

# Using an Add-On Case Room to Reduce Over-Utilized Time

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# Using an Add-On Case Room to Reduce Over-Utilized Time

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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)

# Topics of Talk on Add-on Case Rooms

- Efficiency of use of OR time
  - Decision-making to reduce over-utilized time
  - Bin packing principles for case scheduling
  - Behavior on day of surgery when displays do not provide recommendations
  - Allocating OR time based on maximizing the efficiency of use of OR time
  - Behavior before and on day of surgery without evidence-based displays



# Example of *Under-Utilized OR Time*

- Allocated time is from 7:15 AM to 3:30 PM
  - These are hours into which cases are scheduled
- An OR's last case of the day ends at 1:30 PM
- There are 2 hours of under-utilized OR time
  - Under-utilized time is from 1:30 PM to 3:30 PM

McIntosh C et al. Anesth Analg 2006

Dexter F, Epstein RH. Periop Care Oper Room Manag 2024



# Example of *Over-Utilized OR Time*

- Allocated time is from 7 AM to 4 PM
- OR's last case of the day ends at 6 PM
- There are 2 hours of *over-utilized OR time*
  - Over-utilized OR time is from 4 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



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- OR nurses, nurse anesthetists, and anesthesiologists are full-time employees
- Allocated time is from 8 AM to 3:30 PM
- There is estimated to be 8.5 hr of cases
- Turnover and extubation times are brief
- OR finishes at 3:30 PM, instead of 4:30 PM
- Has OR efficiency been increased?





# 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

Dexter F et al. Anesthesiology 2004



# Meaning of Maximizing OR Efficiency on Day of Surgery

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***Constant***



# Meaning of Maximizing OR Efficiency on Day of Surgery

Inefficiency of use of OR time (\$)  $\cong$   
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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

Inefficiency of use of OR time (\$)  $\cong$   
~~(Cost per hour of over-utilized OR time)~~  
 $\times$  (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
  - Allocated time was from 8 AM to 3:30 PM, which is 7.5 hr
  - Reducing turnover and extubation times resulted in cases finished in 7.5 hr instead of in the expected 8.5 hr
    - Finished at 3:30 PM instead of at 4:30 PM
    - Had 0 hours of over-utilized time instead of 1 hour of over-utilized time



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- Scenario
  - Allocated time was from 8 AM to 3:30 PM, which is 7.5 hr
  - Reducing turnover and extubation times resulted in cases finished in 7.5 hr instead of in the expected 8.5 hr
    - Finished at 3:30 PM instead of at 4:30 PM
    - Had 0 hours of over-utilized time instead of 1 hour of over-utilized time
  - Increased efficiency of use of OR time 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
- Allocated time is from 8 AM to ~~3:30~~ 6 PM
- There is estimated to be 8.5 hr of cases
- Turnover and extubation times are brief
- OR finishes at 3:30 PM, instead of 4:30 PM
- Has OR efficiency been increased?



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- Scenario
  - Allocated time is from 8 AM to ~~3:30~~ **6** PM
  - Reducing turnover and extubation times resulted in cases finished in 7.5 hr instead of in the expected 8.5 hr
  - No increase in OR efficiency



# Scenario 1 – Can Working Fast Increase OR Efficiency?

- Scenario

- Allocated time is from 8 AM to ~~3:30~~ **6** PM

- Reducing turnover and extubation times resulted in cases finished in 7.5 hr instead of in the expected 8.5 hr

- No increase in OR efficiency

Good (rational) OR management operational decision-making is highly sensitive to the OR allocations, and requires knowing the allocated hours for each OR

# Topics of Talk on Add-on Case Rooms

- Efficiency of use of OR time
- Decision-making to reduce over-utilized time
- Bin packing principles for case scheduling
- Behavior on day of surgery when displays do not provide recommendations
- Allocating OR time based on maximizing the efficiency of use of OR time
- Behavior before and on day of surgery without evidence-based displays



# Scenario 2 – Anesthesiologist Reduces Turnover Times

- Allocated time is from 7:15 AM to 3:30 PM
- Anesthesiologist is assigned to supervise resident physicians in OR 3 and OR 4
- These ORs have just finished their first cases
- The second and last case of the day in OR 3 is expected to be finished at 2:30 PM
- The second and last case of the day in OR 4 is expected to be finished at 4:30 PM
- Which OR should anesthesiologist start next?



# Scenario 2 – Anesthesiologist Reduces Turnover Times

- The cases will be performed safely regardless of the decision, thus not influencing decision
- *OR efficiency*
  - OR 3 expected 0 hr of over-utilized OR time
    - Finish 2:30 PM, but allocated time to 3:30 PM
  - OR 4 expected 1 hr of over-utilized OR time
    - Finish 4:30 PM, but allocated time to 3:30 PM
- If the patient for OR 4 is ready, the anesthesiologist should start OR 4 first



# Scenario 2 – Anesthesiologist Reduces Turnover Times

- Allocated time is from 7:15 AM to ~~3:30~~ **6** PM
- Anesthesiologist is assigned to supervise resident physicians in OR 3 and OR 4
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- The second and last case of the day in OR 3 is expected to be finished at 2:30 PM
- The second and last case of the day in OR 4 is expected to be finished at 4:30 PM
- Which OR should anesthesiologist start next?



# Scenario 2 – Anesthesiologist Reduces Turnover Times

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





# Scenario 2 – Anesthesiologist Reduces Turnover Times

- Moral
  - To make good (rational) OR management operational decisions, you need to know the allocated hours for each OR
    - Calculated based on minimizing the inefficiency of use of OR time



# Scenario 2 – Anesthesiologist Reduces Turnover Times

- Moral
  - To make good (rational) OR management operational decisions, you need to know the allocated hours for each OR
    - Calculated based on minimizing the inefficiency of use of OR time
      - Will discuss later in the talk



# Scenario 3 – Moving Cases

- Allocated time is from 7:15 AM to 3:30 PM
- Add-on case room empty, no pending cases
- OR 12 is running behind
  - Its last case, scheduled from 2 PM to 3:30 PM, will not start until 5 PM
  - Anesthesia and nursing team assigned to the add-on room can perform the case safely
  - Surgeon and patient are ready
- Move the case from OR 12 to add-on room?



# Scenario 3 – Moving Cases

- The case will be performed safely regardless of the decision, thus not influencing decision
- *OR efficiency* is affected by the decision
  - Case performed entirely in over-utilized OR time if case is not moved
  - Over-utilized OR time likely reduced by at least 1.5 hr if case is moved
  - Move the case into the add-on case room
    - Even though not an add-on case, doing so achieves organizational priorities

# Scenario 4 – When Scheduled Hours Exceed Allocated Time

- Saturday and Sunday allocated time is 3 ORs x 24 hr for non-elective cases

Dexter F et al. Anesth Analg 2016



# Scenario 4 – When Scheduled Hours Exceed Allocated Time

- Saturday and Sunday allocated time is 3 ORs x 24 hr for non-elective cases
- Not once in years have 3 ORs run non-stop for 24 hr on either Saturday or Sunday
- Under what circumstances would a 4<sup>th</sup> room be opened on a Saturday?
  - Base list on rational organizational priorities



# Scenario 4 – When Scheduled Hours Exceed Allocated Time

- *Patient safety*
  - With three ORs, a case could not reliably start by when the surgeon says it needs to start
- *Access to OR time*
  - No influence on decisions since urgent cases
- *OR efficiency*
  - Never open 4<sup>th</sup> OR other than for safety reasons, because would first fully fill the 3 ORs, which has never happened



# Scenario 4 – When Scheduled Hours Exceed Allocated Time

- *Patient safety*
    - With three ORs, a case could not reliably start by when the surgeon says it needs to start
  - *Access to OR time*
    - No influence on decisions since urgent cases
  - *OR efficiency*
    - Never open 4<sup>th</sup> OR other than for safety reasons, because would first fully fill the 3 ORs, which has never happened
- **“Allocated” ≠ maximum ORs at same time**



# Topics of Talk on Add-on Case Rooms

- Efficiency of use of OR time
- Decision-making to reduce over-utilized time
- Bin packing principles for case scheduling
- Behavior on day of surgery when displays do not provide recommendations
- Allocating OR time based on maximizing the efficiency of use of OR time
- Behavior before and on day of surgery without evidence-based displays



# Bin Packing Surgical Cases

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Dexter F et al. Anesthesiology 1999

Dexter F, Traub RD. Anesth Analg 2002

Dexter F et al. Anesthesiology 2004

Shi P et al. Anesth Analg 2016



# Bin Packing Surgical Cases

- Allocated time from 7 AM to 5 PM
- Time remaining in ORs at 2 PM
  - 3 hours in add-on OR [ available immediately ]
  - 2 hours in OR 2 [ available in 1 hr ]
  - 1 hour in OR 3 [ available in 2 hr ]
  - 0 hours in all other ORs
- Three add-on cases listed in sequence of submission: 0.7 hr, 2.9 hr, 1.8 hr
- All can safely wait a few hours
- Perform cases in what sequence?

# Bin Packing Surgical Cases

- Sort the cases based on estimated duration from longest to shortest
  - Consider the cases in this descending order
  - Longest add-on case is assigned first
- Assign each case to OR meeting two criteria
  - Has no restrictions on equipment or personnel preventing the case from being put into the OR
  - Sufficient extra time available for the new case



# Bin Packing Surgical Cases

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*Safety*



# Bin Packing Surgical Cases

- Sort the cases based on estimated duration from longest to shortest
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why?



# Reason for Add-on Surgical Case Scheduling Result

- Sort the cases based on estimated duration from longest to shortest
  - Consider the cases in this descending order
  - Longest add-on case is assigned first
- Assign each case to OR meeting two criteria
  - Has no restrictions on equipment or personnel preventing the case from being put into the OR
  - Sufficient ext time available for the new case

why?



# Reason for Add-on Surgical Case Scheduling Result

- On average, only 1/5 ORs with scheduled cases will have time available for add-on case
- Average time remaining in these ORs each day will be around 1.3 hr, with large SD 1.6 hr
- Average OR time of add-on cases including their turnover times around 3.4 hr (SD 1.7 hr)
  - Long, since add-on case scheduling applies to cases at hospitals, rarely outpatient facilities

Dexter F et al. Anesthesiology 1999





# Reason for Add-on Surgical Case Scheduling Result

- On average, only 1/5 ORs with scheduled cases will have time available for add-on case
- Average time remaining in these ORs each day will be around 1.3 hr, with large SD 1.6 hr
- Average OR time of add-on cases including their turnover times around 3.4 hr (SD 1.7 hr)
  - Long, since add-on case scheduling applies to cases at hospitals, rarely outpatient facilities
- Because 0 or 1 add-on cases per OR not designated for add-on cases



# Bin Packing Surgical Cases

- Sort the cases based on estimated duration from longest to shortest
  - Consider the cases in this descending order
  - Longest add-on case is assigned first
- Assign each case to OR meeting two criteria
  - Has no restrictions on equipment or personnel preventing the case from being put into the OR
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# Bin Packing Surgical Cases

- Sort the cases based on estimated duration from longest to shortest
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Why?



# Reason for Add-on Surgical Case Scheduling Result

- Sort the cases based on estimated duration from longest to shortest
    - Consider the cases in this descending order
    - Longest add-on case is assigned first
  - Assign each case to OR meeting two criteria
    - Has no restrictions on equipment or personnel preventing the case from being put into the OR
    - Sufficient extra time available for the new case
- Reduces the hours of over-utilized OR time!



# Scenario 5 – Applying Bin Packing Principles

- Allocated time is from 7 AM to 5 PM
- Current time is 6:50 AM
- Add-on case OR has on-going case expected to end at 9 AM
- There is currently only one add-on case queued, scheduled time 2 hours
- Case can go into add-on case OR starting around 9:30 AM or start at 2:45 PM in OR 6
- Surgeon does not care when the case starts, but wants to know its start time, now

# Scenario 5 – Applying Bin Packing Principles

- Based on preceding bin packing results, both likely equally good choices
  - Balance of multiple factors including
    - Chance another long add-on case scheduled
    - Chance cancellation or delay, especially among cases of patients who are inpatient preoperatively (i.e., add-on cases)

Epstein RH, Dexter F. Anesth Analg 2015

Shi P et al. Anesth Analg 2016

# Scenario 5 – Applying Bin Packing Principles

- How use the add-on case OR if keep it empty?
  - Reduce turnover time of a surgeon with > 8 hours of cases in his OR that day
  - After the swap, consider OR from where the case was moved to be the add-on OR

# Topics of Talk on Add-on Case Rooms

- Efficiency of use of OR time
- Decision-making to reduce over-utilized time
- Bin packing principles for case scheduling
- Behavior on day of surgery when displays do not provide recommendations
- Allocating OR time based on maximizing the efficiency of use of OR time
- Behavior before and on day of surgery without evidence-based displays





# Managerial Behavior

- Common behavior is to keep each provider busy during her assigned hours
  - Same as optimal behavior, just learned, for decisions involving single ORs
  - Not same as optimal behavior for decisions involving multiple ORs, especially when allocated hours differ among ORs

Dexter F et al. Anesth Analg 2007

Stepaniak PS et al. Anesth Analg 2009

Wang J et al. Anesth Analg 2013



# Managerial Behavior

- For scenarios involving pairs of ORs, decisions made without electronic recommendations (displays) less accurate than random chance ( $37\% < 50\%$ ,  $P = 0.011$ )
- Displays with recommendations increase the accuracy of decisions ( $P < 0.0001$ )
- Displays with information on over-utilized time but without recommendations do not increase accuracy ( $P = 0.40$ )



# Managerial Behavior

- When monitoring managers' performance, good criterion is use by their facility of either:
  - Displays providing recommendations
  - Displays providing information and checklists for how to use the information

Stepaniak PS, Dexter F. Anesth Analg 2013



# Managerial Behavior

- When monitoring managers' performance, good criterion is use by their facility of either:
  - Displays providing recommendations
  - Displays providing information and checklists for how to use the information
- Use anesthesia group – facility agreement to codify the performance criteria

Dexter F, Epstein RH. Anesth Analg 2008

Dexter F, Epstein RH. Anesth Analg 2015



# Topics of Talk on Add-on Case Rooms

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# Calculating Allocated OR Time

- 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
- Relative cost of 1 hr over-utilized OR time =  $2.0 \times$  that of 1 hr under-utilized OR time

McIntosh C et al. Anesth Analg 2006

Pandit JJ, Dexter F. Anesth Analg 2009

Dexter F, Epstein RH. Periop Care Oper Room Manag 2024

# Calculating Allocated OR Time

- 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***



# Calculating Allocated OR Time

- Consider standard deviation of orthopedics' workload on Mondays = 5 hr, a typical value
- 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
  - 6) 4 ORs : 2 × 8 hr, 2 × 10 hr



# Calculating Allocated OR Time

- Consider standard deviation of orthopedics' workload on Mondays = 5 hr, a typical value
- 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
  - 6) 4 ORs : 2 × 8 hr, 2 × 10 hr

# Calculating Allocated OR Time

- 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**



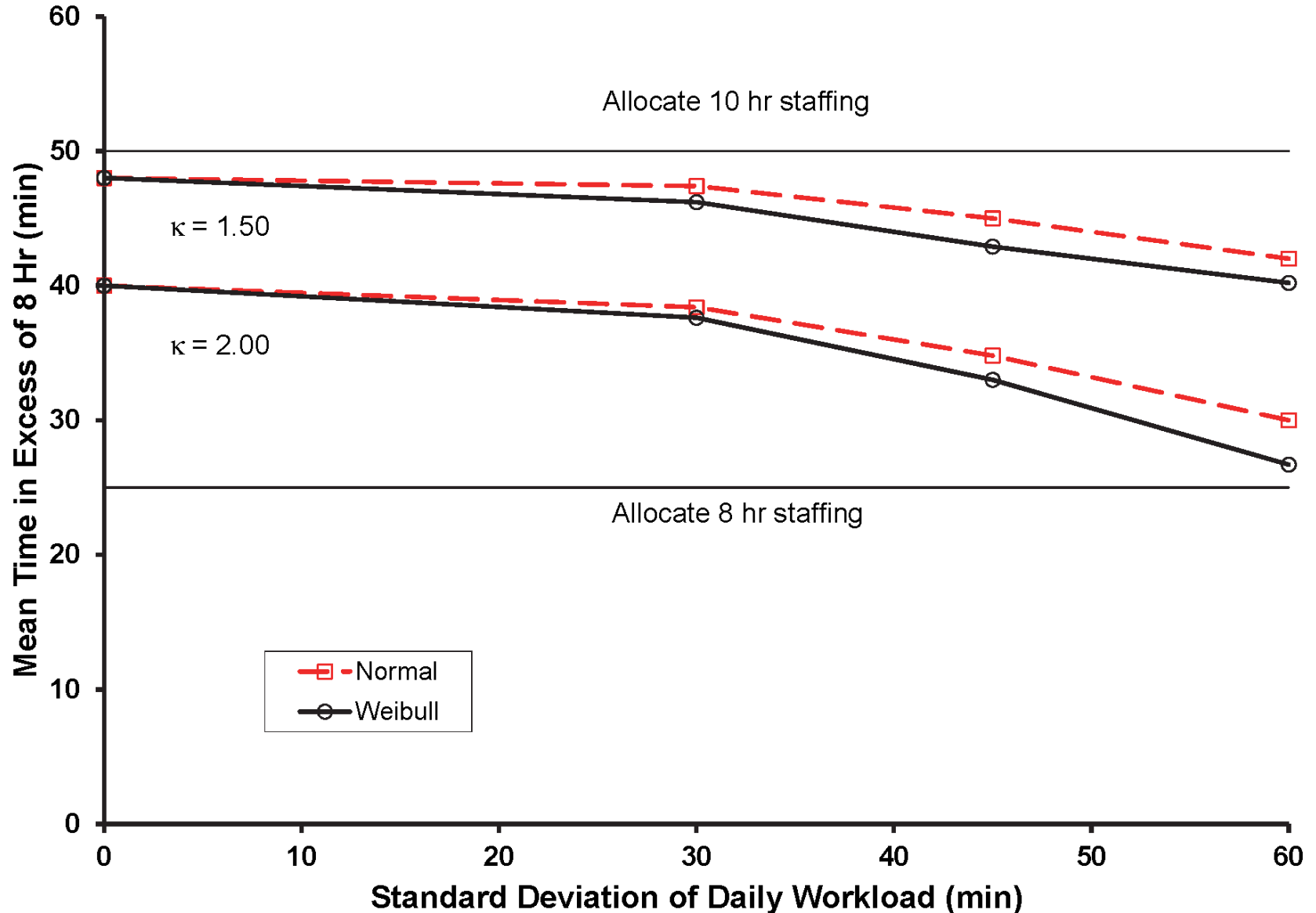
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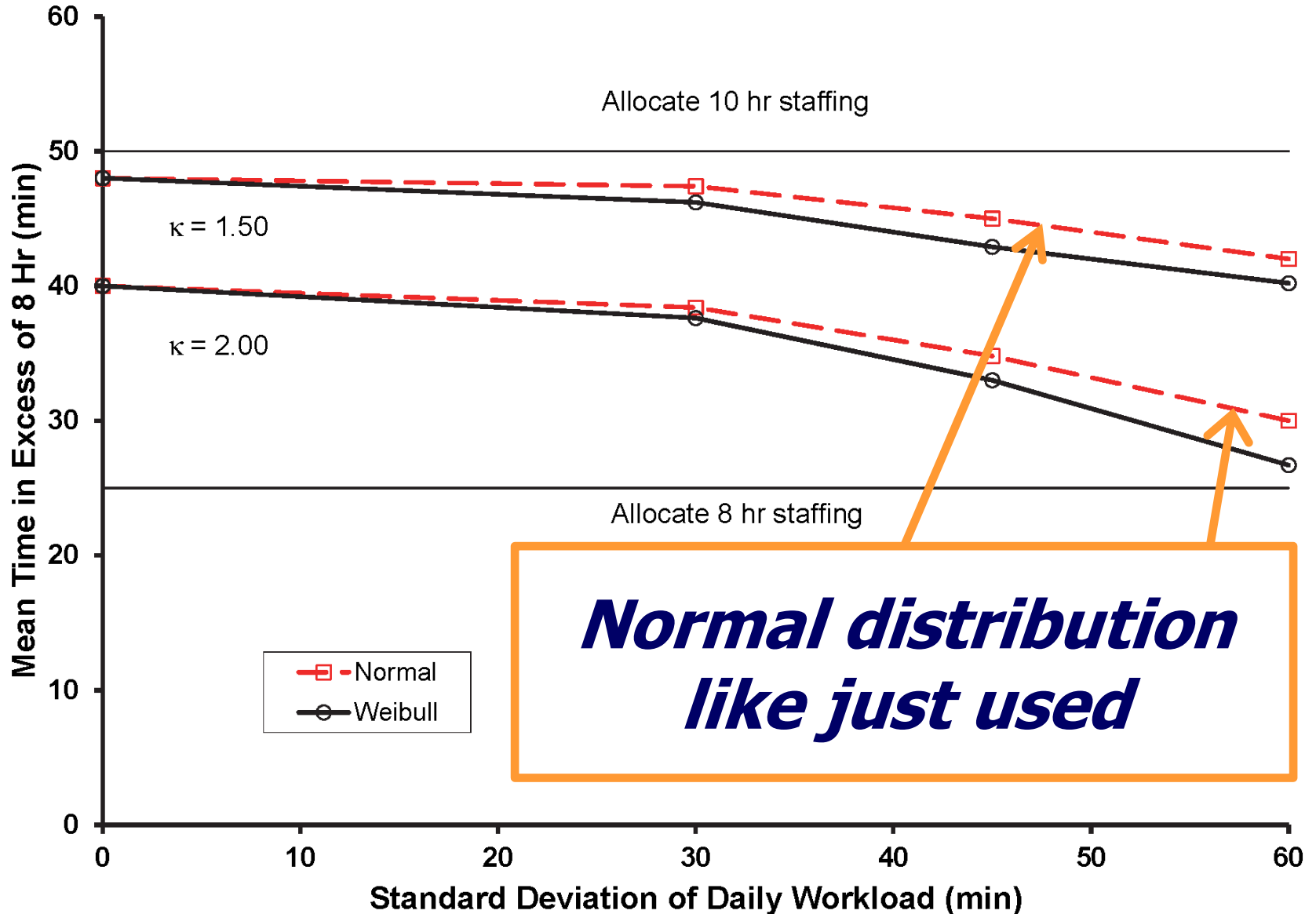
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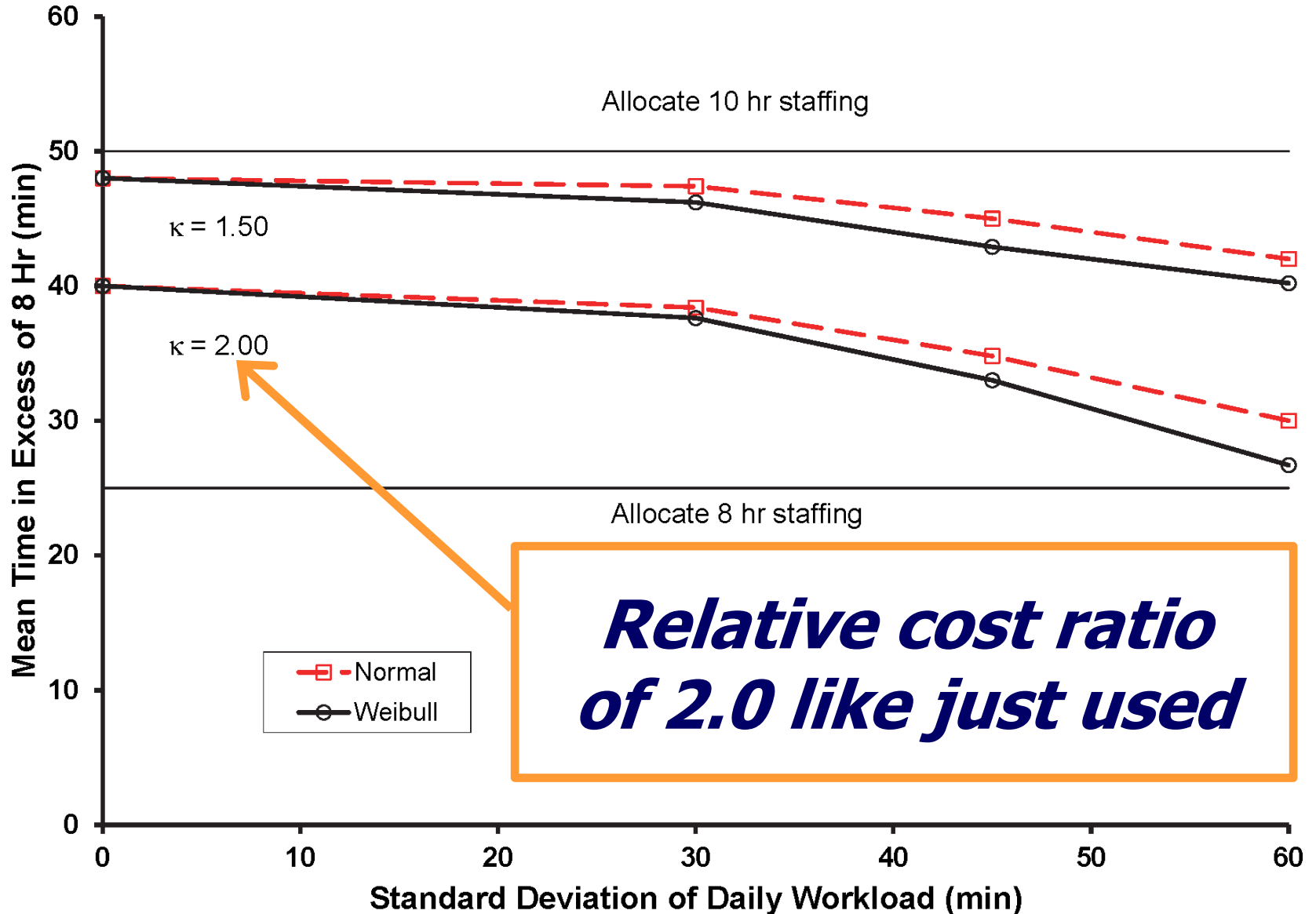
# Allocated Times for Single ORs From Pandit & Dexter 2009



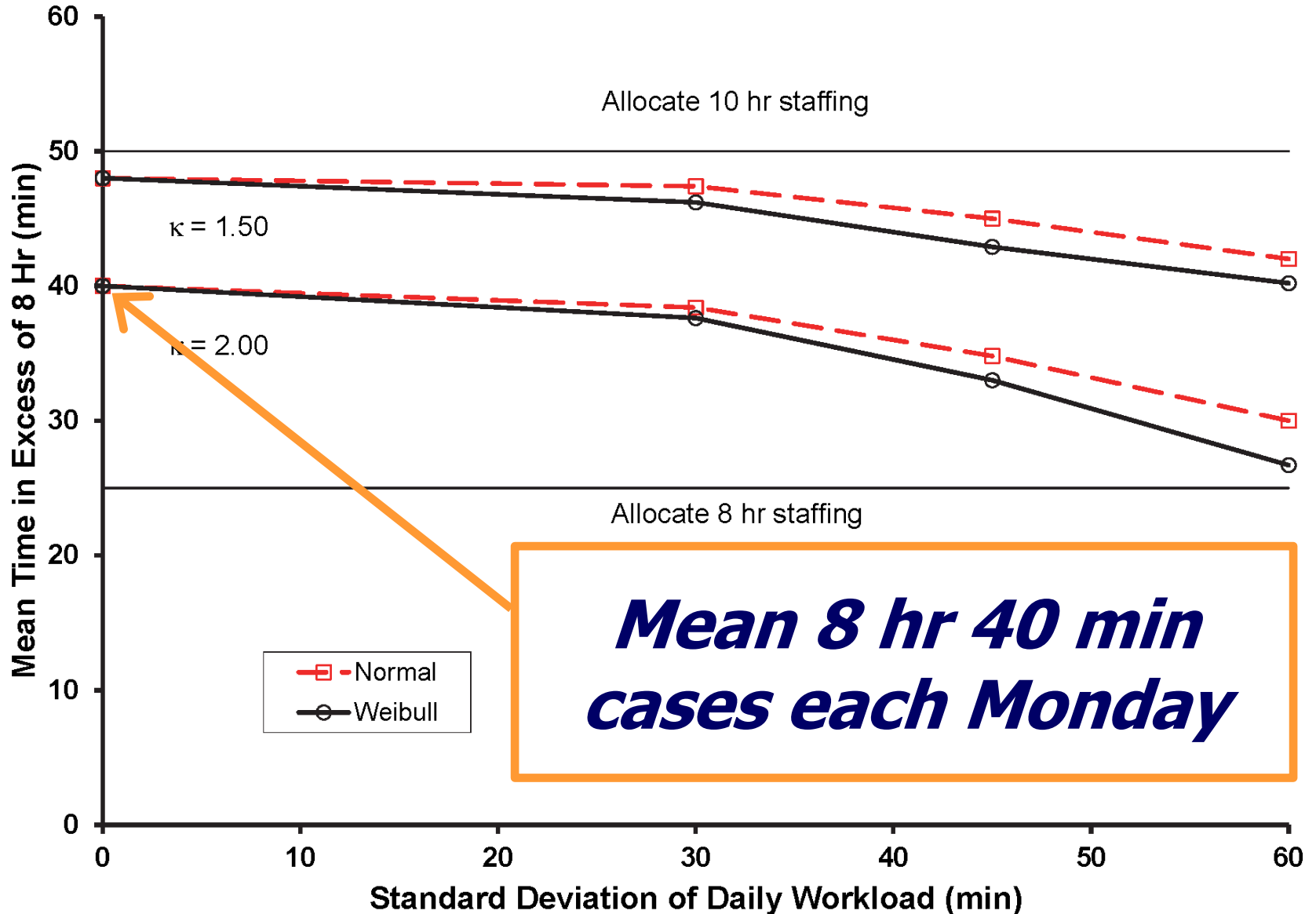
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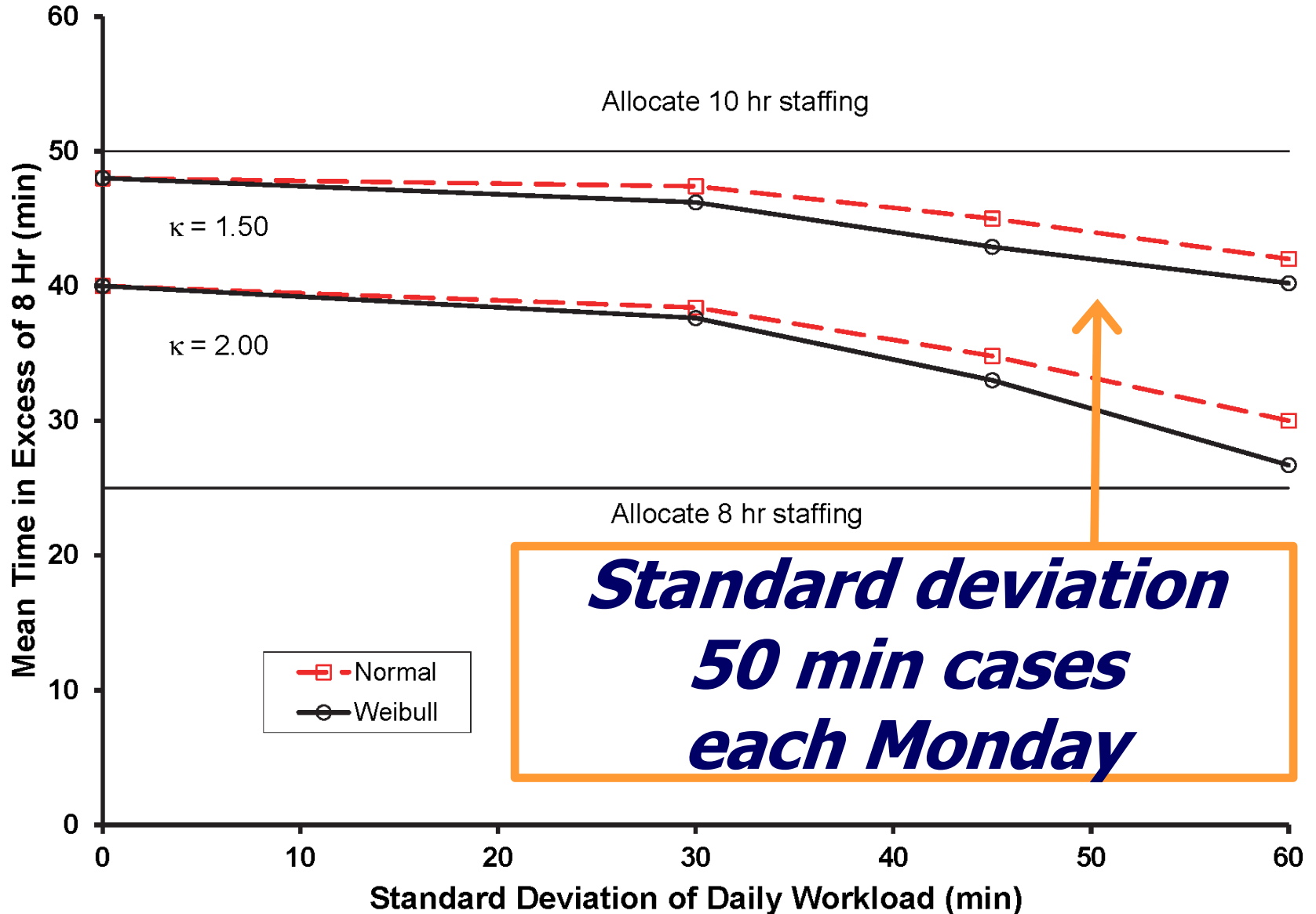


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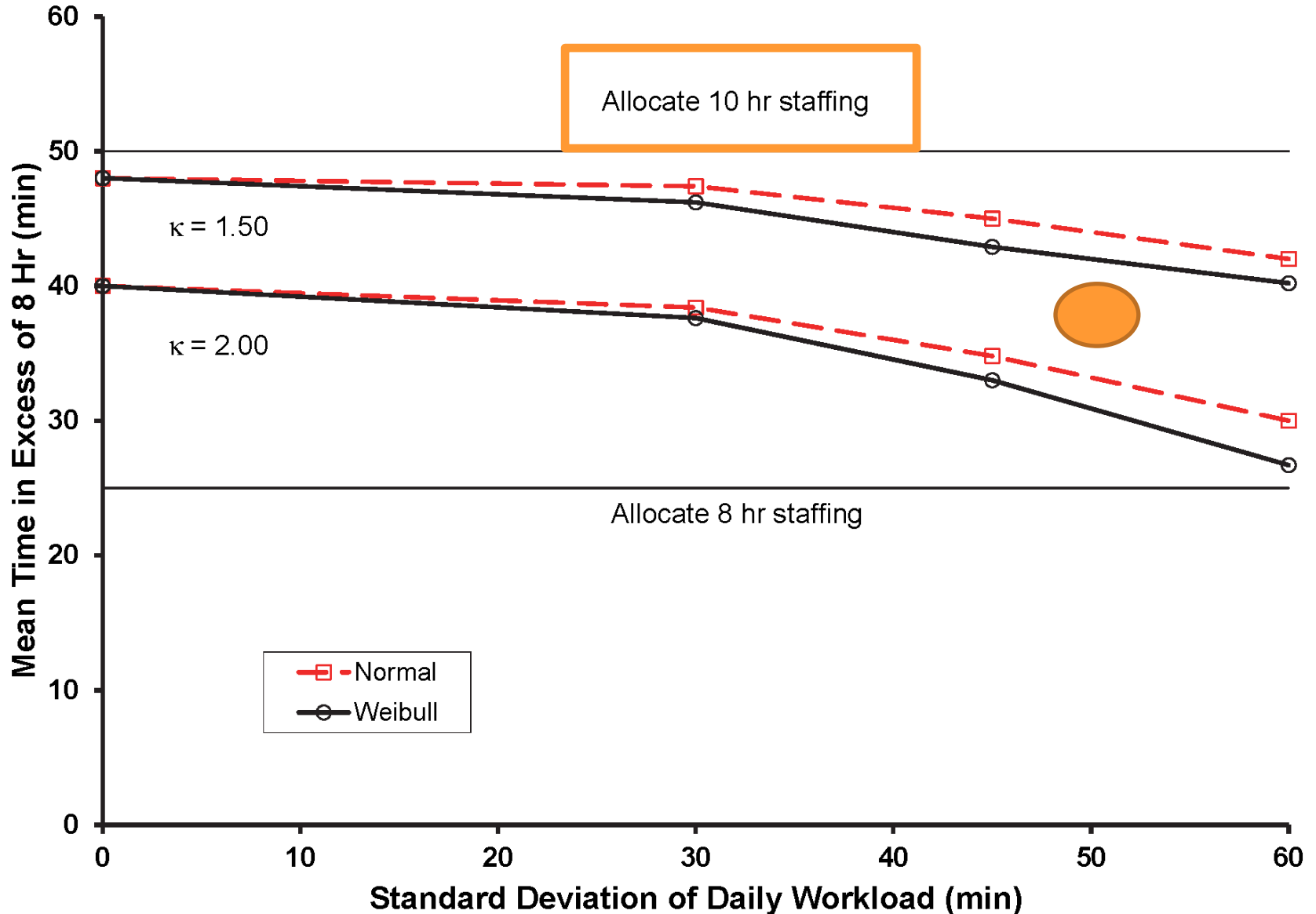




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# Topics of Talk on Add-on Case Rooms

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# Managerial Behavior

- Repeating from 10 minutes ago
  - Decisions described are not those observed in practice, due to cognitive biases
- Not limitations of politics, culture, buy in, personalities, or organizational inertia
  - Rather, it's simply not intuitive to people and what seems intuitive is sub-optimal

Wachtel RE, Dexter F. Anesth Analg 2010



# Managerial Behavior

- Provide electronic displays with evidence-based recommendations
  - Include OR allocations calculated based on maximizing efficiency of use of OR time
- Provide education, the value of which is increased trust in the recommendations

Dexter F et al. Anesth Analg 2007

Wachtel RE, Dexter F. J Grad Med Educ 2010



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# Question and Answer #1

- OR nurses, nurse anesthetists, and anesthesiologists are full-time employees
- Allocated time is from 8 AM to 6:00 PM
- There is estimated to be 8.5 hr of cases
- Turnover and extubation times are brief
- OR finishes at 3:30 PM, instead of 4:30 PM
- Has OR efficiency been increased?



# Question and Answer #1

- OR nurses, nurse anesthetists, and anesthesiologists are full-time employees
- Allocated time is from 8 AM to 6:00 PM
- There is estimated to be 8.5 hr of cases
- Turnover and extubation times are brief
- OR finishes at 3:30 PM, instead of 4:30 PM
- Has OR efficiency been increased?

➤ No





# Question and Answer #2

- Allocated time is from 7:15 AM to 3:30 PM
- Add-on case room empty, no pending cases
- OR 12 is running behind
  - Its last case, scheduled from 2 PM to 3:30 PM, will not start until 5 PM
  - Anesthesia and nursing team assigned to the add-on room can perform the case safely
  - Surgeon and patient are ready
- Why move case from OR 12 to add-on room?



# Question and Answer #2

- Allocated time is from 7:15 AM to 3:30 PM
- Add-on case room empty, no pending cases
- OR 12 is running behind
  - Its last case, scheduled from 2 PM to 3:30 PM, will not start until 5 PM
  - Anesthesia and nursing team assigned to the add-on room can perform the case safely
  - Surgeon and patient are ready
- Why move case from OR 12 to add-on room?
  - Reduction in hours of over-utilized OR time

# Question and Answer #3

- Surgical suite has ORs allocated for 8 or 10 hr
- Add-on OR has 4 hr open, OR 2 has 3 hr open
- At 1 PM, add-on cases' durations are 3 hr and 2 hr, both can start right now and go into either of the two ORs
- Assign the longer add-on case to the add-on case OR or to OR 2 and why?



# Question and Answer #3

- Surgical suite has ORs allocated for 8 or 10 hr
- Add-on OR has 4 hr open, OR 2 has 3 hr open
- At 1 PM, add-on cases' durations are 3 hr and 2 hr, both can start right now and go into either of the two ORs
- Assign the longer add-on case to the add-on case OR or to OR 2 and why?
- OR 2, since substantial probability of another add-on case, known since the allocated time for the add-on case OR is 10 hr

# Question and Answer #4

- OR managers make decisions on scheduling add-on cases and moving cases among ORs using electronic displays
- One group gets displays that include calculation of expected hours of over-utilized OR time in each OR and one group does not
- Are the quality of the decisions made better with the calculated information provided?



# Question and Answer #4

- OR managers make decisions on scheduling add-on cases and moving cases among ORs using electronic displays
- One group gets displays that include calculation of expected hours of over-utilized OR time in each OR and one group does not
- Are the quality of the decisions made better with the calculated information provided?

➤ No



# Question and Answer #5

- OR time is allocated at a surgical suite either for 8 hours or 10 hours
- A service on Tuesdays has a mean of 8 hr 40 min with a standard deviation of 50 min
- Allocate 8 hr or 10 hr and why?



# Question and Answer #5

- OR time is allocated at a surgical suite either for 8 hours or 10 hours
- A service on Tuesdays has a mean of 8 hr 40 min with a standard deviation of 50 min
- Allocate 8 hr or 10 hr and why?
- 10 hr maximizes efficiency of use of OR time





# Additional Information on Operating Room Management

- [www.FranklinDexter.net/education.htm](http://www.FranklinDexter.net/education.htm)
  - Full course (e.g., medical directors and analysts)
  - Lectures on day of surgery decision making, case duration prediction, allocating OR time, 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

