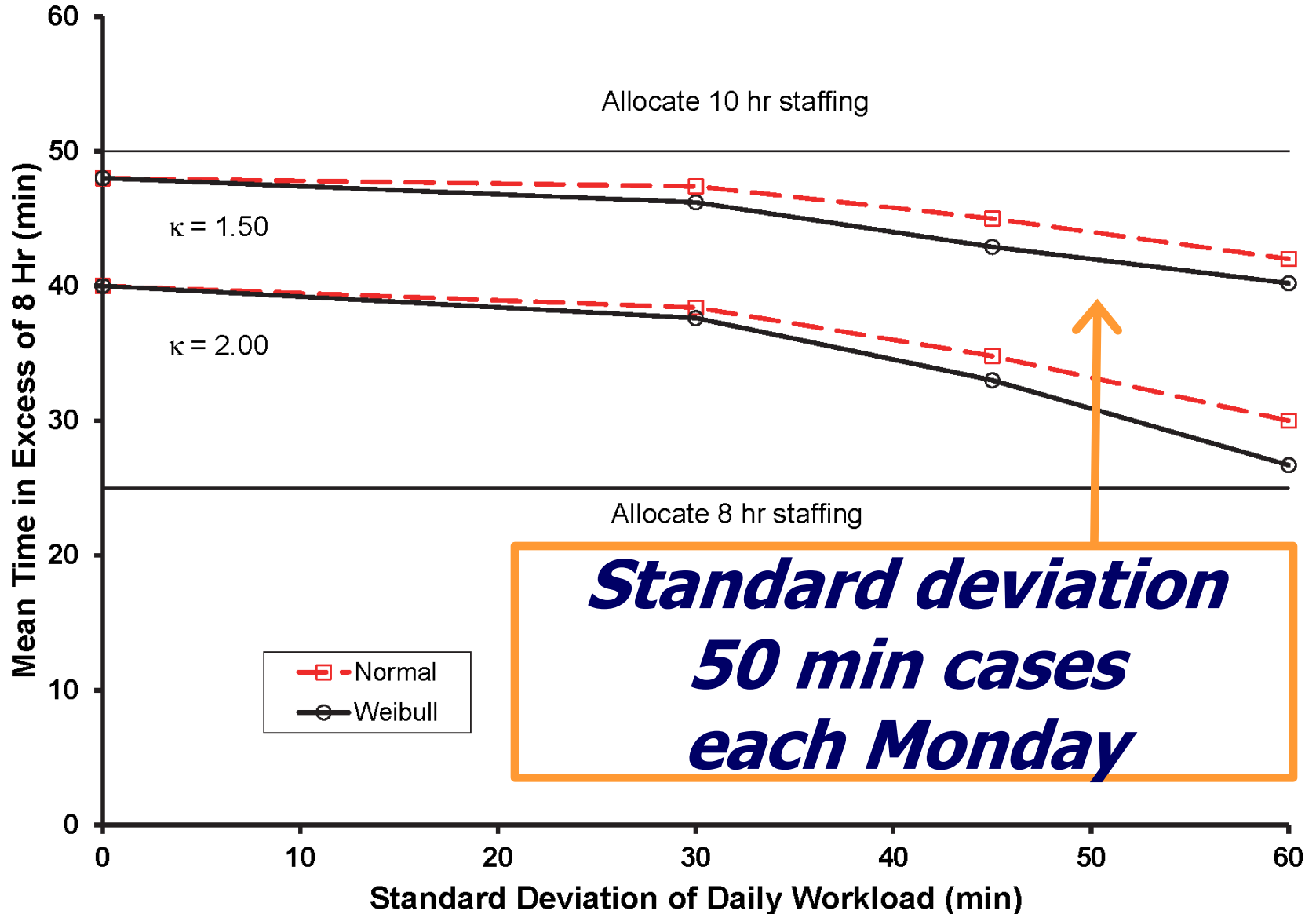
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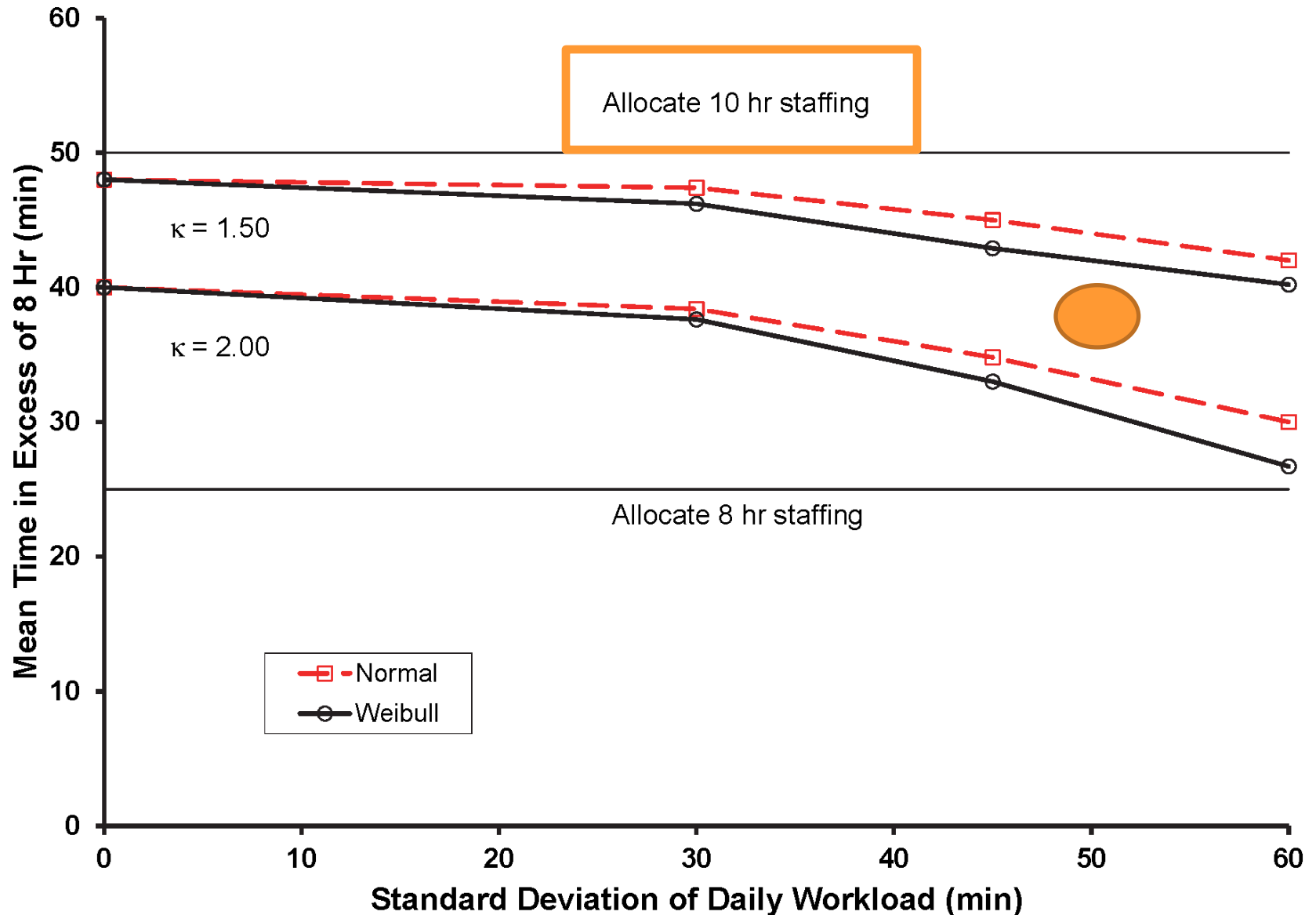
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# Increasing Efficiency of Use of OR Time

- Vertical axis relates to mean
  - Commonly used to report adjusted utilization
- Horizontal axis relates to standard deviation





# Increasing Efficiency of Use of OR Time

- Vertical axis relates to mean
  - Commonly used to report adjusted utilization
- Horizontal axis relates to standard deviation
- When objective is to increase efficiency of use of OR time, focus includes both mean and the standard deviation, principally the latter



# Sequence of the Talk

- What precisely is OR efficiency?
- OR efficiency applies to existing workload
- Review principles using scenarios
- Service-specific staffing based on OR efficiency
  - Important to use the statistical methods
    - How to use the statistical methods



# Example of “Real World” OR Allocation (Staffing) Problem

- Officially, on paper, a service has been allocated three ORs for 8 hr Mon-Fri
- In reality, its total hours of elective cases including turnover times each day of the week averages 29 hours, with a range of 26 hours to 32 hours
- OR allocation based on maximizing OR efficiency adjusts staffing to match reality



# Example of “Real World” OR Allocation (Staffing) Problem

- Staff work 5 days a week for 8 hr, 4 days a week for 10 hr, or 3 days a week for 13 hr
- Reasonable allocation choices:
  - Two OR for 13 hr
  - One OR for 8 hr + two for 10 hr
  - Two OR for 8 hr + one for 13 hr
  - Three OR for 10 hr
  - One OR for 8 hr + one for 10 hr + one for 13 hr
  - Four OR for 8 hr
  - Two OR for 10 hr + one for 13 hr

# Example of “Real World” OR Allocation (Staffing) Problem

- Based on 2002 mean US compensation, the range in annual OR & anesthesia costs among allocations is \$245,000 per year

Abouleish AE et al. Anesth Analg 2003

Kuehl NK. AORN J 2003



# Example of “Real World” OR Allocation (Staffing) Problem

- Based on 2002 mean US compensation, the range in annual OR & anesthesia costs among allocations is \$245,000 per year
- My interpretation of the message
  - Implementation is the mathematics
  - As for any mathematics problem, **be sure** that you are getting the correct answer





# Most Hospitals Have $> 1$ Duration of Allocated Hours

- Calculate allocated hours by service and by day of the week to minimize the expected inefficiency of use of OR time
- If allocated hours in each OR were same for each service on a day of the week, and each service also had the same mean workload per OR, then standard deviation in workload among ORs on each day would be small

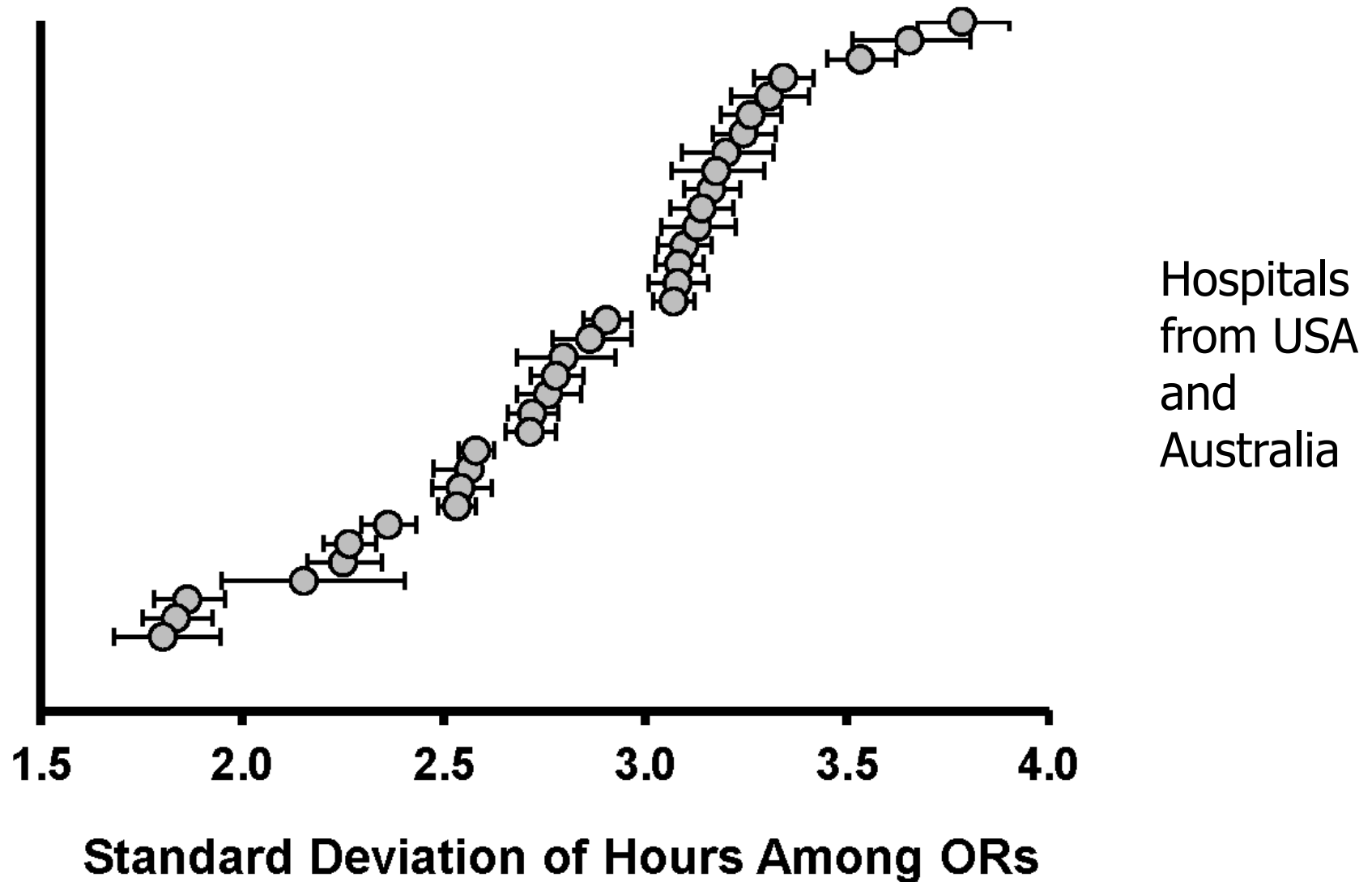


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- If allocated hours in each OR were same for each service on a day of the week, and each service also had the same mean workload per OR, then standard deviation in workload among ORs on each day would be small
  - Reality  $> 3$  hours for many hospitals



# Most Hospitals Have > 1 Duration of Allocated Hours



# Examples of Applying Statistical Method to Anesthesia Staffing

- For 12 of 14 suites, statistical method found a staffing plan with costs at least 10% less than that being used by the managers
  - Managers did not have right number of staff, working the right number of hours, on the right days of the week, for specific surgical services

Dexter F et al. Anesth Analg 2001

Abouleish AE et al. Anesth Analg 2003

Freytag S et al. Der Chirurg 2005

McIntosh C et al. Anesth Analg 2006

Lehtonen JM et al. Int J Health Care Qual Assur 2013

# Experimental Studies Explain Why Method Often Unused

- Two cognitive biases
  - Pull to center (mean)
    - Essentially schedule staff as if allocated hours were based on a relative cost ratio of 1.10 instead of 1.75
  - Ignore analysis of 9 months of data in lieu of service's usage during past 2 weeks
    - Recency bias

Wachtel RE, Dexter F. Anesth Analg 2010



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    - Essentially schedule staff as if allocated hours were based on a relative cost ratio of 1.10 instead of 1.75
  - Ignore analysis of 9 months of data in lieu of service's usage during past 2 weeks
    - Recency bias
- Issue is psychology, not politics, culture, buy in, personalities, or organizational inertia



# Experimental Studies Explain Why Method Often Unused

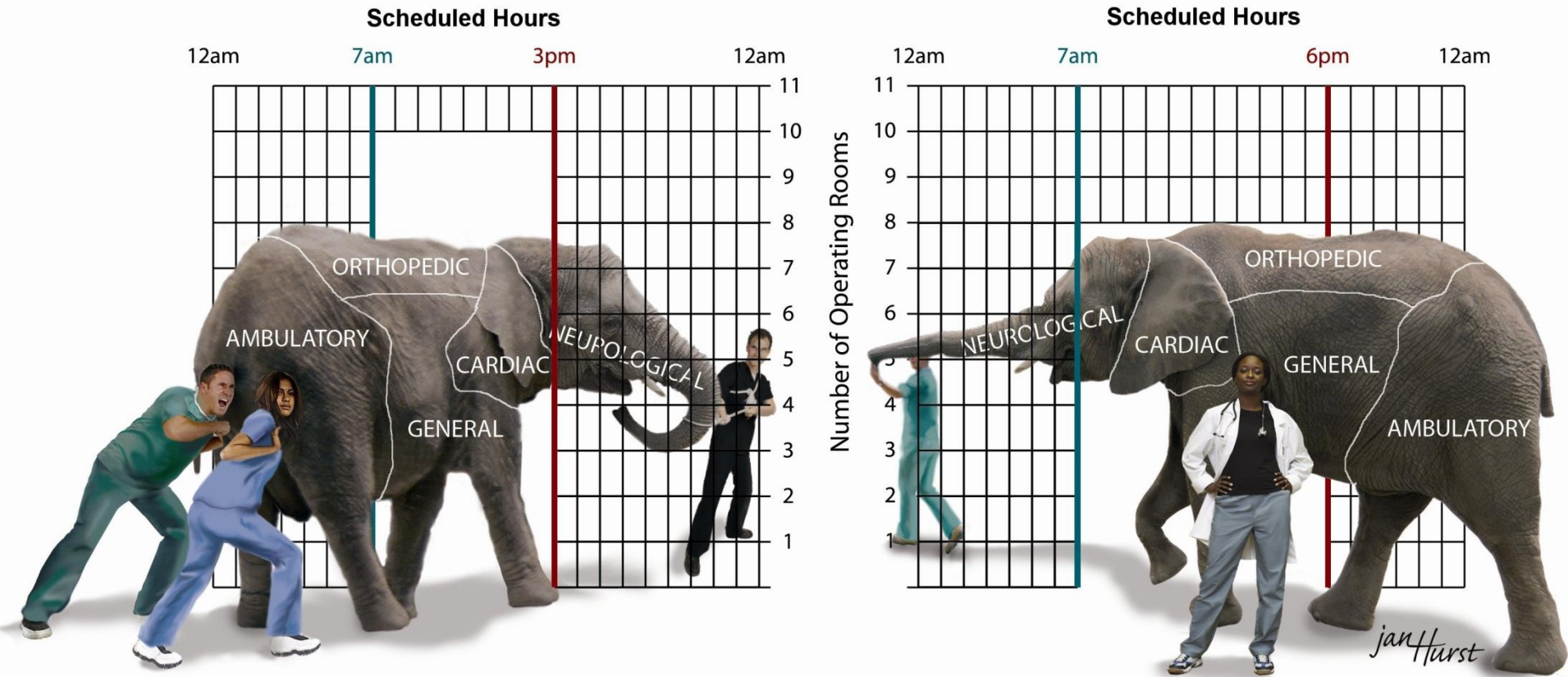
- Two cognitive biases
  - Factors with little or no impact
    - More frequent feedback
    - Graphical user interface
    - Information in reports
    - Experience
    - Education



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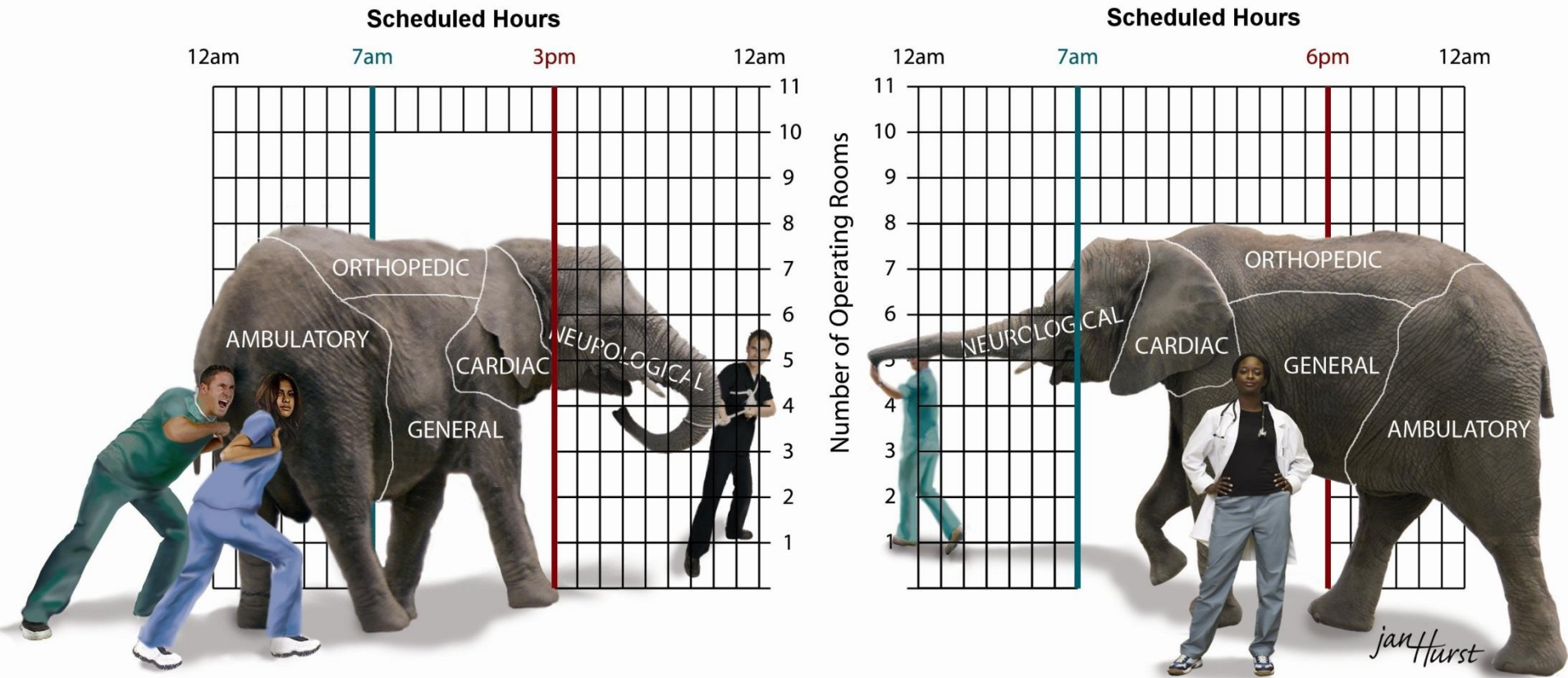
- Two cognitive biases
  - Factors with little or no impact
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    - Information in reports
    - Experience
    - *Education*
- Education increases trust in the use of the mathematics (technology)

# Experimental Studies Explain Why Method Often Unused



Large hospital reported to me how my review article changed their organization: all their ORs now staffed 7 AM to 6 PM

# Experimental Studies Explain Why Method Often Unused



➤ Implementation is the mathematics



# What Attributes of the Education Increase Trust?

- Presence of data in a reading has no significant influence on trust ( $P = 0.148$ )
- Presence of formulas in a reading increases trust in the quality, usefulness, and reliability of the reading ( $P = 0.0019$ )
  - Mathematics integral to development of trust
  - Cue that article can be trusted

Dexter F, Van Swol LM. A & A Case Rep 2016




# Sequence of the Talk







- What precisely is OR efficiency?
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- Review principles using scenarios
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  - Important to use the statistical methods
    - How to use the statistical methods
      - Types of data
      - Seasonal variation in OR workload
      - How many months of data to use
      - Application to staff scheduling and assignment



# OR Information System, AIMS, or Anesthesia Billing Data

Microsoft Excel - XLSInputDataSample.xls

File Edit View Insert Format Tools Data Window Help 

     100% 

N29 =

	A	B	C	D	E	F	G	H	I
1	Room	DateIn	TimeIn	DateOut	TimeOut	Service	NoAnesthesia	Urgent	Holiday
2	1	1/1/1998	8:09	1/1/1998	9:04	ORT			X
3	1	1/1/1998	23:00	1/2/1998	1:12	SUR			X
4	1	1/2/1998	9:13	1/2/1998	10:37	GYN			
5	1	1/2/1998	16:30	1/2/1998	18:37	POD			
6	2	1/2/1998	7:36	1/2/1998	7:59	GYN			
7	2	1/2/1998	8:16	1/2/1998	9:11	GYN			
8	2	1/2/1998	10:37	1/2/1998	11:02	POD			
9	2	1/2/1998	11:20	1/2/1998	12:23	POD			
10	2	1/2/1998	12:38	1/2/1998	13:58	POD			
11	2	1/2/1998	14:17	1/2/1998	16:15	POD			
12	3	1/2/1998	8:44	1/2/1998	9:00	ENT			
13	3	1/2/1998	8:10	1/2/1998	8:30	ENT			
14	3	1/2/1998	11:30	1/2/1998	12:02	ENT			
15	3	1/2/1998	9:14	1/2/1998	9:46	ENT			
16	3	1/2/1998	10:05	1/2/1998	11:21	ENT			
17	3	1/2/1998	12:20	1/2/1998	13:40	ENT			

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# Seasonal Variation Does Not Need to be Considered Routinely

- Statistical methods assume that trends affect total group workload slowly
  - Little systematic variation month to month
  - Instead, change occurs year to year
- Is this simplification appropriate for most anesthesia groups and surgical suites?

Dexter F, Traub RD. Anesth Analg 2000

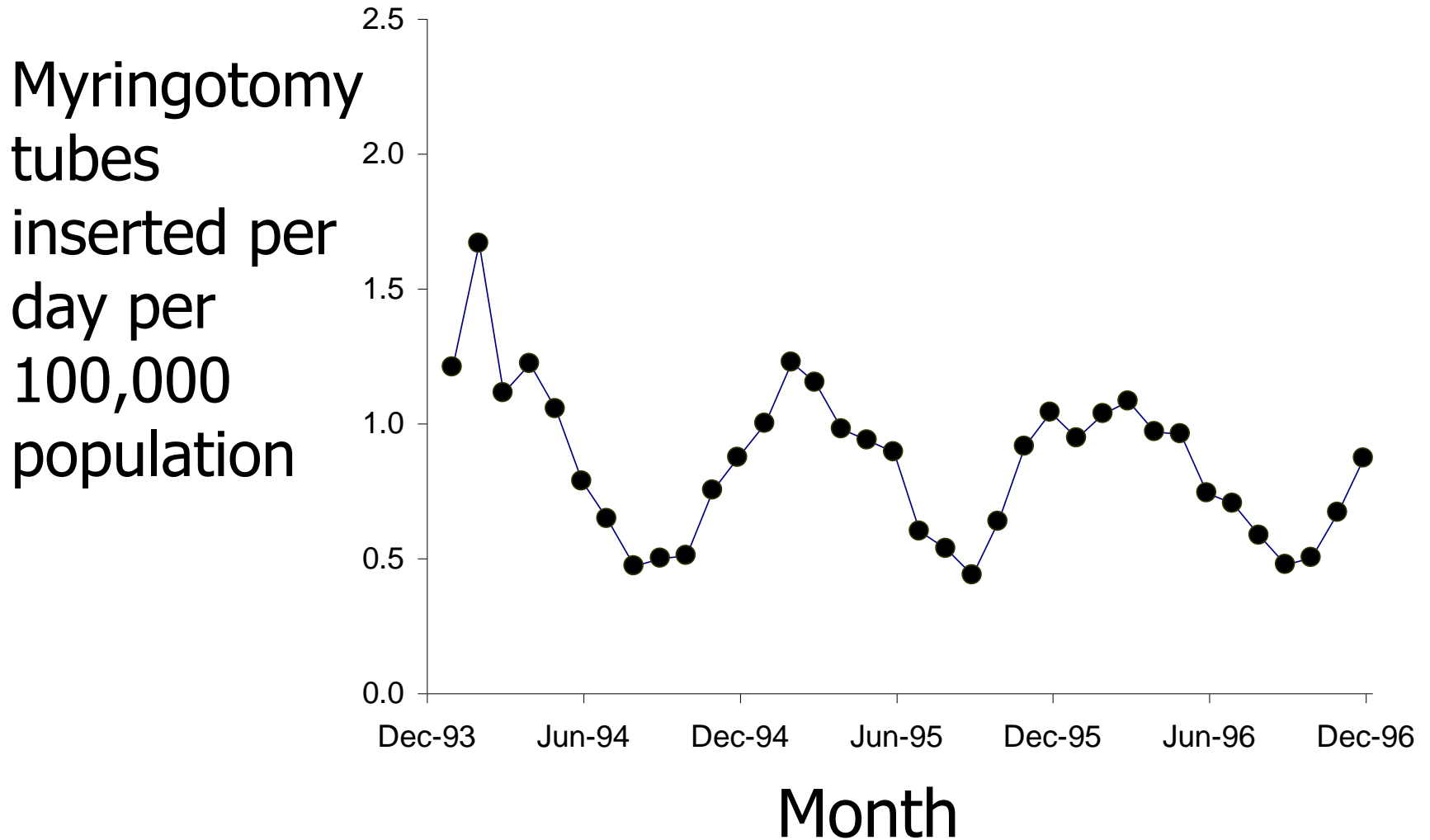


# Seasonal Variation Does Not Need to be Considered Routinely

- Analyze data from the US National Survey of Ambulatory Surgery (1994 – 1996)
- Expect anesthesia workload not to vary systematically over 11-month periods
- Positive control
  - Myringotomy tube placement
  - Incidence of otitis media peaks toward the end of winter

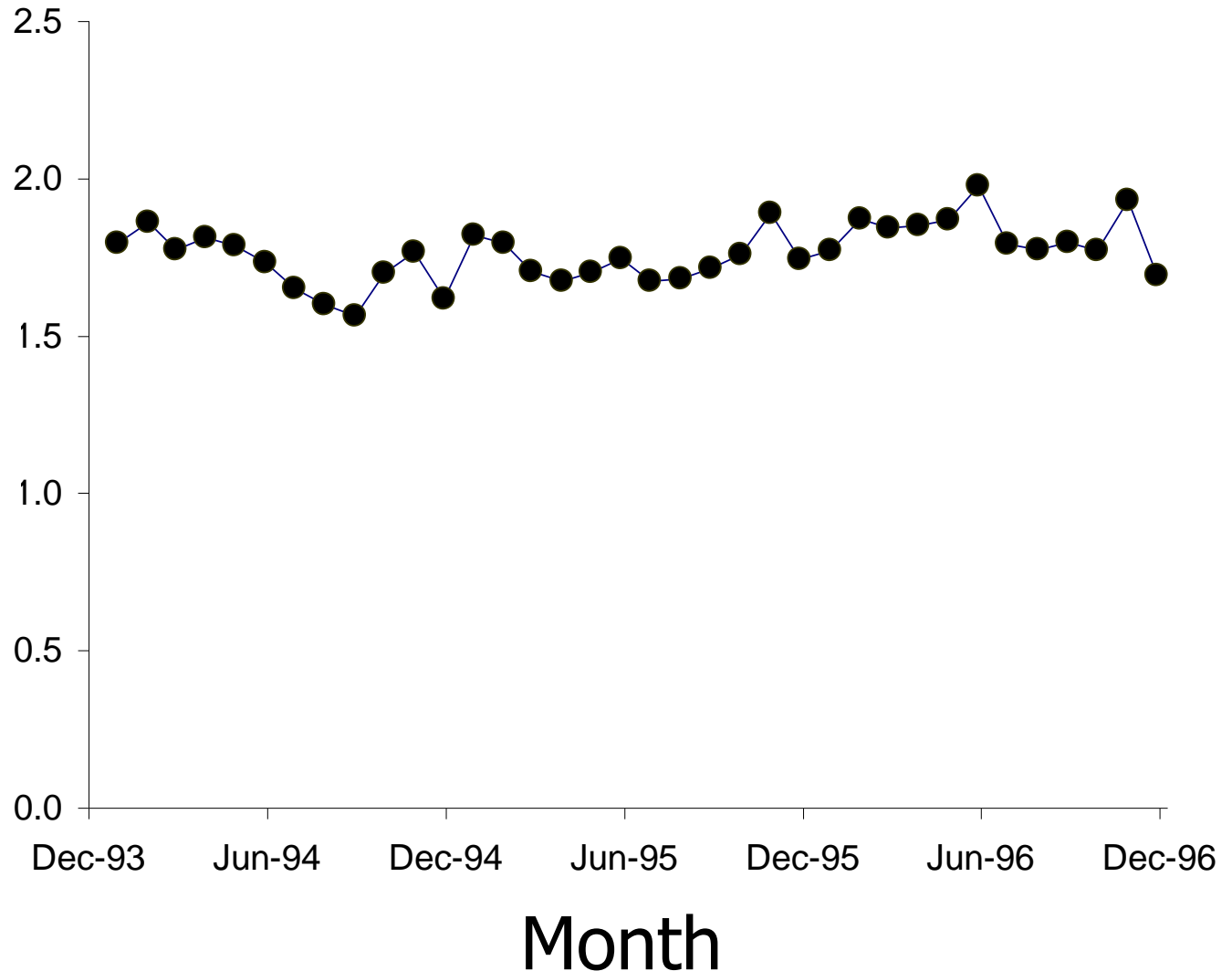


# Positive Control – Seasonal Variation in Myringotomy Tubes



# Anesthesia Caseload Does Not Vary Systematically Over < 1 Yr

Cases with anesthesia provider per day per 10,000 population





# Sequence of the Talk

- What precisely is OR efficiency?
- OR efficiency applies to existing workload
- Review principles using scenarios
- Service-specific staffing based on OR efficiency
  - Important to use the statistical methods
  - How to use the statistical methods
    - Types of data
    - Seasonal variation in OR workload
    - How many months of data to use
    - Application to staff scheduling and assignment

# Months of Data for Accurate OR Allocations

- Use two years of data from a 7 OR, community, multiple specialty hospital
- Divide the 507 workdays of data into:
  - Training dataset to identify staffing solution
    - From 30 to 270 consecutive workdays
  - Testing dataset to evaluate its performance
  - Repeat the process hundreds of times

Epstein RH, Dexter F. Anesth Analg 2002

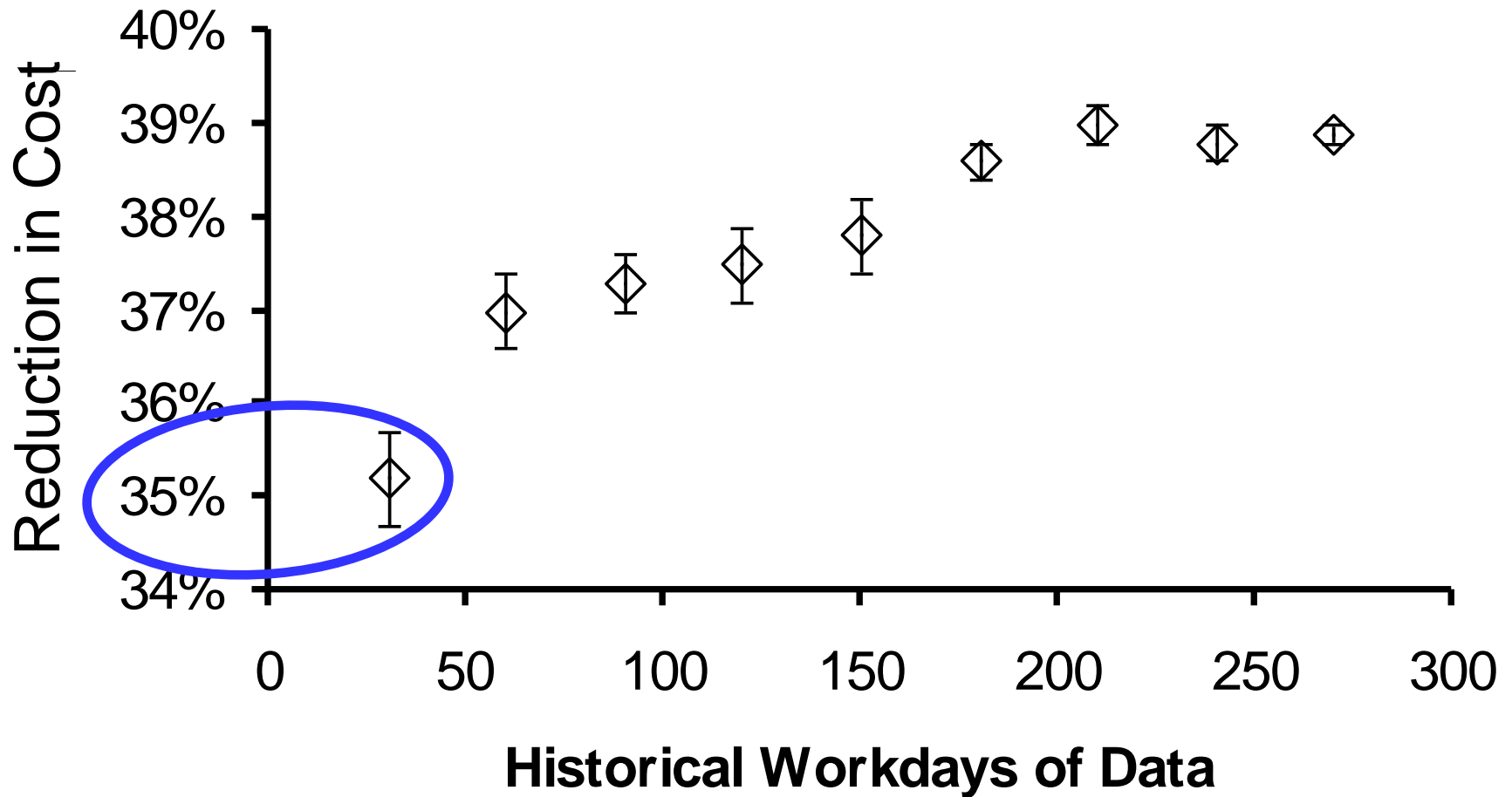


# Least Amount of Data for OR Allocations and Staffing

- Suppose install a new information system
  - Operating room
  - Anesthesia electronic medical record
  - Anesthesia billing
- Data will be used partly to adjust OR staffing (allocations) based on OR efficiency
- How soon can the data be used, so that a return on investment can be achieved?



# Staffing Solutions to ↓ Staffing Cost Identified with 30 Workdays of Data

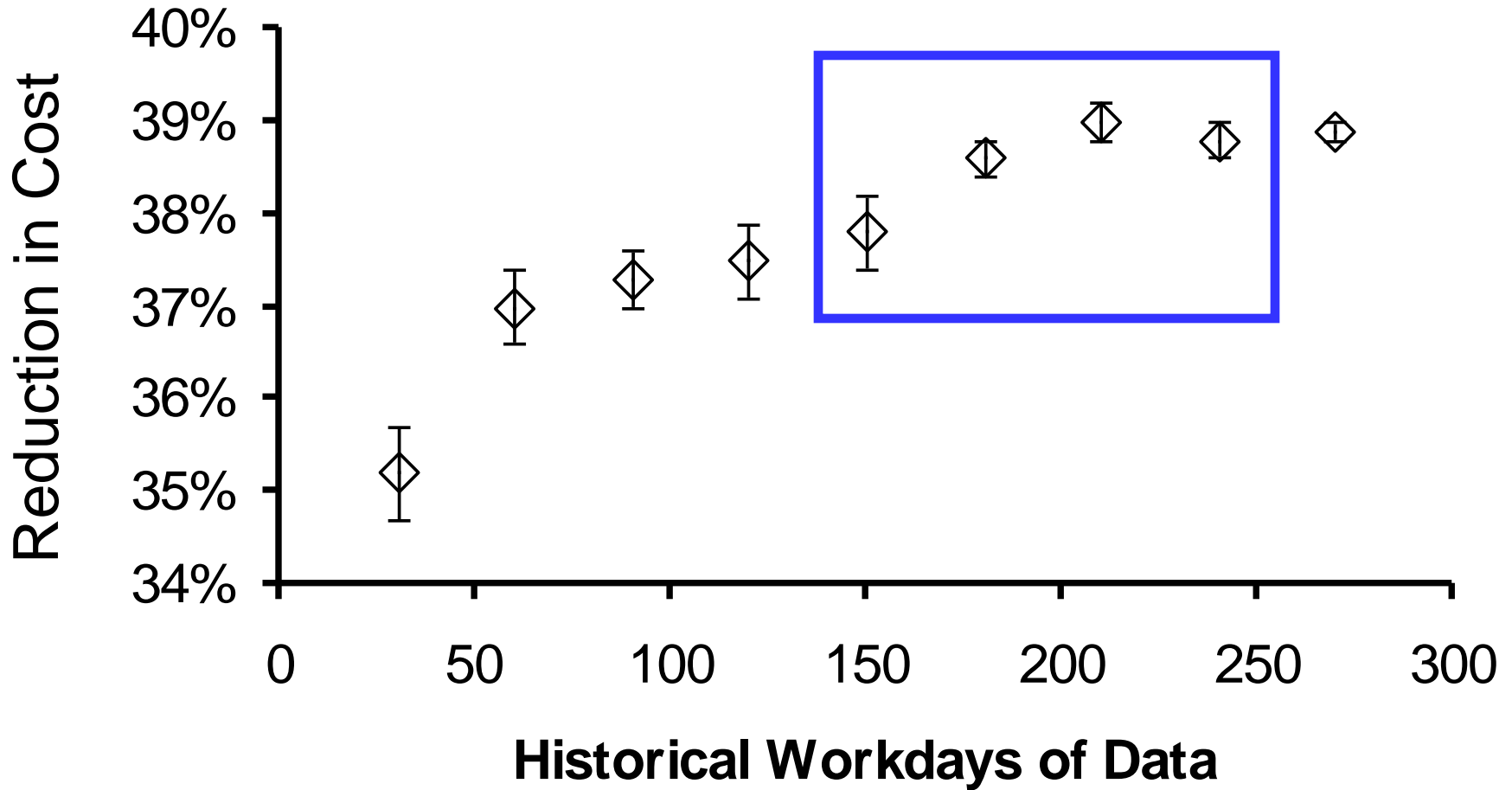


# Months of Data to Use Routinely for OR Allocation

- Staffing is re-evaluated quarterly
- How many months of OR workload data should be used in the calculations?
  - If too brief, results may be spurious due to surgeon illness, holidays, etc. (recency bias)
  - If too long, results may not reflect trends in workload, such as recruitment of new surgeon



# No Significant ↓ Staffing Cost by Using More > 9 Months of Data





# Sequence of the Talk

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# Application to Staff Scheduling and to Staff Assignment

- Scenario for anesthesia residents
  - Calculate OR allocation of 1 OR general thoracic surgery Mon-Tue and 2 ORs Wed-Fri
  - Maximum 1 resident can be scheduled to thoracic weekly and be assigned to cases

Dexter F et al. Anesth Analg 2010



# Application to Staff Scheduling and to Staff Assignment

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- Ignore OR allocations when staff scheduling
  - Schedule 2 residents to thoracic weekly



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- Ignore OR allocations when staff scheduling
  - Schedule 2 residents to thoracic weekly
    - Anesthesia assignment office appears to be performing poorly for Mon and Tue



# Application to Staff Scheduling and to Staff Assignment

- Scenario for anesthesiologists using teams
  - Orthopedics' OR allocations are 4 ORs Mon, 3 ORs Tue-Thu, and 2 ORs on Fri

Lubarsky DA, Reves JG. J Am Coll Surg 2005





# Application to Staff Scheduling and to Staff Assignment

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  - Staff scheduling must then be by team and must include different numbers of allocated ORs for each day of the week

Dexter F et al. Anesth Analg 2010





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    - To start multiple peripheral nerve blocks in preoperative area on-time, staff scheduling also needs to include anesthesiologists' arrival times

Chelly JE et al. J Clin Anesth 2010



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  - Staff scheduling must then be by team and must include different numbers of allocated ORs for each day of the week
    - To start multiple peripheral nerve blocks in preoperative area on-time, staff scheduling also needs to include anesthesiologists' arrival times
- If plan for 3 ORs daily, anesthesia assignment office falsely appears to perform poorly each Monday

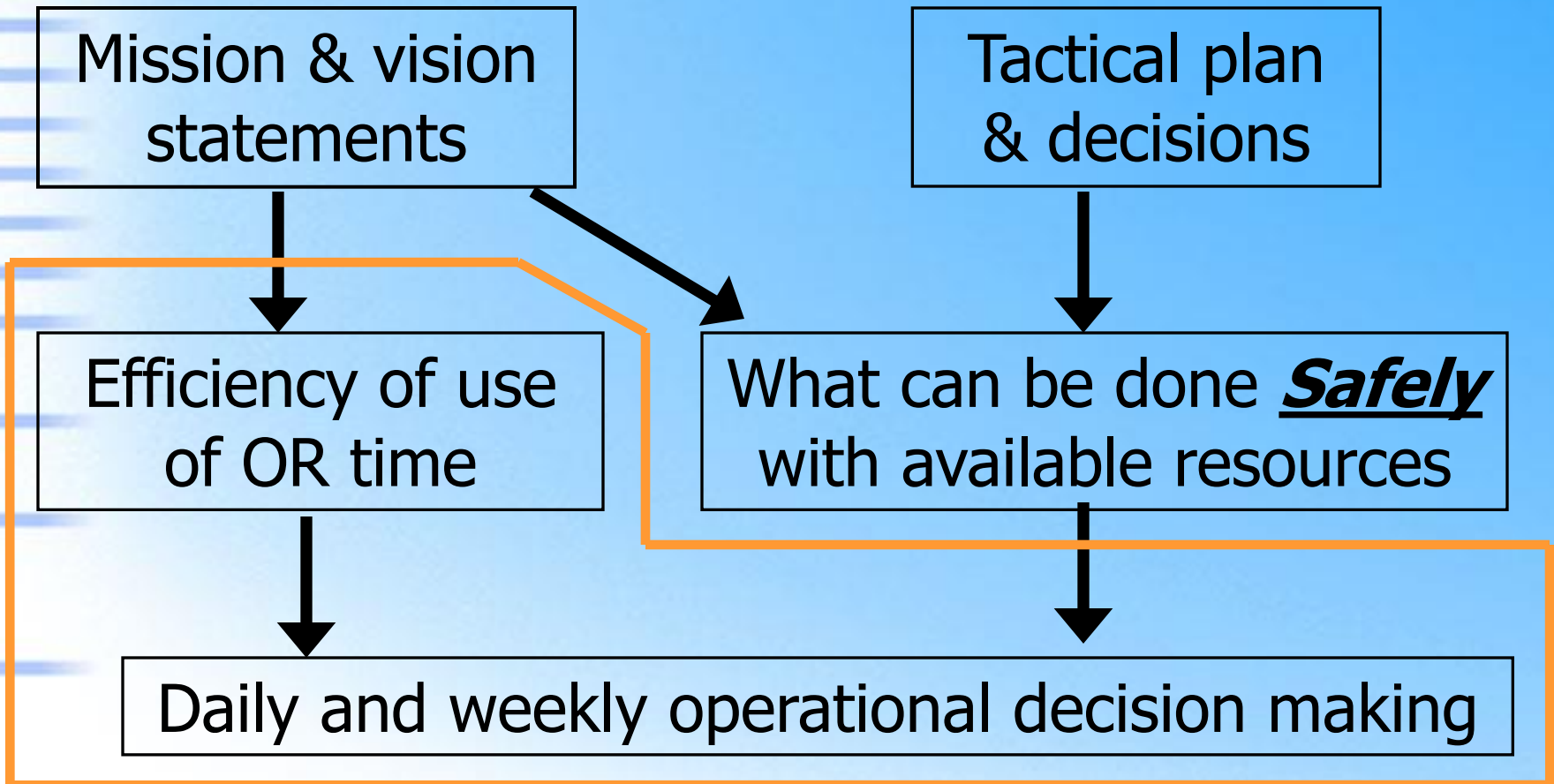
# Application to Staff Scheduling and to Staff Assignment

- Schedule 10 nurse anesthetists each Monday
  - 3 ambulatory surgery center and 3 orthopedics
  - 1 cardiac surgery, 1 neurological surgery, 1 gynecological surgery and 1 ophthalmology
- If goal is teams, staff assignment should not be 10 individuals to 10 rooms, but ...
  - 3 scheduled to be at ambulatory surgery center assigned to 3 rooms' cases, etc.

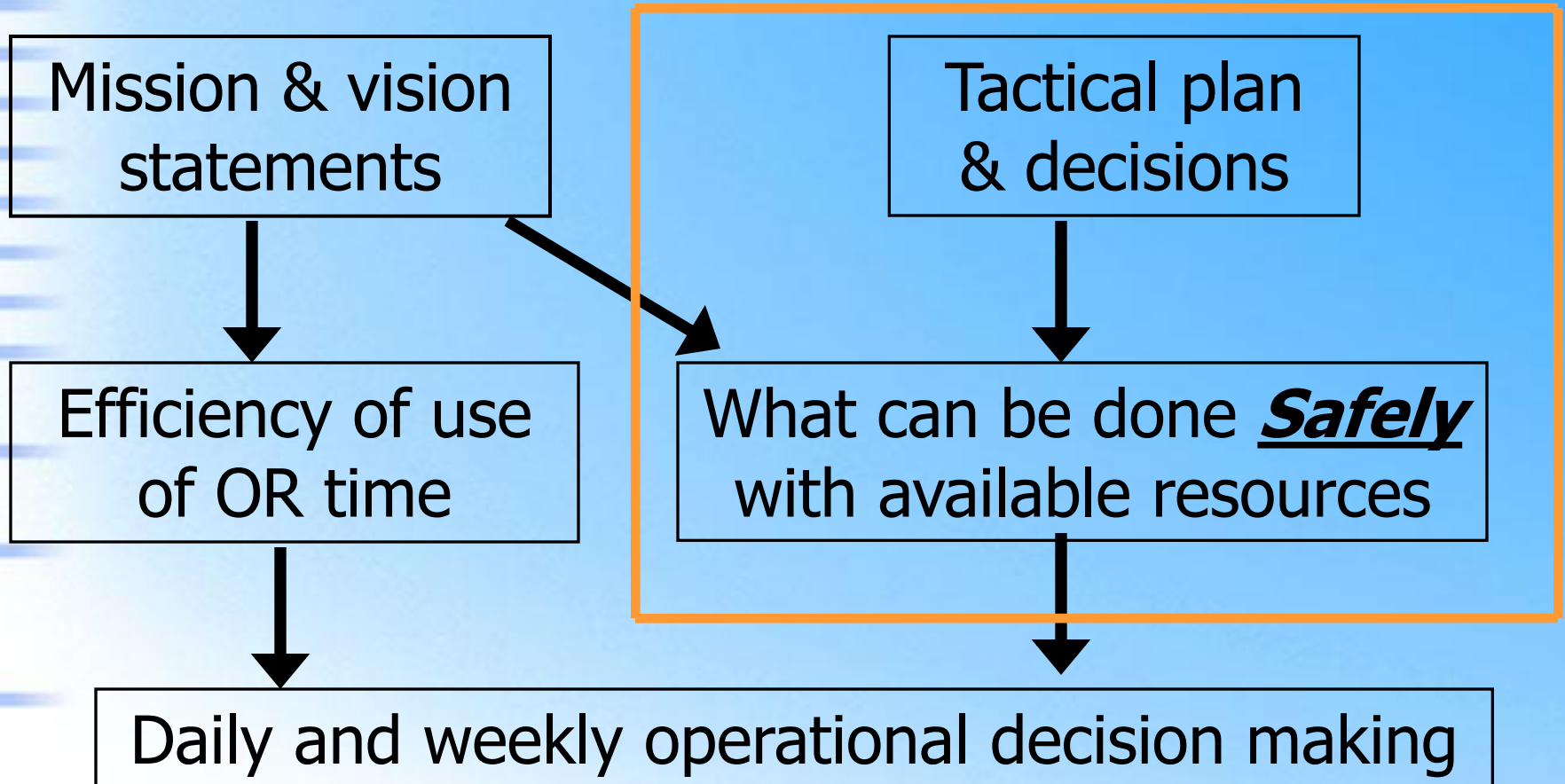
Dexter F et al. Anesth Analg 2010



# Review – Topics of the Talk are Operational Decision Making



# Review – Topics of the Talk are Operational Decision Making



Such tactical issues limit how much work gets done

# **Review – Topics of the Talk and Consider an Application**

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# **How Decide Whether to Schedule Some ORs for 8 hr and Some for 10 hr?**

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# How Decide Whether to Schedule Some ORs for 8 hr and Some for 10 hr?

- What precisely is inefficiency of use of OR time?
- OR efficiency applies to existing workload
- Review principles using scenarios
- Service-specific staffing based on OR efficiency
  - Important to use the statistical methods
  - How to use the statistical methods

# Additional Information on Operating Room Management

- [www.FranklinDexter.net/education.htm](http://www.FranklinDexter.net/education.htm)
  - Example reports with calculations
  - Lectures on drug and supply costs, day of surgery decision making, PACU staffing, anesthesia staffing, financial analysis, and strategic decision-making
- [www.FranklinDexter.net](http://www.FranklinDexter.net)
  - Comprehensive bibliography of peer reviewed articles in operating room and anesthesia group management