Operating Room Staffing and Allocation

- This talk includes many similar slides
  - Paging through produces animation
  - View with Adobe Reader for **<u>mobile</u>**: iPad, iPhone, Android
- Slides were tested using Adobe Acrobat
  - You can select View and then Full Screen
    - First optimize your settings
    - Select Edit, then Preferences, then Full Screen, and then No Transition
- Other PDF readers suitable if scrolling can be disabled
  - Google Chrome PDF Viewer has Select Fit to Page, and then use the right/left arrow keys

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Operating Room Staffing and Allocation

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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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  – Important to use the statistical methods
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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?

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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

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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
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  - 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% −
        (hours of under-utilized OR time) ÷
        (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*
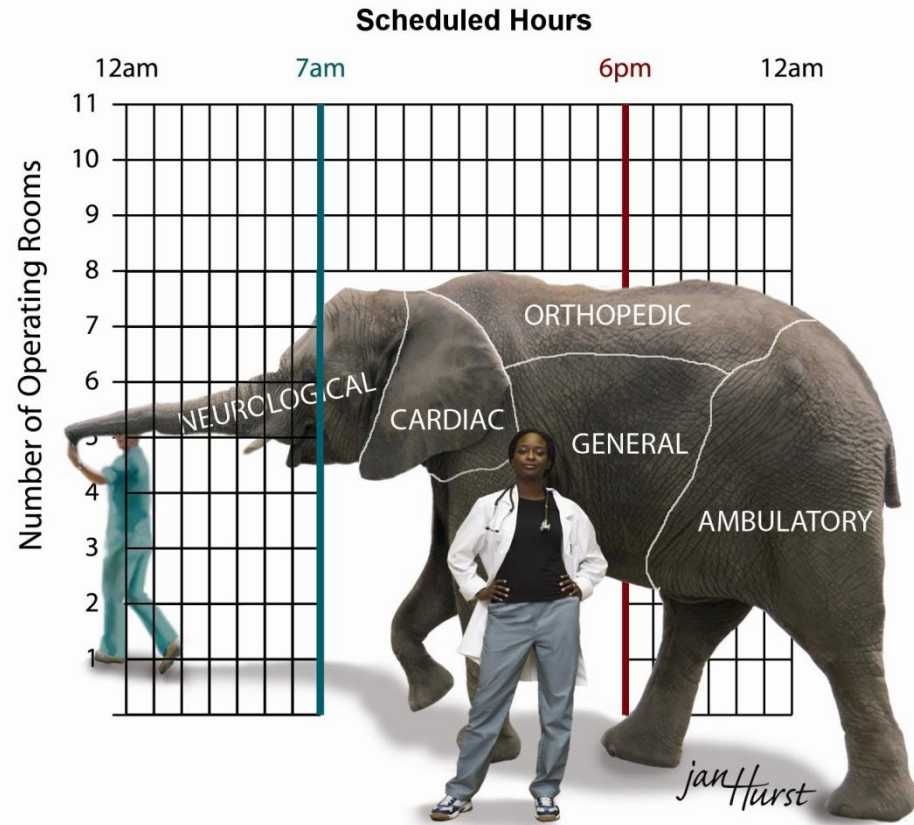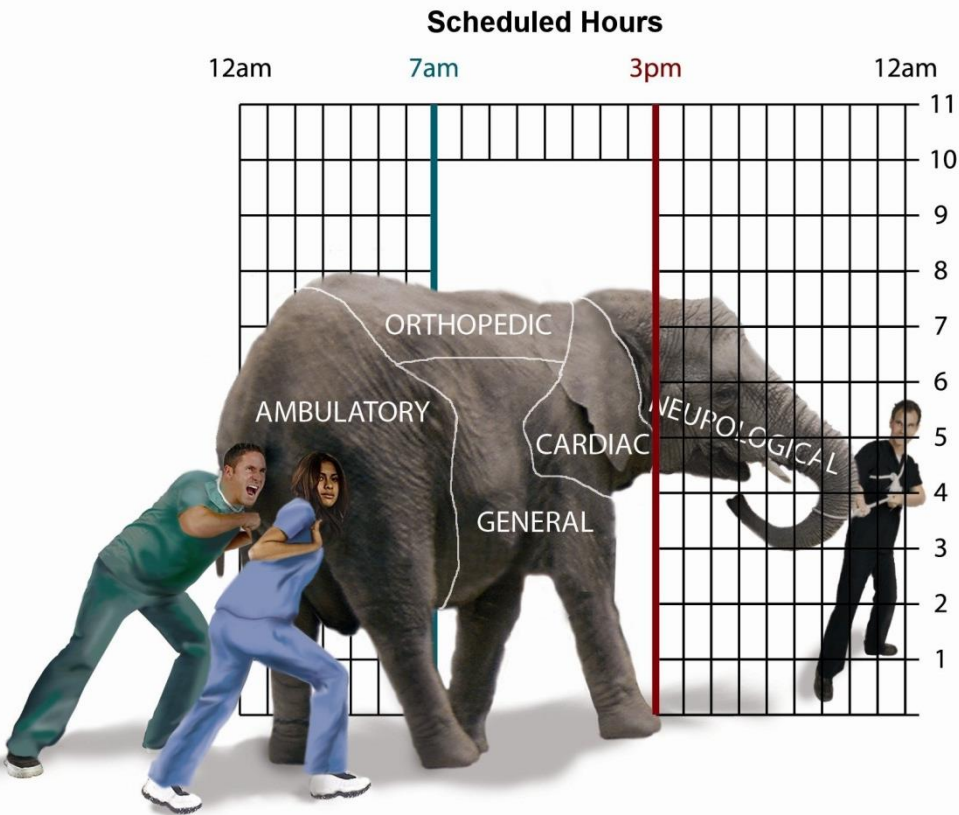 - Over-utilized OR time is from 3 PM to 6 PM

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

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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 ± 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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  - 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
- 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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  - 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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➢ 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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  - Reduces over-utilized OR time with minimal or no increase in under-utilized OR time
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- 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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- As per official policy, surgeons schedule almost all cases for 8 AM to 5 PM
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➢ 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

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

Open Access Case Scheduling Is Current Practice

- Studied the 121 hospitals in Iowa, 2007-2016
  - American Society of Anesthesiologists meeting's Fri-Wed periods compared pairwise with other such periods without holidays during the year
  - Caseloads were the same   (+0.1%, P=0.93)
- Fewer general surgery cases during American College of Surgeons meeting (-2.5%, P=0.003)
- Fewer joint arthroplasties during American Academy of Orthopaedic Surgeons meeting
  (-5.9%, P=0.018)

Dexter F, Epstein RH. J Med Syst 2018

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 ≤ 2 cases per *week* in the baseline year (77.0% ± 2.5% [SE])

- Majority of the growth in outpatient surgery Relative Value Units was among those surgeons (81.9% ± 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
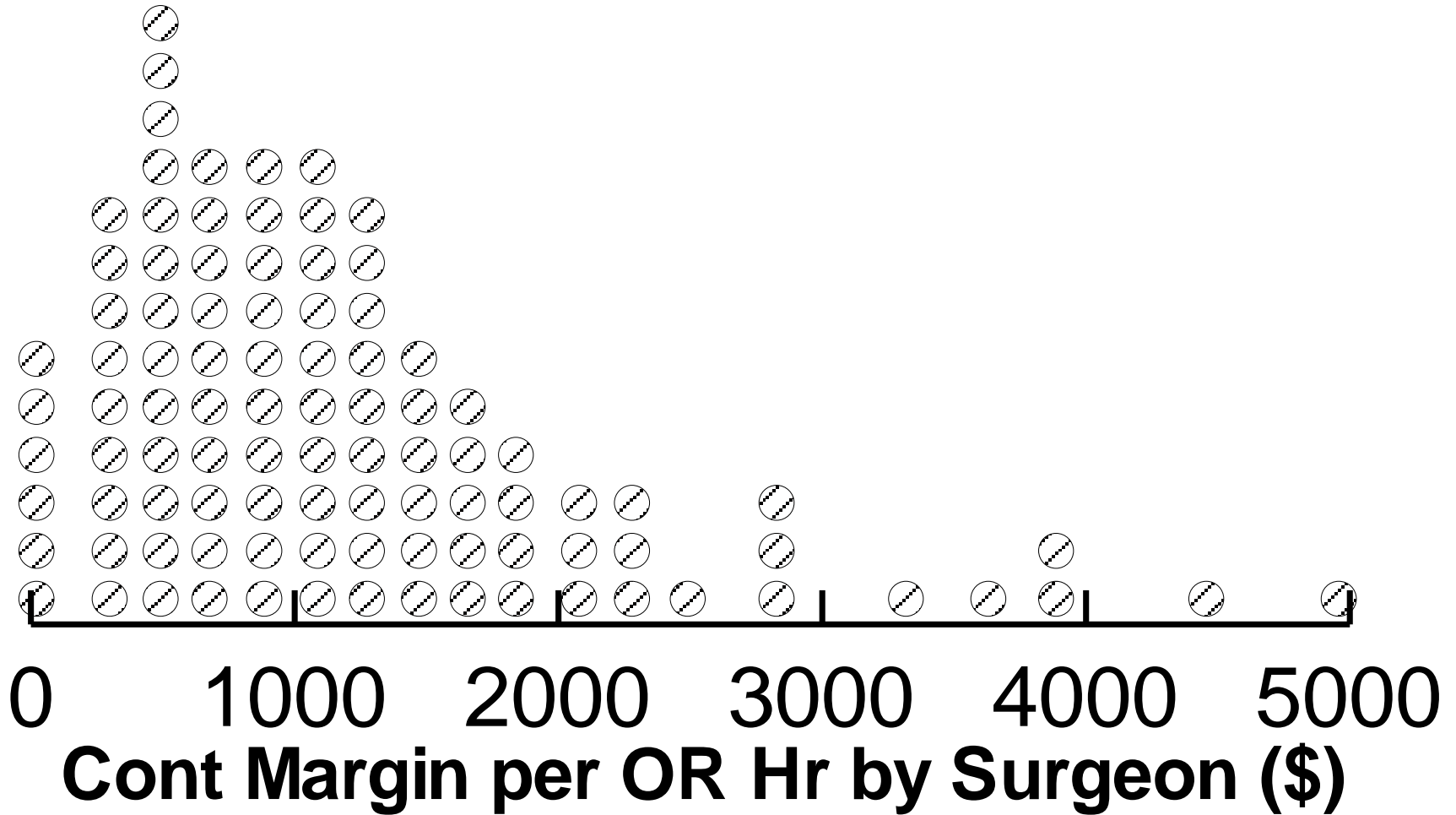 - Make a graph with one circle for each surgeon

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

Cont. Margin per OR Hr by Surgeon ($)

-1000   0   1000   2000   3000   4000   5000
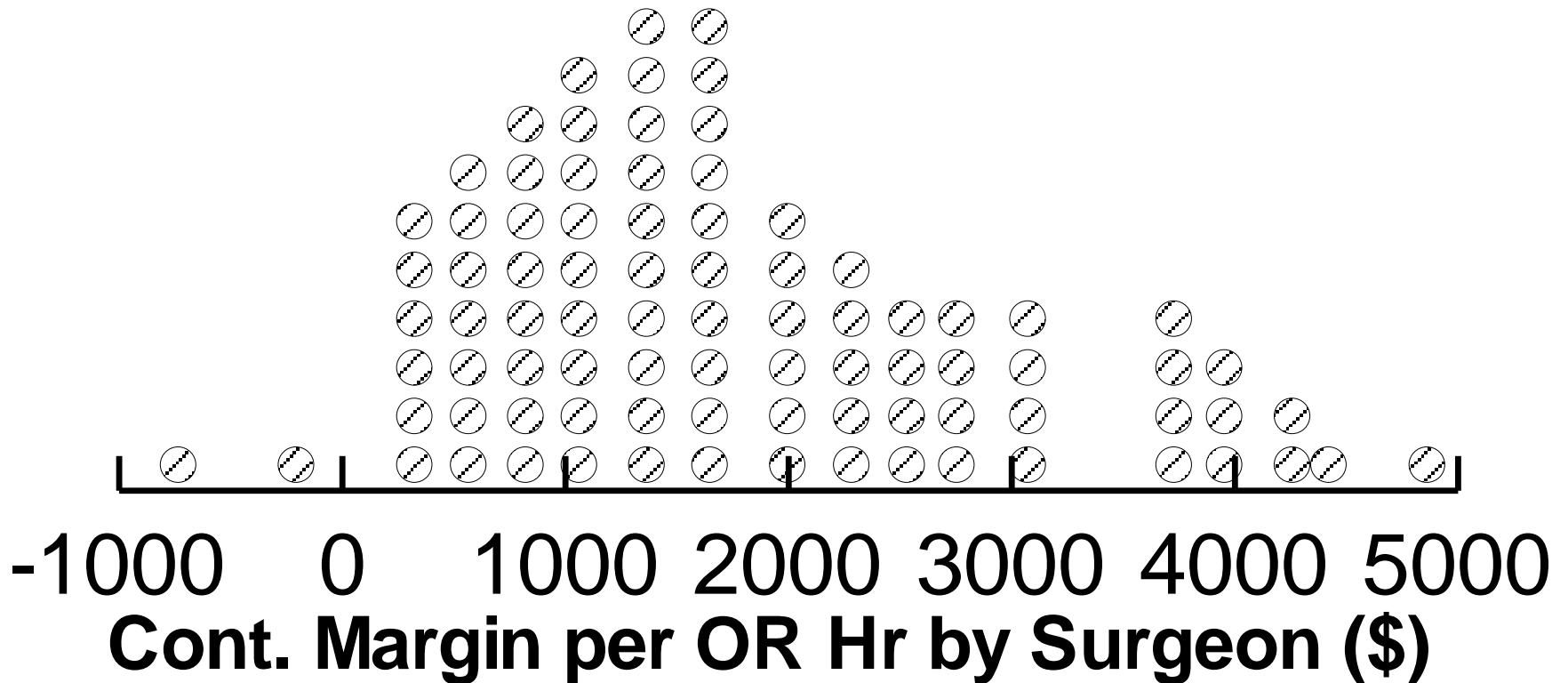
Cont. Margin = Revenue - Variable Costs

Other Hospital Positive Contribution Margin all Surgeons

Cont Margin per OR Hr by Surgeon ($)

0   1000   2000   3000   4000   5000

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 <u>safely</u>, 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 1ˢᵗ Tactically and 2ⁿᵈ 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 meeting
- 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

Rest of talk

  - Managers are responsible for increasing OR efficiency by adjusting *staffing* to match the surgeons' and patients' hours (e.g., 8 or 13 hr)
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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
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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

Dexter F et al. Med Inform Decis Mak 2011

Generate Adapted Scenarios for Organizations

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

Math

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

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

Math

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

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)~~
   $\times$ (hours of under-utilized OR time)
+ (Cost per hour of over-utilized OR time)
   $\times$ (hours of over-utilized OR time)

Dexter F, Traub RD. Anesth Analg 2002

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Constant

- 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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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	4 PM – 2 ORs
3 PM – 5 ORs	5 PM – 0.2 ORs

- Mean ORs in use after intervention

2 PM – 5 ORs	4 PM – 1 ORs
3 PM – 4 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

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
- Some days he finishes at 8 PM
  - Over-utilized OR time = 3 hours
- ➢ Valiant and noble effort, but of no substantive impact on OR efficiency

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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 ORs $\times$ 10 hr = 30 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

4) 4 ORs: 4 × 8 hr, 0 × 10 hr

5) 4 ORs: 3 × 8 hr, 1 × 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[th] 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 66th 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 × 8 hr, 3 × 10 hr`

- Standard deviation = 5 hr, typical value

  `4) 4 ORs: 4 × 8 hr, 0 × 10 hr`

- Standard deviation = 10 hr, large value

  `5) 4 ORs: 3 × 8 hr, 1 × 10 hr`

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- Standard deviation = 10 hr, large value

   5) 4 ORs: 3 × 8 hr, 1 × 10 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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    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 hr = (0 + 1 + 0) + 1.75 × (4 + 0 + 7)
- If staff 2 OR for 8 hours for the service

  14.00 hr = (4 + 9 + 1) + 1.75 × (0 + 0 + 0)
- If staff 3 OR for 8 hours for the service

  38.00 hr = (12 + 17 + 9) + 1.75 × (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
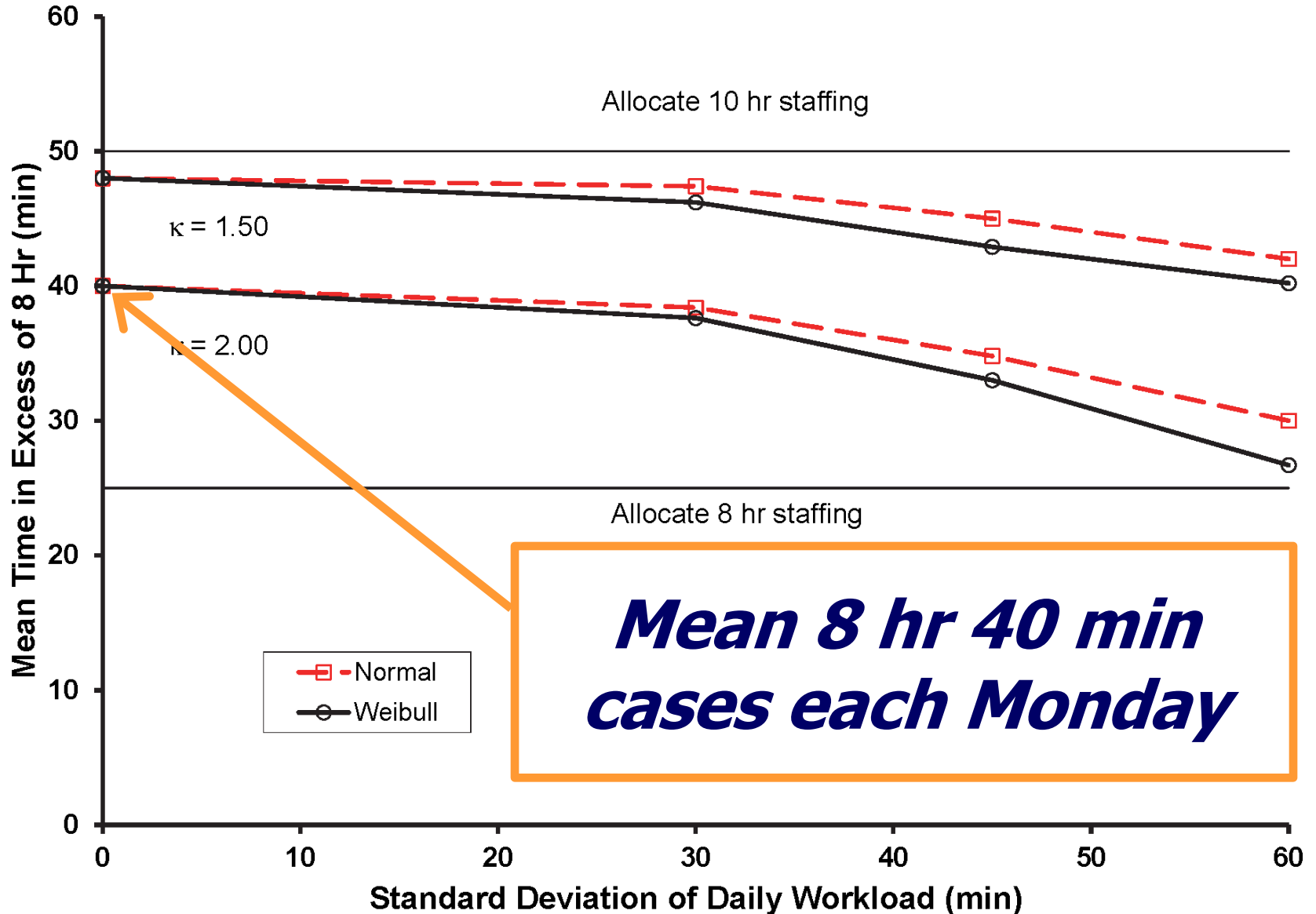
Allocated Times for Single ORs From Pandit & Dexter 2009
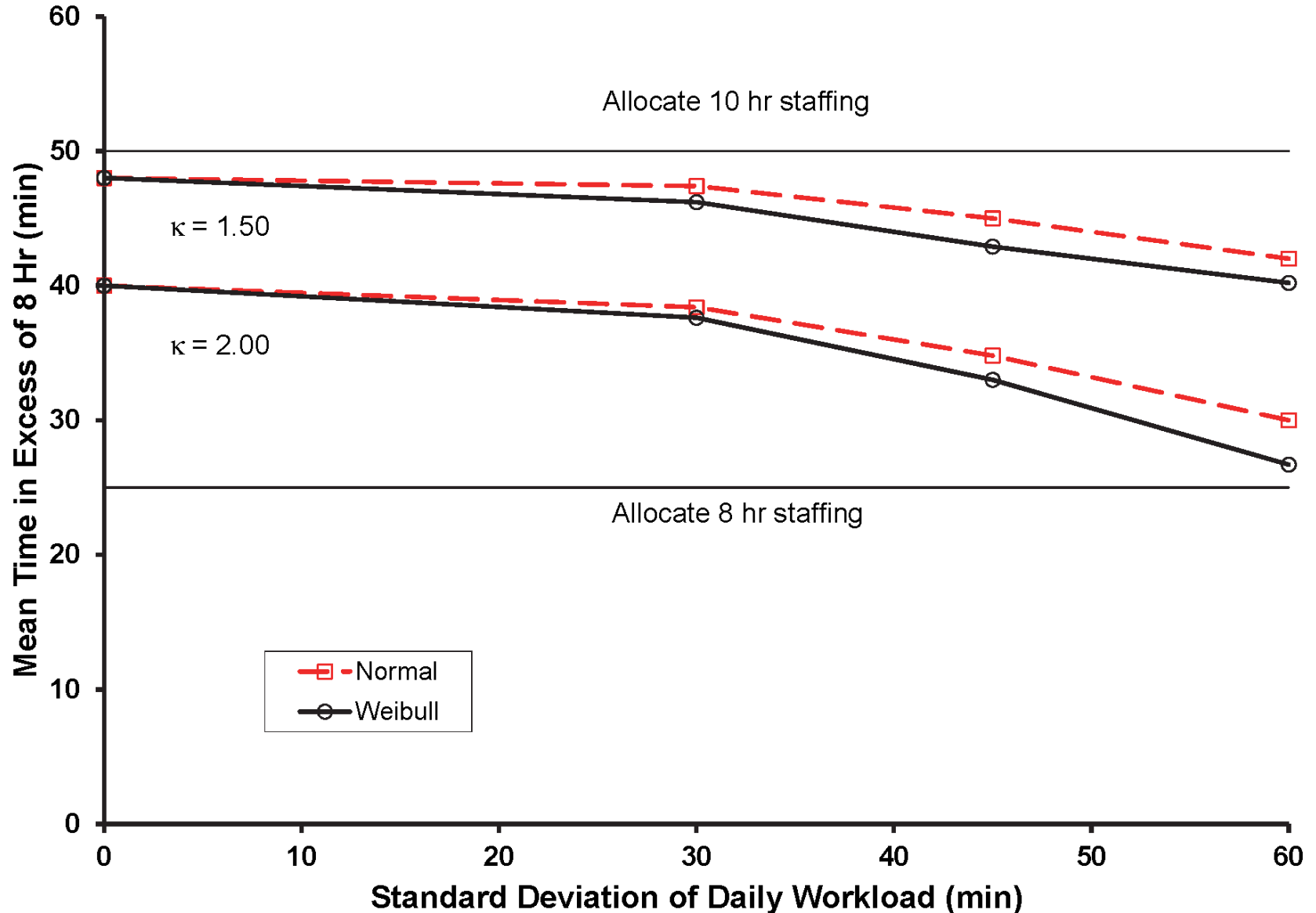
Allocated Times for Single ORs From Pandit & Dexter 2009

Allocated Times for Single ORs From Pandit & Dexter 2009

Allocated Times for Single ORs From Pandit & Dexter 2009

Allocate 10 hr staffing

$\kappa = 1.50$

$\kappa = 2.00$

Allocate 8 hr staffing

Mean Time in Excess of 8 Hr (min)

Standard Deviation of Daily Workload (min)

Normal

Weibull

Mean 8 hr 40 min cases each Monday
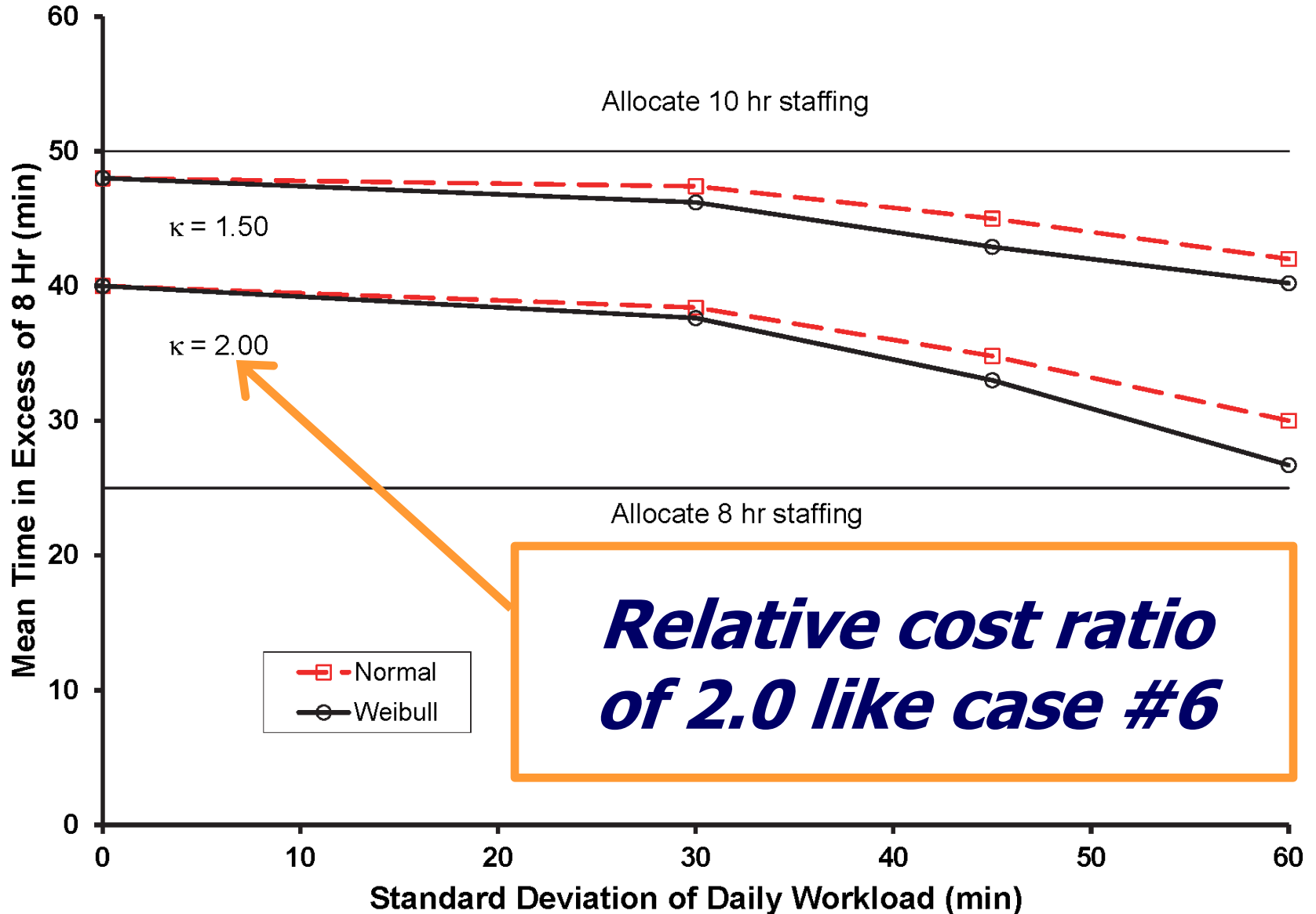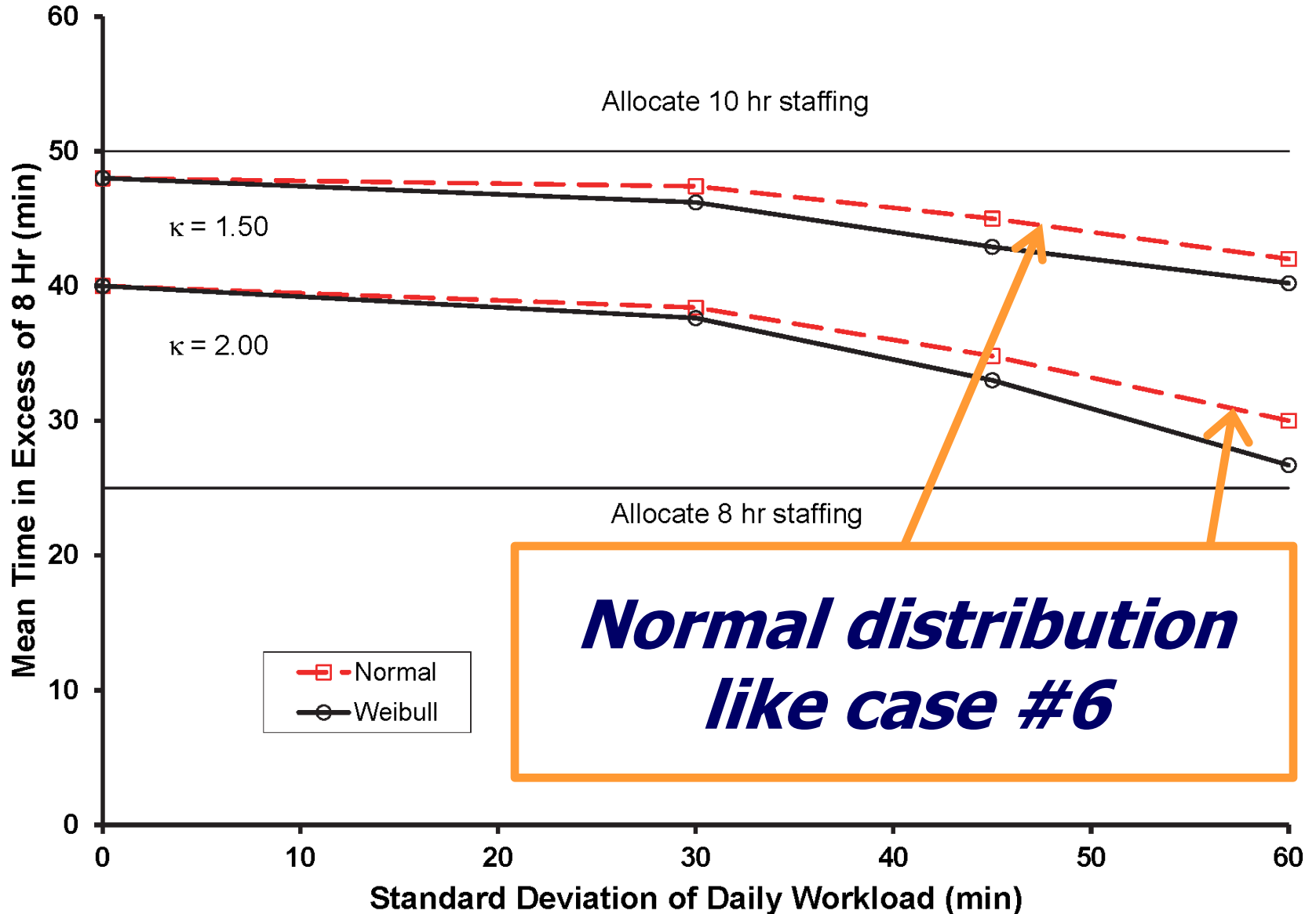
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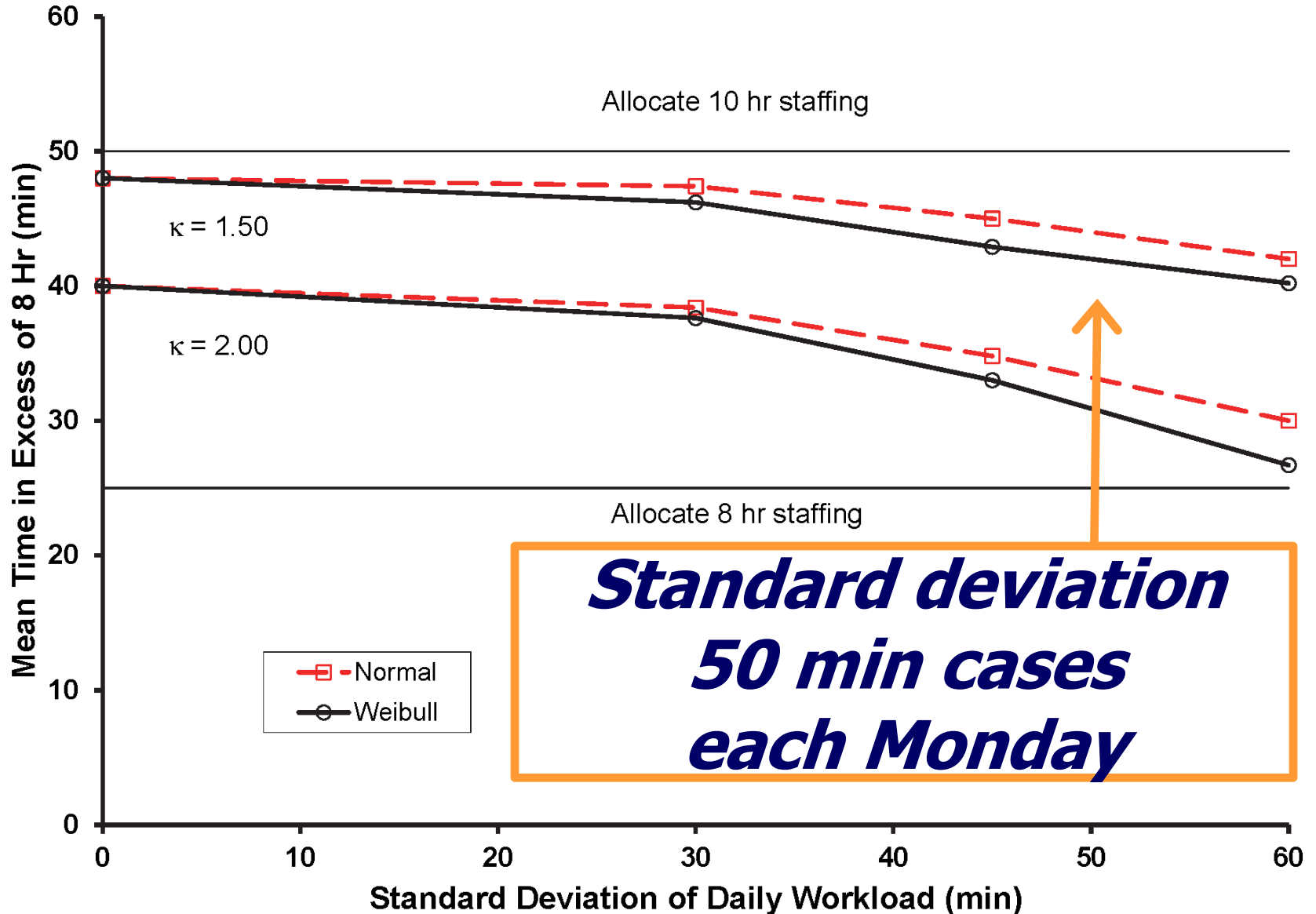
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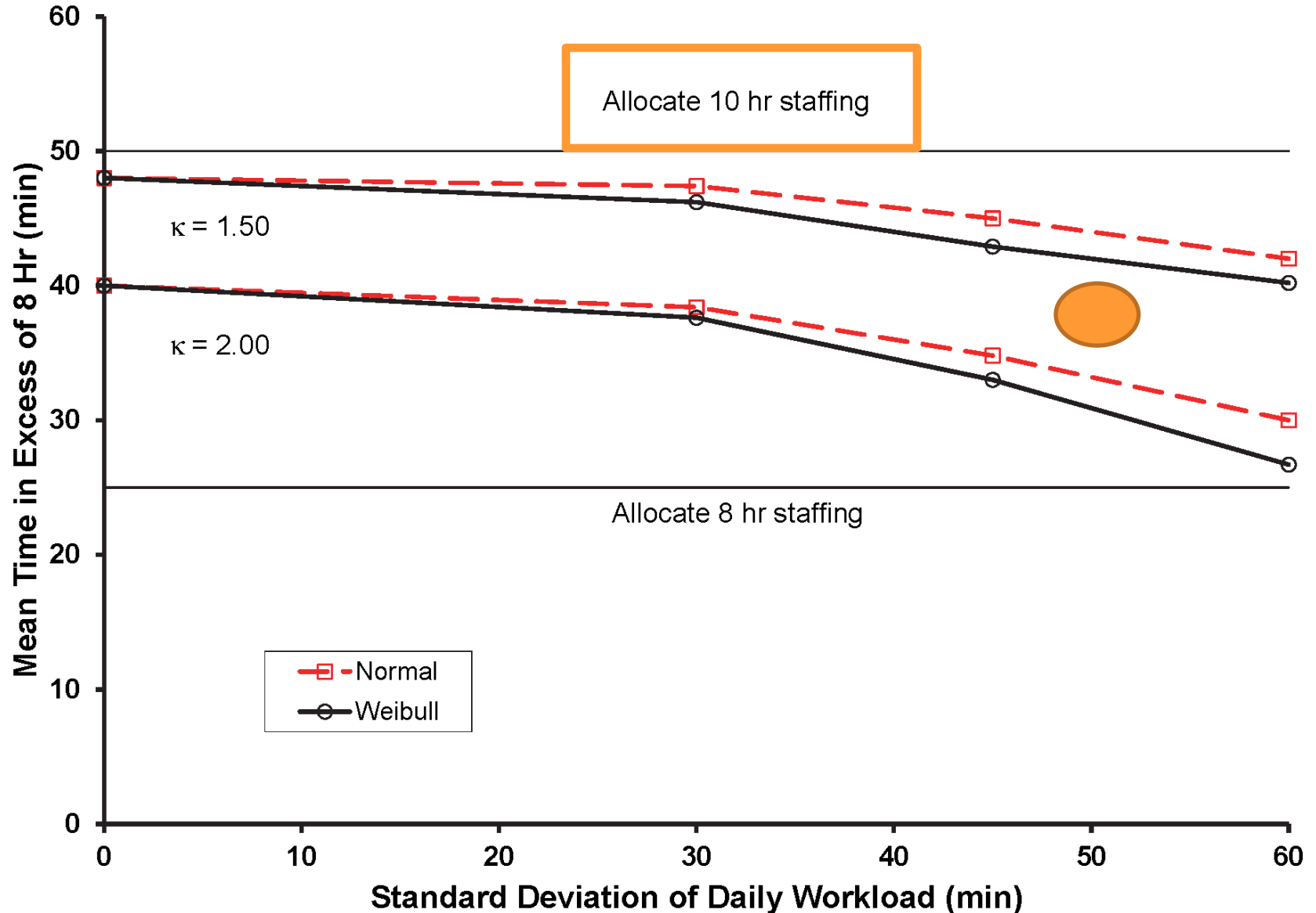
Increasing Efficiency of Use of OR Time

- 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
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- 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
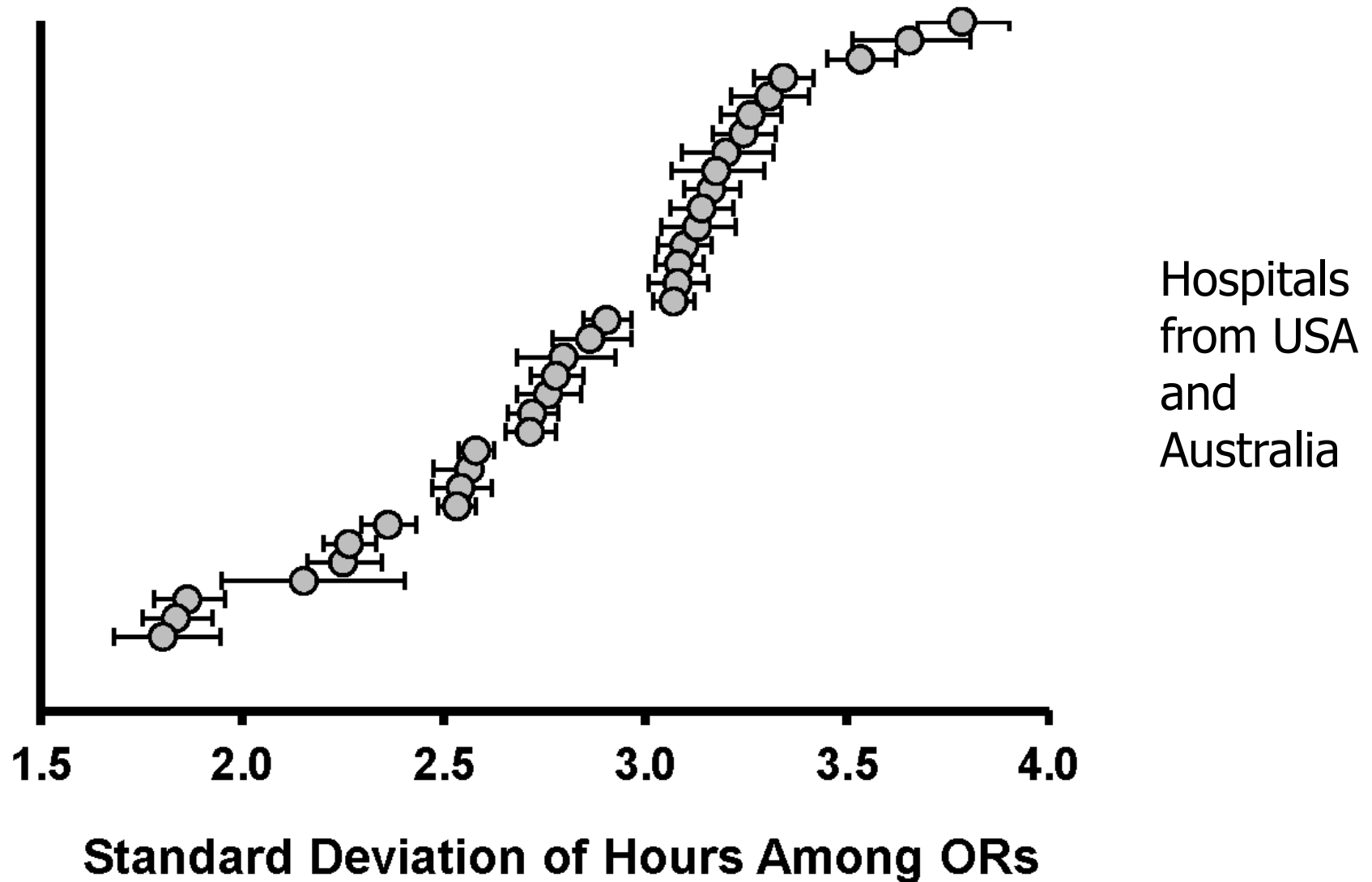 – As for any mathematics problem, ***be sure*** that you are getting the correct answer

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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  ➢ Reality > 3 hours for many hospitals

Marcon E, Dexter F. Anesth Analg 2007

Most Hospitals Have > 1 Duration of Allocated Hours

Hospitals from USA and Australia

Standard Deviation of Hours Among ORs

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

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
- Issue is psychology, not politics, culture, buy in, personalities, or organizational inertia
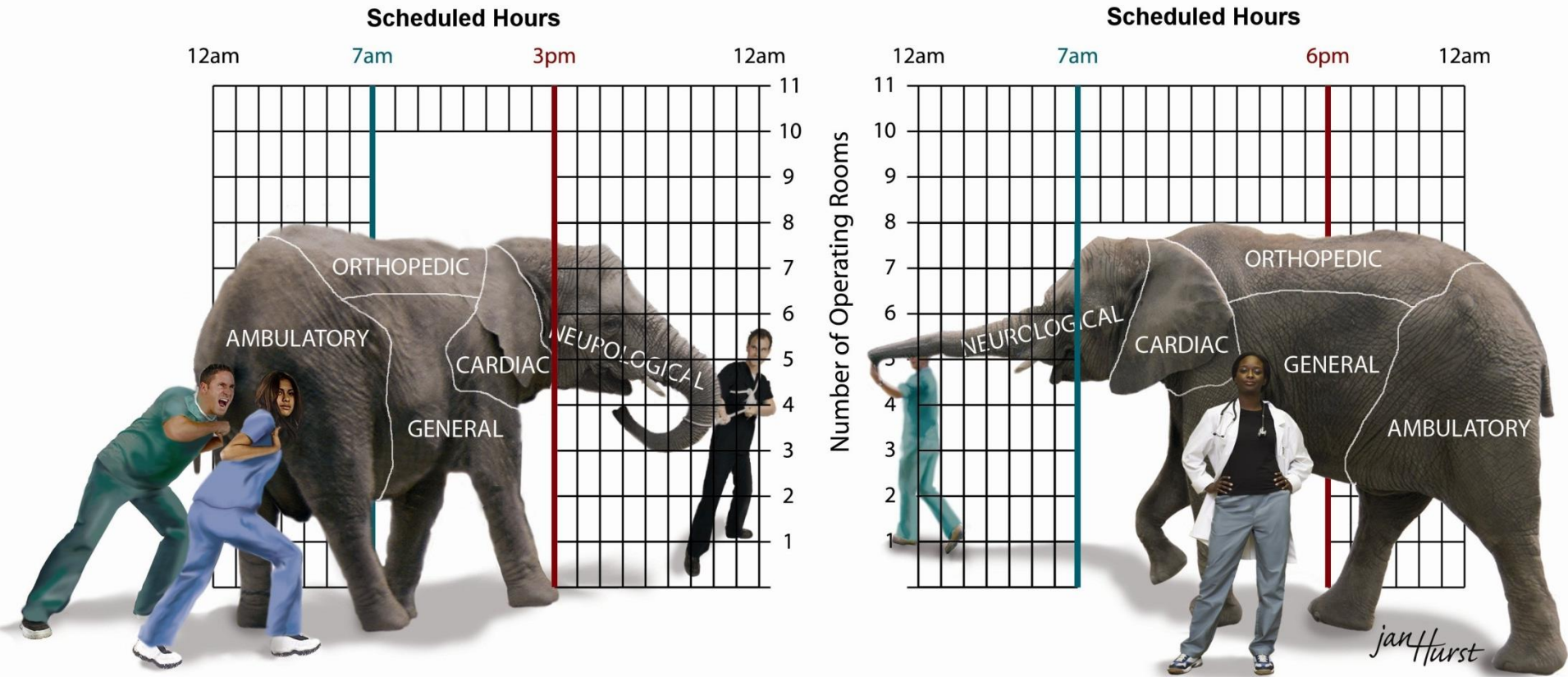
# Experimental Studies Explain Why Method Often Unused

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

Experimental Studies Explain Why Method Often Unused

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

Wachtel RE, Dexter F. J Grad Med Educ 2010

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
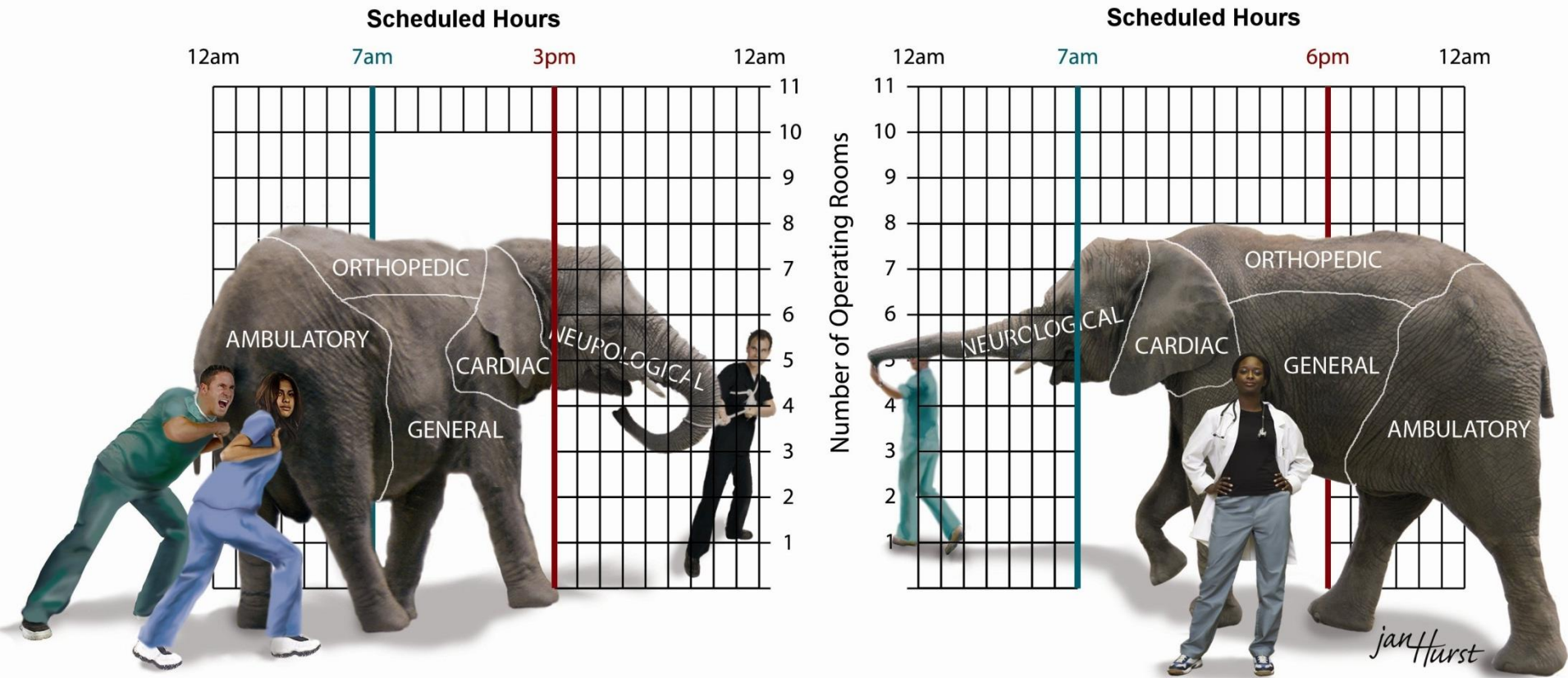
➢Implementation is the mathematics

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?
- 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

OR Information System, AIMS, or Anesthesia Billing Data

File   Edit   View   Insert   Format   Tools   Data   Window   Help   Send

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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    - Types of data
    - ➢ Seasonal variation in OR workload
    - How many months of data to use
    - Application to staff scheduling and assignment

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
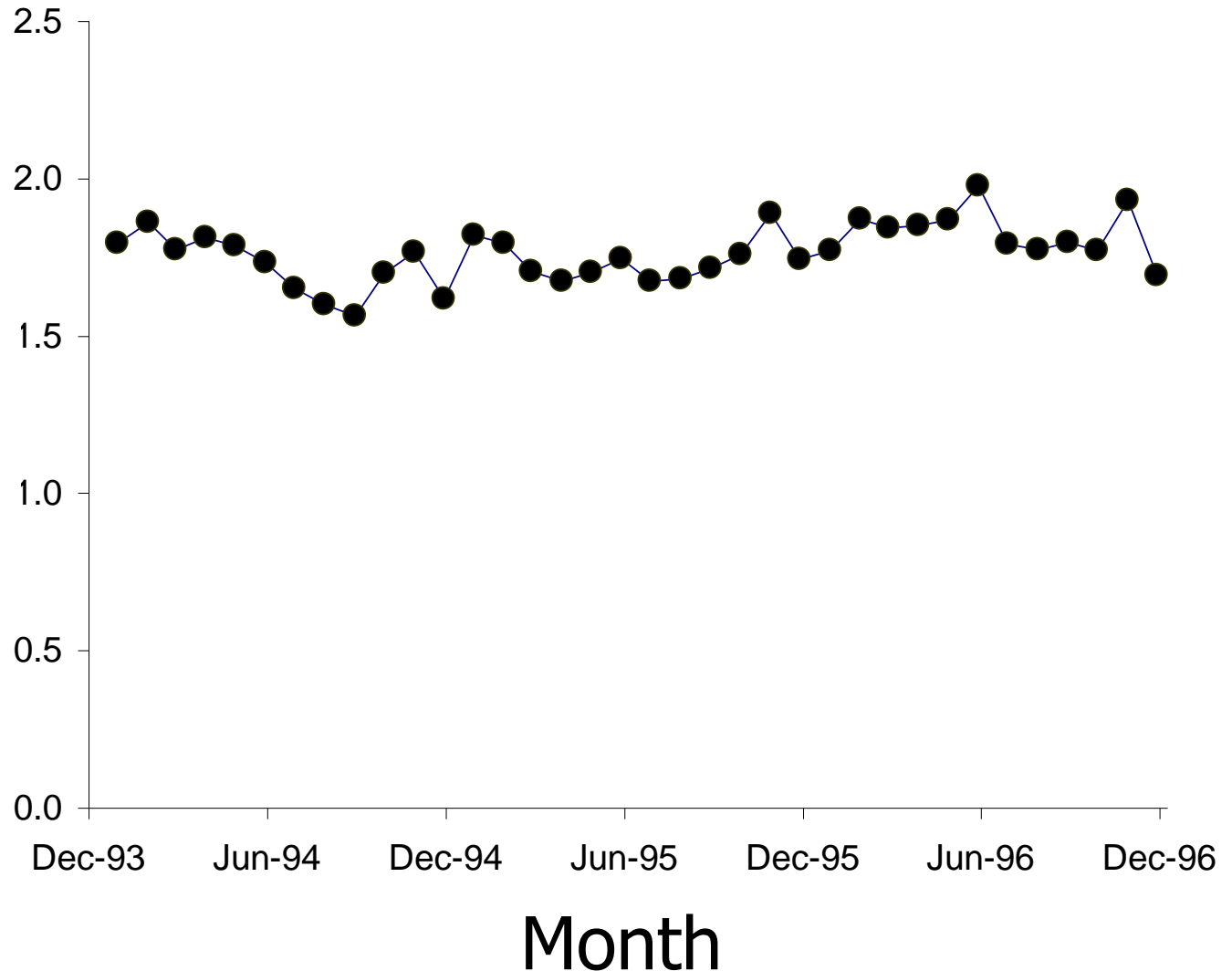 - Incidence of otitis media peaks toward the end of winter

Positive Control – Seasonal Variation in Myringotomy Tubes
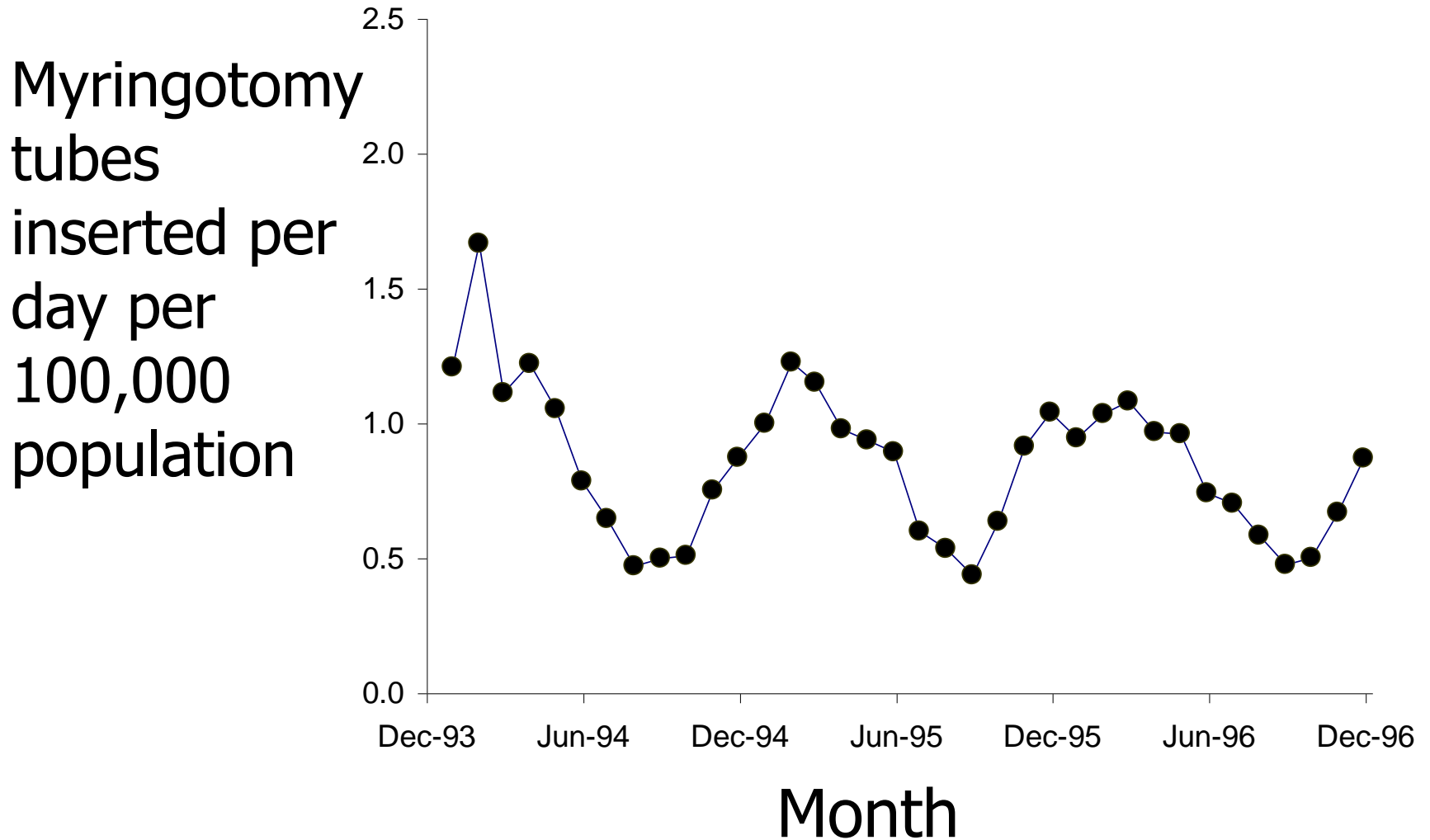
Anesthesia Caseload Does Not Vary Systematically Over < 1 Yr

Cases with anesthesia provider per day per 10,000 population

Month

Sequence of the Talk

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  - 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
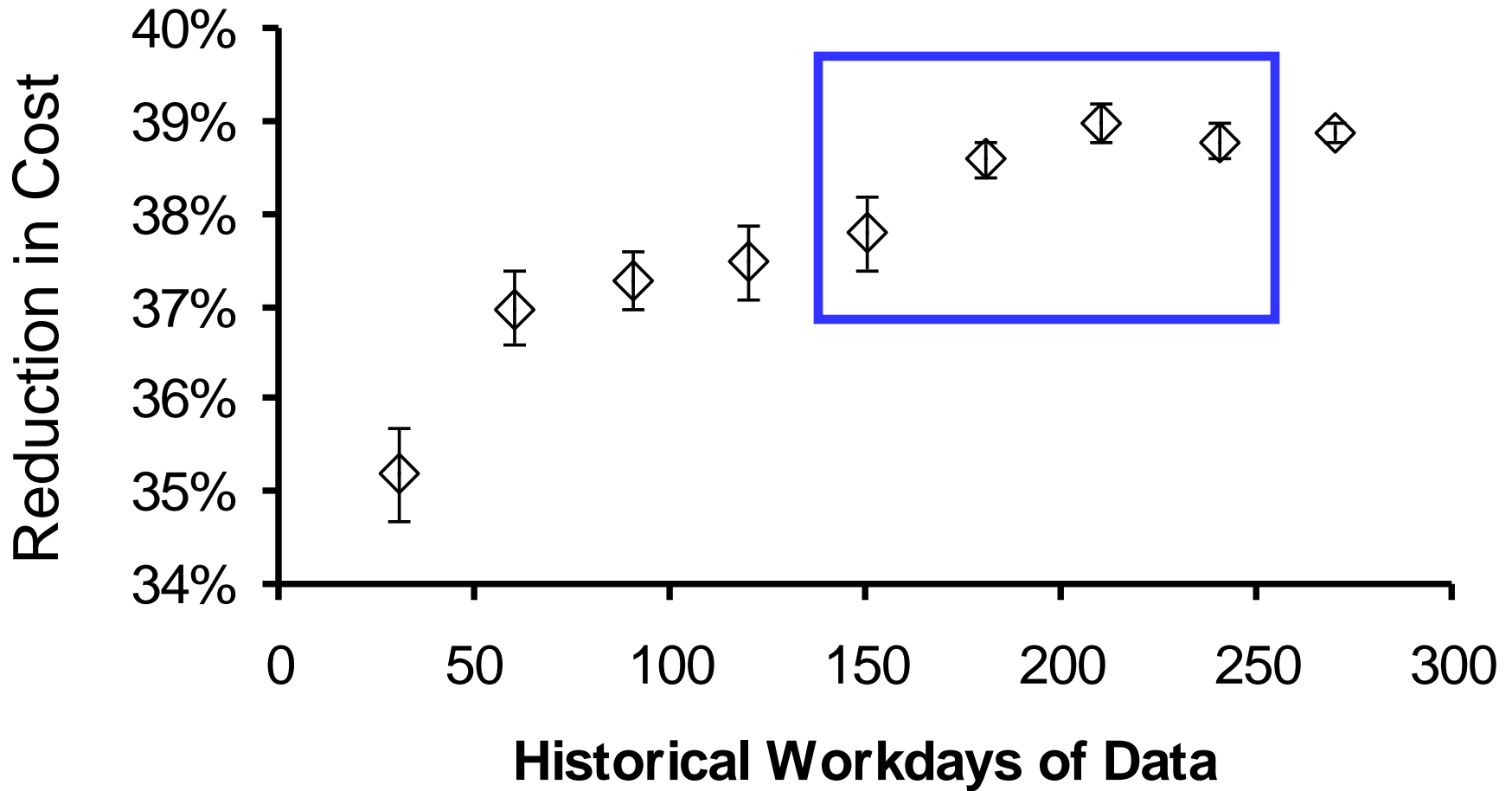
Sequence of the Talk

- 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

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

Application to Staff Scheduling and to Staff Assignment

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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

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

Application to Staff Scheduling and to Staff Assignment

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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

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
  - 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
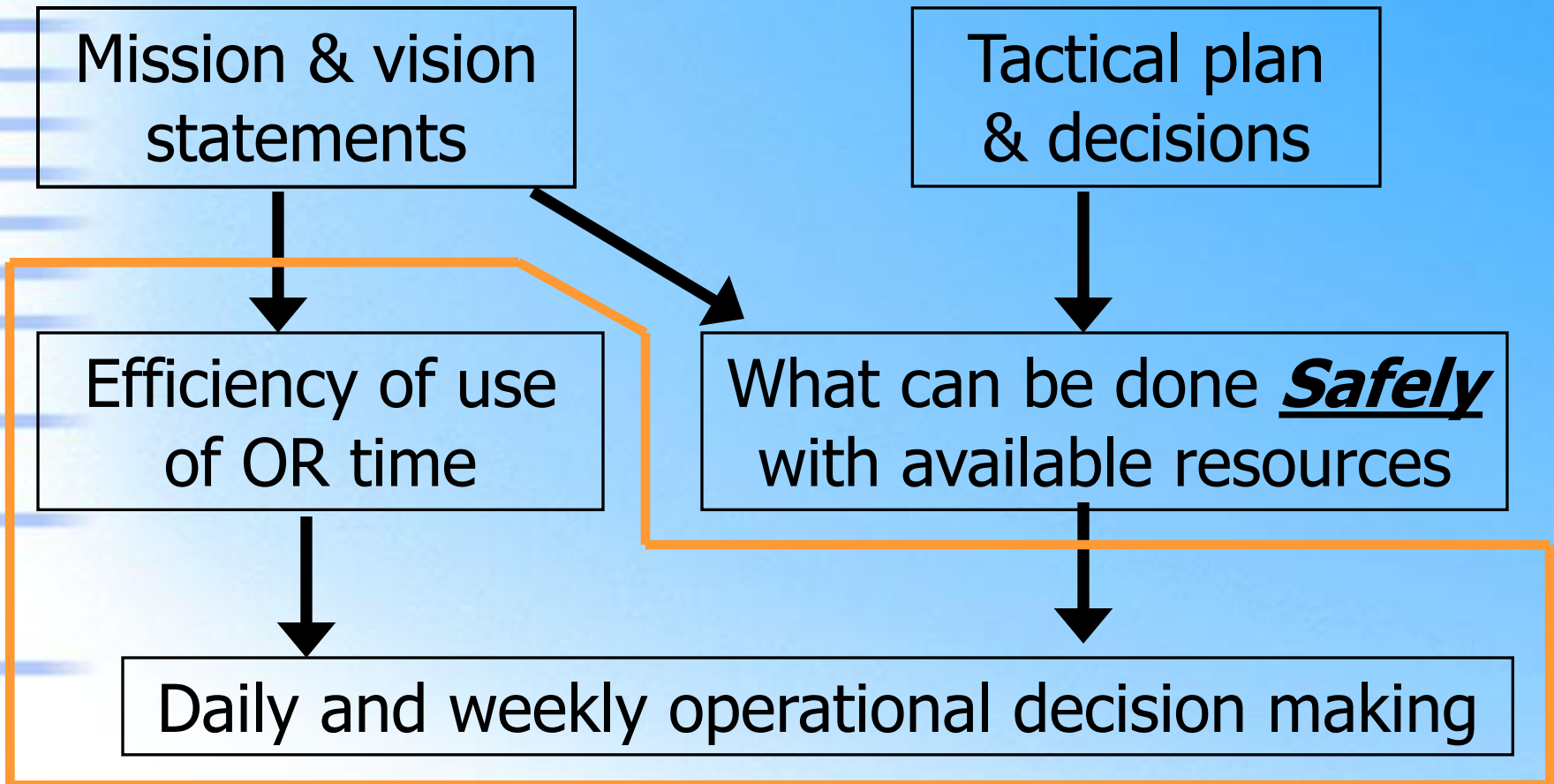
Application to Staff Scheduling and to Staff Assignment

- 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.
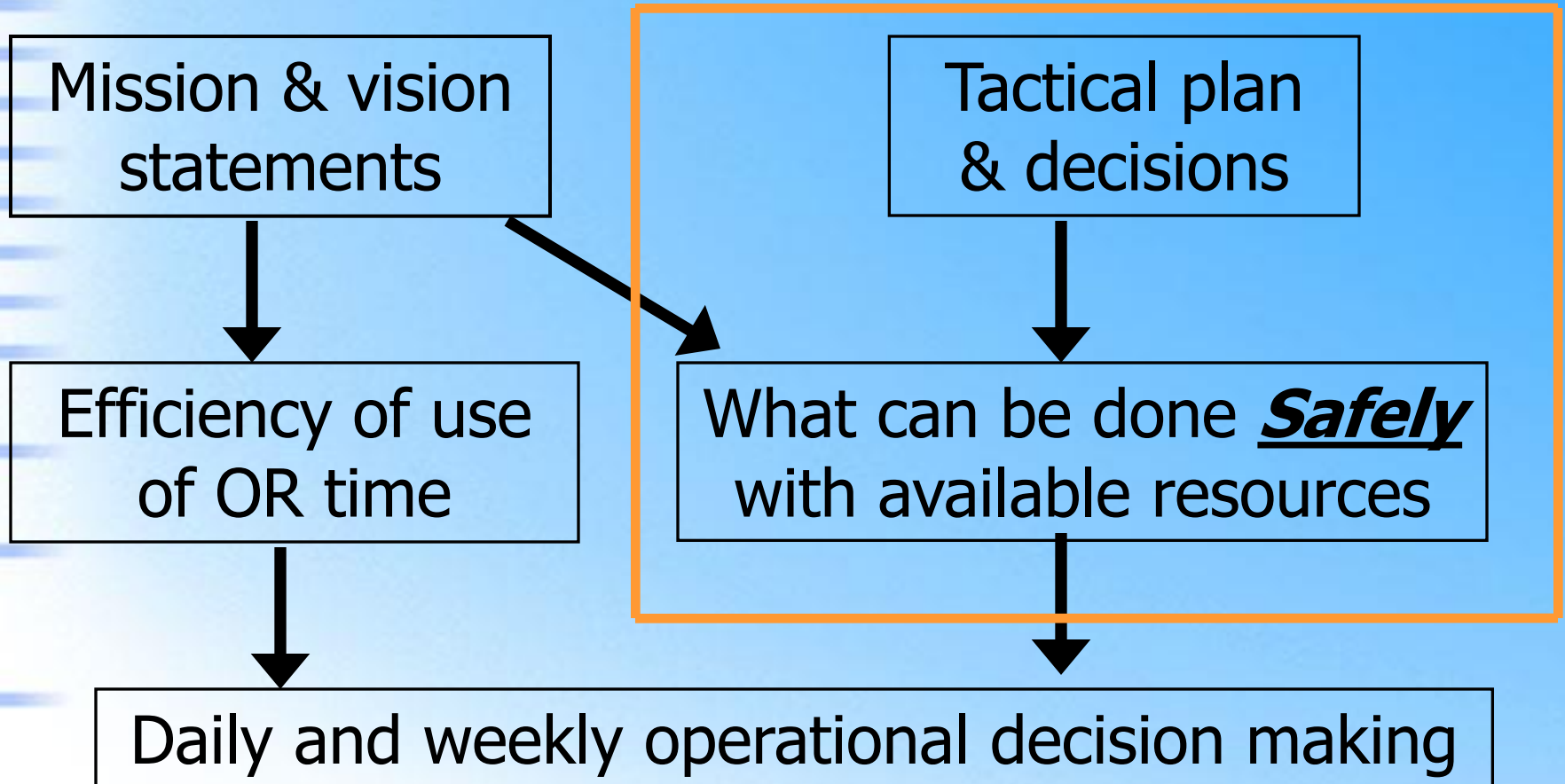
Dexter F et al. Anesth Analg 2010

Review – Topics of the Talk are Operational Decision Making

Mission & vision statements

Tactical plan & decisions

Efficiency of use of OR time

What can be done ***Safely*** with available resources

Daily and weekly operational decision making

Review – Topics of the Talk are Operational Decision Making

| Mission & vision statements | Tactical plan & decisions |

Efficiency of use of OR time

What can be done **_Safely_** with available resources

Daily and weekly operational decision making

Such tactical issues limit how much work gets done

Review – Topics of the Talk and Consider an Application

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

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
  - 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
  - Comprehensive bibliography of peer reviewed articles in operating room and anesthesia group management