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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Meaning of Maximizing OR Efficiency on Day of Surgery

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

~~(Cost per hour of over-utilized OR time)~~
× (hours of over-utilized OR time)

Constant

Meaning of Maximizing OR Efficiency on Day of Surgery

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

~~(Cost per hour of over-utilized OR time)~~
  × (hours of over-utilized OR time)

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)~~
× (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 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

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  – 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 4th 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 4th 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

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  - Never open 4th 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

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

Dexter F et al. Anesthesiology 1999

Dexter F, Traub RD. Anesth Analg 2002

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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

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why?

Reason for Add-on Surgical Case Scheduling Result

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  - 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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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

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- 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

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- Sort the cases based on estimated duration from longest to shortest
  - Consider the cases in this descending order
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  - 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)

Dexter F et al. Anesth Analg 2007

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 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

- 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 66th 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?

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  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[th] percentile of the normal distribution function with mean 30 hr and standard deviation *10* hr equals *34 hr*
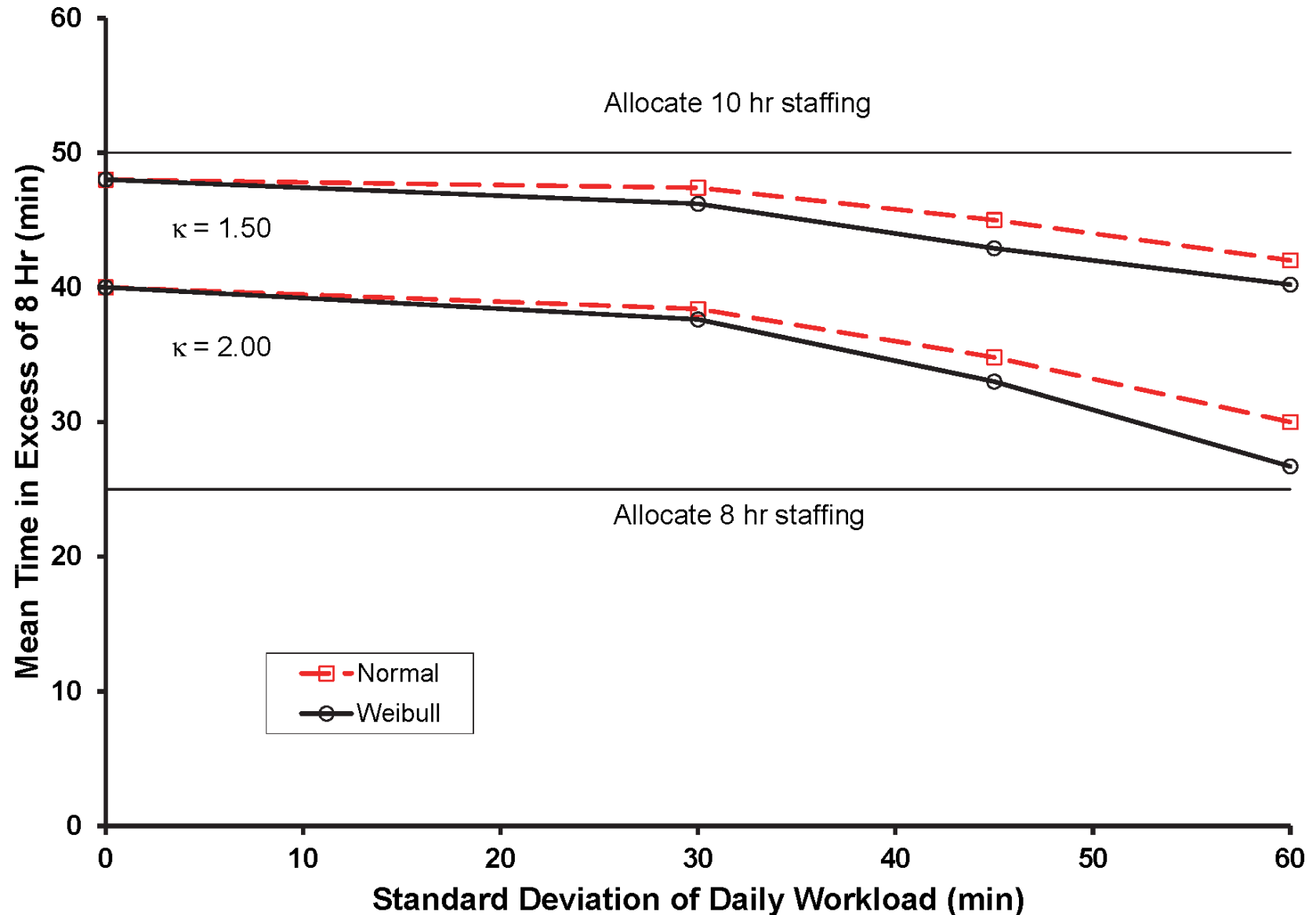
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    3)  3 ORs: 0 × 8 hr, 3 × 10 hr
    4)  4 ORs: 4 × 8 hr, 0 × 10 hr
    5)  4 ORs: 3 × 8 hr, 1 × 10 hr
    6)  4 ORs: 2 × 8 hr, 2 × 10 hr
    ```

Calculating Allocated OR Time

- Consider standard deviation of orthopedics' workload on Mondays = 10 hr, a large value

- Using the mean of 30 hr, what staffing plan maximizes efficiency of use of OR time?

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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
```

Allocated Times for Single ORs From Pandit & Dexter 2009

Mean Time in Excess of 8 Hr (min) vs Standard Deviation of Daily Workload (min)

Allocate 10 hr staffing

κ = 1.50

κ = 2.00

Allocate 8 hr staffing

Normal

Weibull

Allocated Times for Single ORs From Pandit & Dexter 2009

- Suppose normal distribution, mean workload 30 hours, standard deviation 5 hours, relative cost ratio of 2.00, and 10 hours allocated time
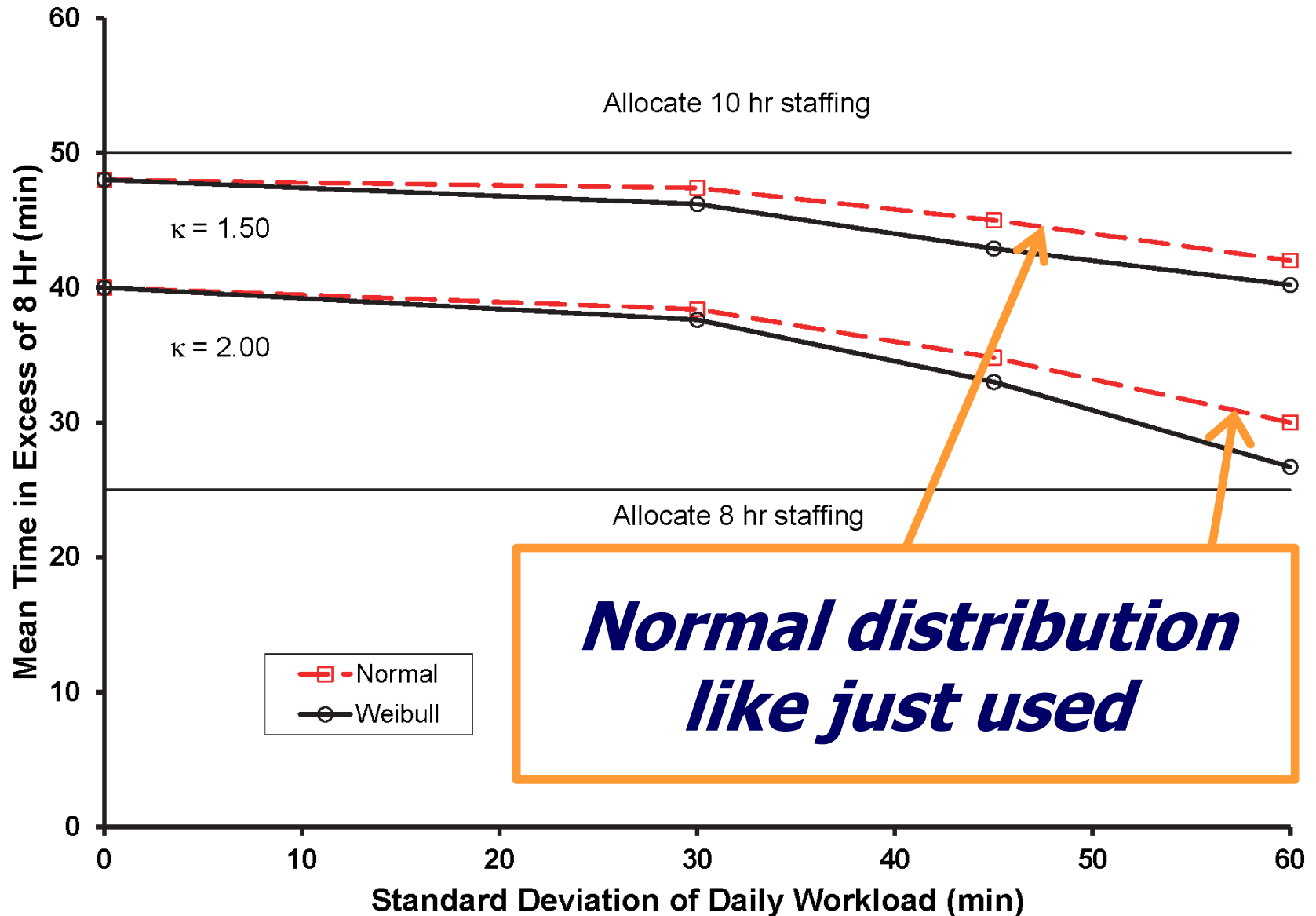
- Inefficiency of use of OR time proportional to:

```
= AVERAGE( LET( X,
         NORM.INV( RANDARRAY(1000000), 30, 5 ),
         IF( X < 10, 10 - X, 2.0*( X - 10 ))))
```

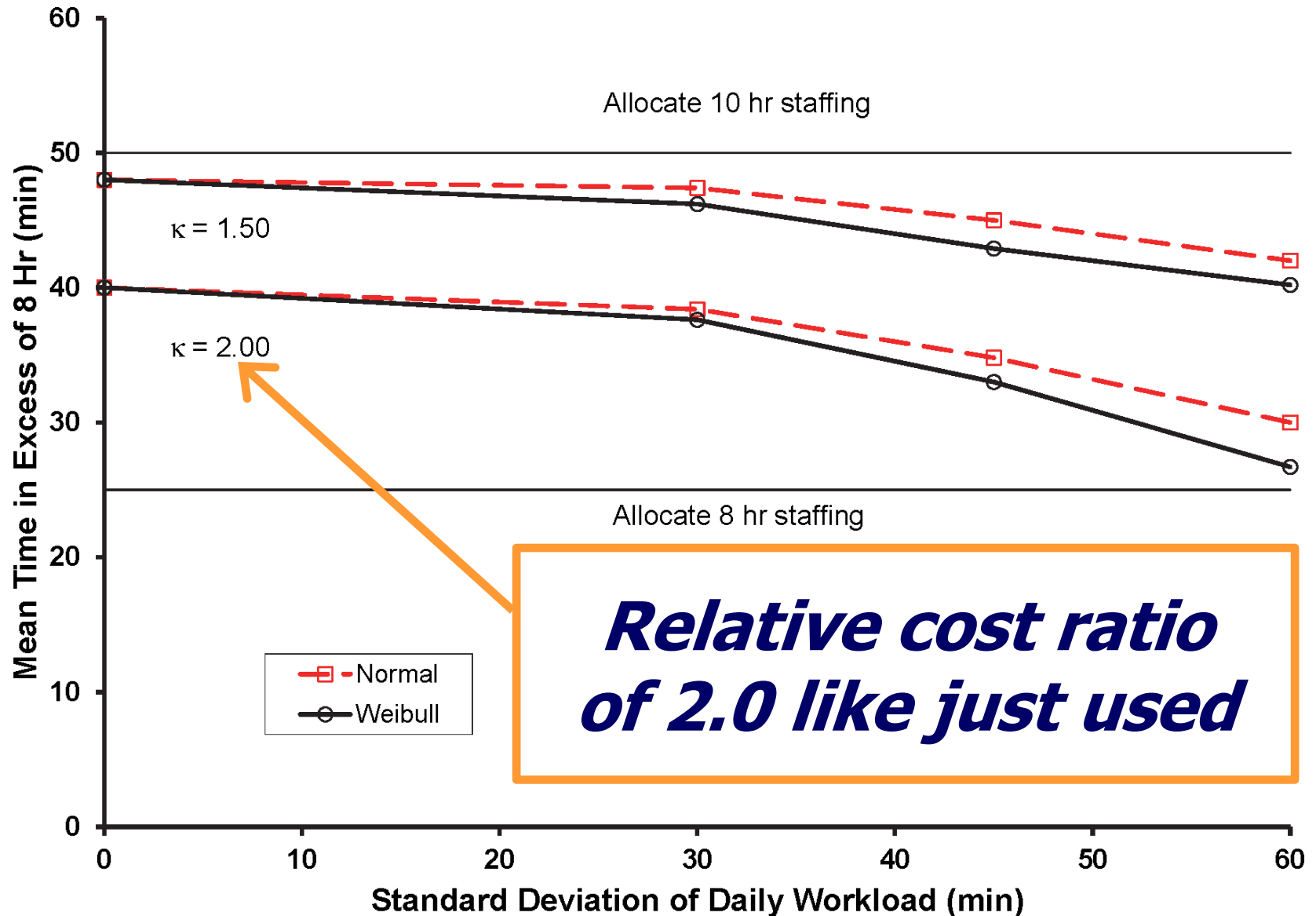Dexter F, Epstein RH. JVS Vasc Insights 2024
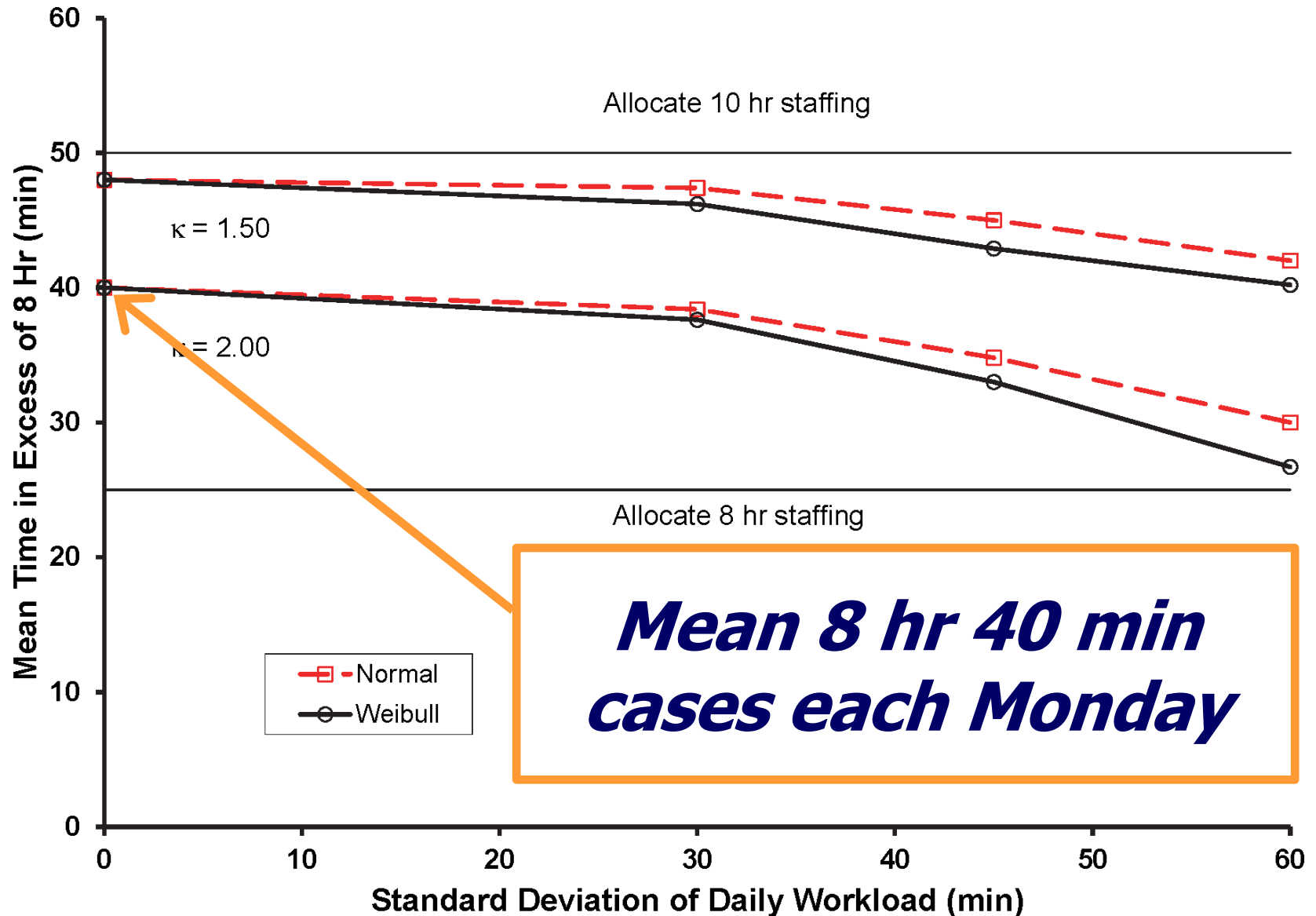
Dexter F et al. Am J Vet Res 2024
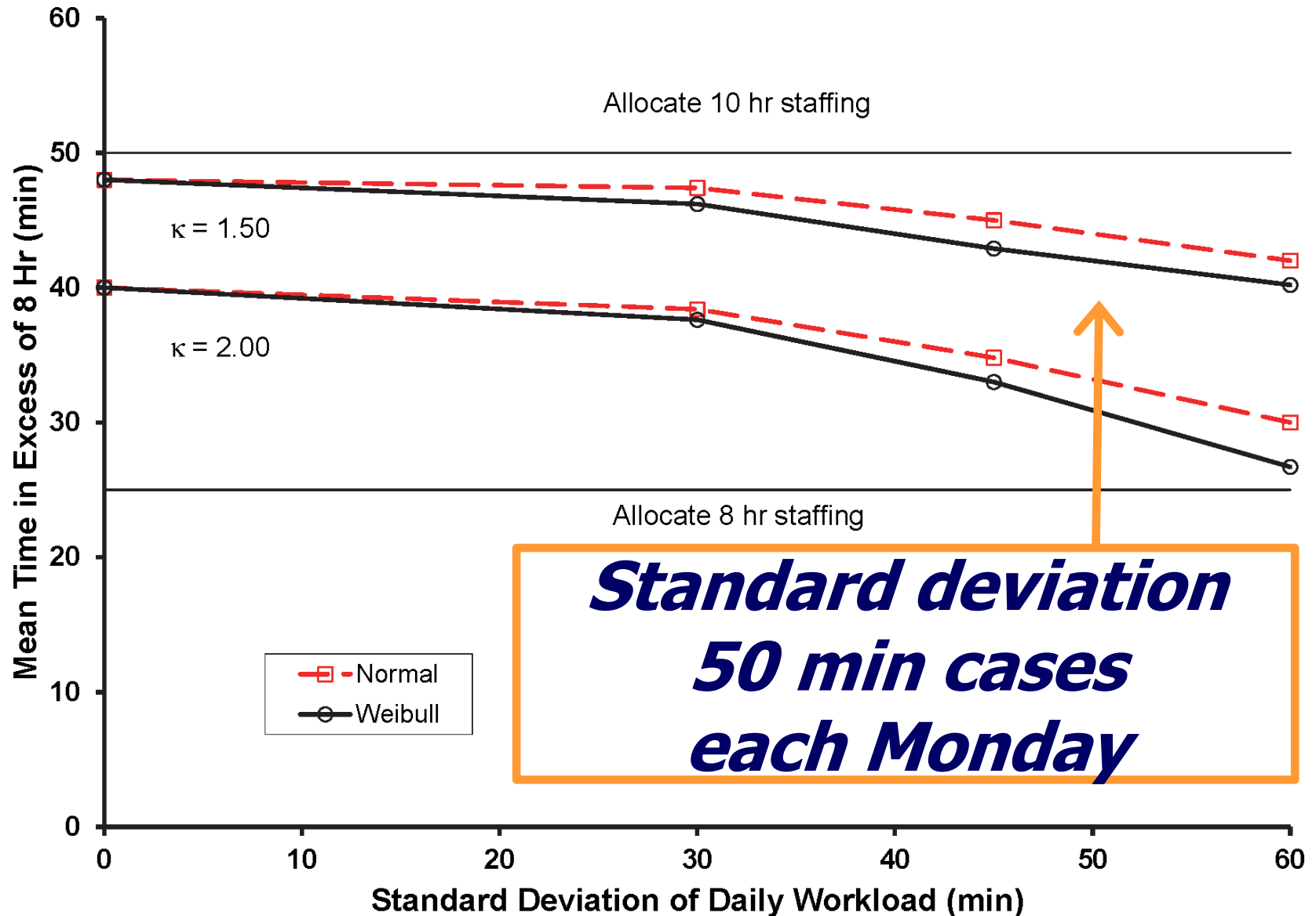
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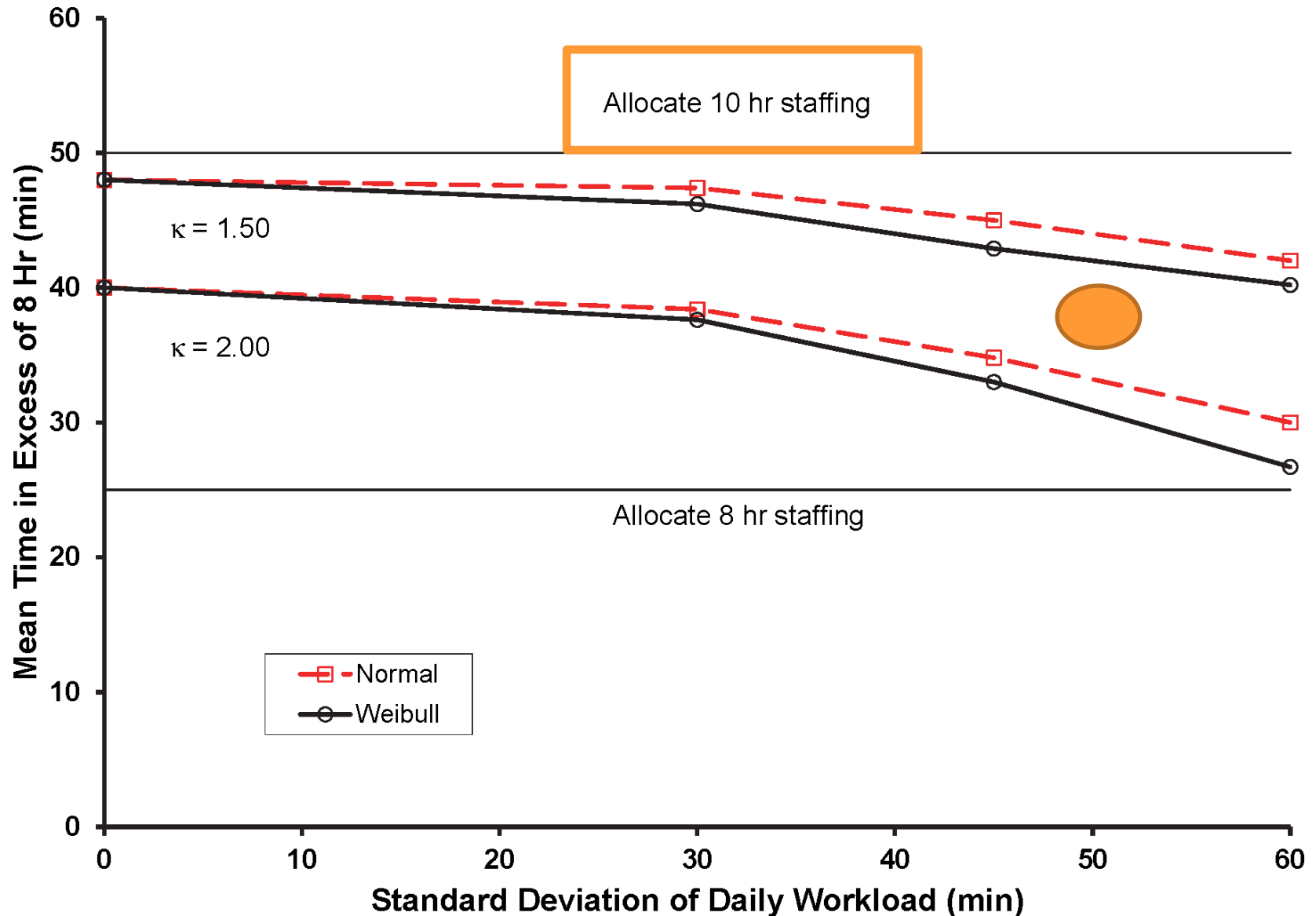
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- Efficiency of use of OR time

- 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

- 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

Topics of Talk on Add-on Case Rooms

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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 te 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?

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Question and Answer #5

- OR time is allocated at a surgical suite either for 8 hours or 10 hours
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  ➢ 10 hr maximizes efficiency of use of OR time

Additional Information on Operating Room Management

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