Reducing Variability in Anesthesia Work Hours by Good Decision-Making on the Day of Surgery

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Reducing Variability in Anesthesia Work Hours by Good Decision-Making on the Day of Surgery

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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 Reducing Variability

- Review of principles in calculating allocated OR time for use in reducing over-utilized time
- Decision-making on the day of surgery to reduce over-utilized time
- Review of why use displays to guide decision-making on the day of surgery
- Monitoring reduced variability in work hours

Topics of Talk on Reducing Variability

- Dexter F, Wachtel RE, Epstein RH. Decreasing the hours that anesthesiologist and nurse anesthetists work late by making decisions to reduce the hours of over-utilized operating room time. *Anesthesia & Analgesia* 122: 831-842, 2016

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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

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

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 OR allocation 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

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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 66th percentile of the normal distribution function with mean 30 hr and standard deviation ***10*** hr equals ***34 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 OR allocation maximizes efficiency of use of OR time?

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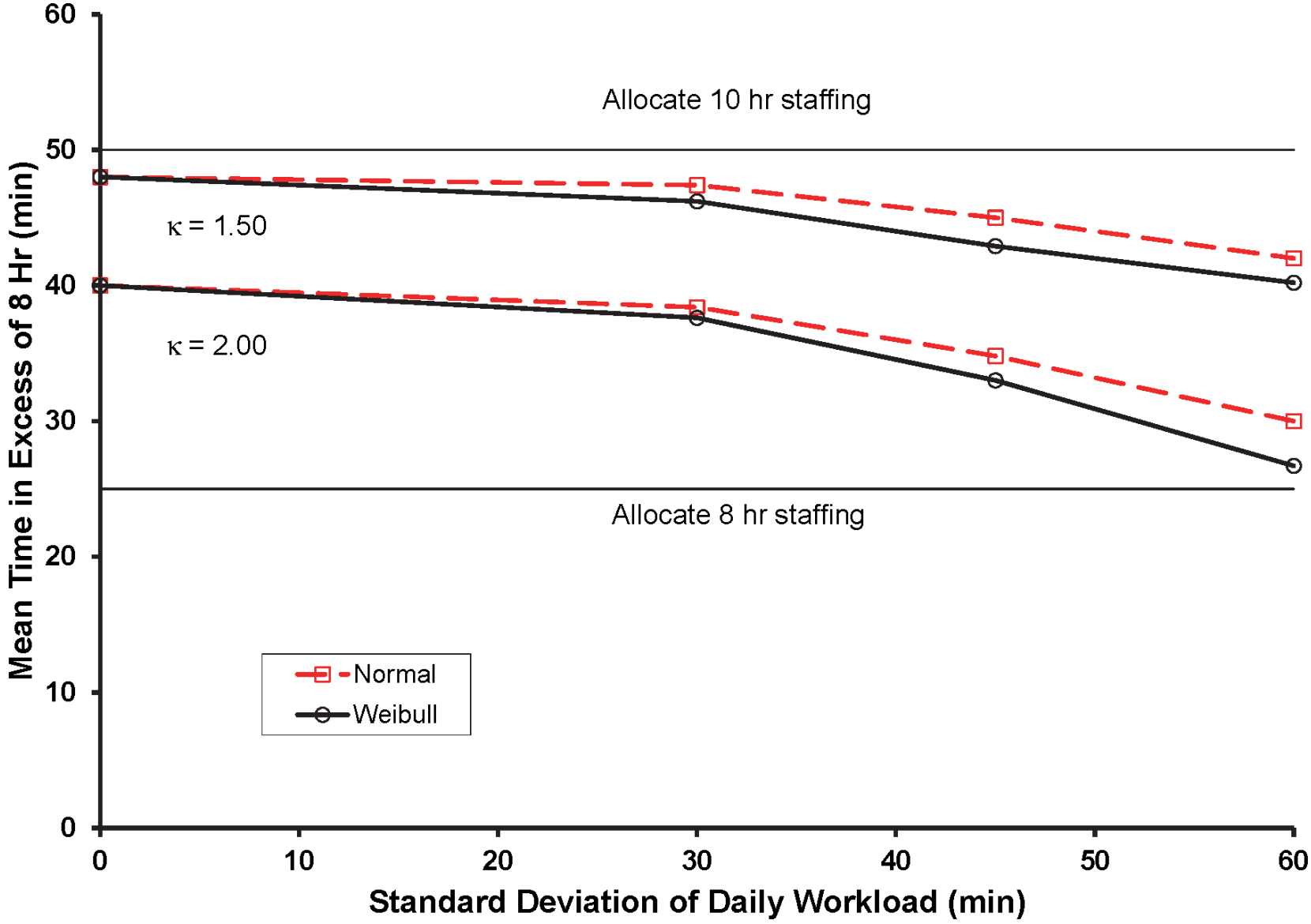
Allocated Times for Single ORs From Pandit & Dexter 2009



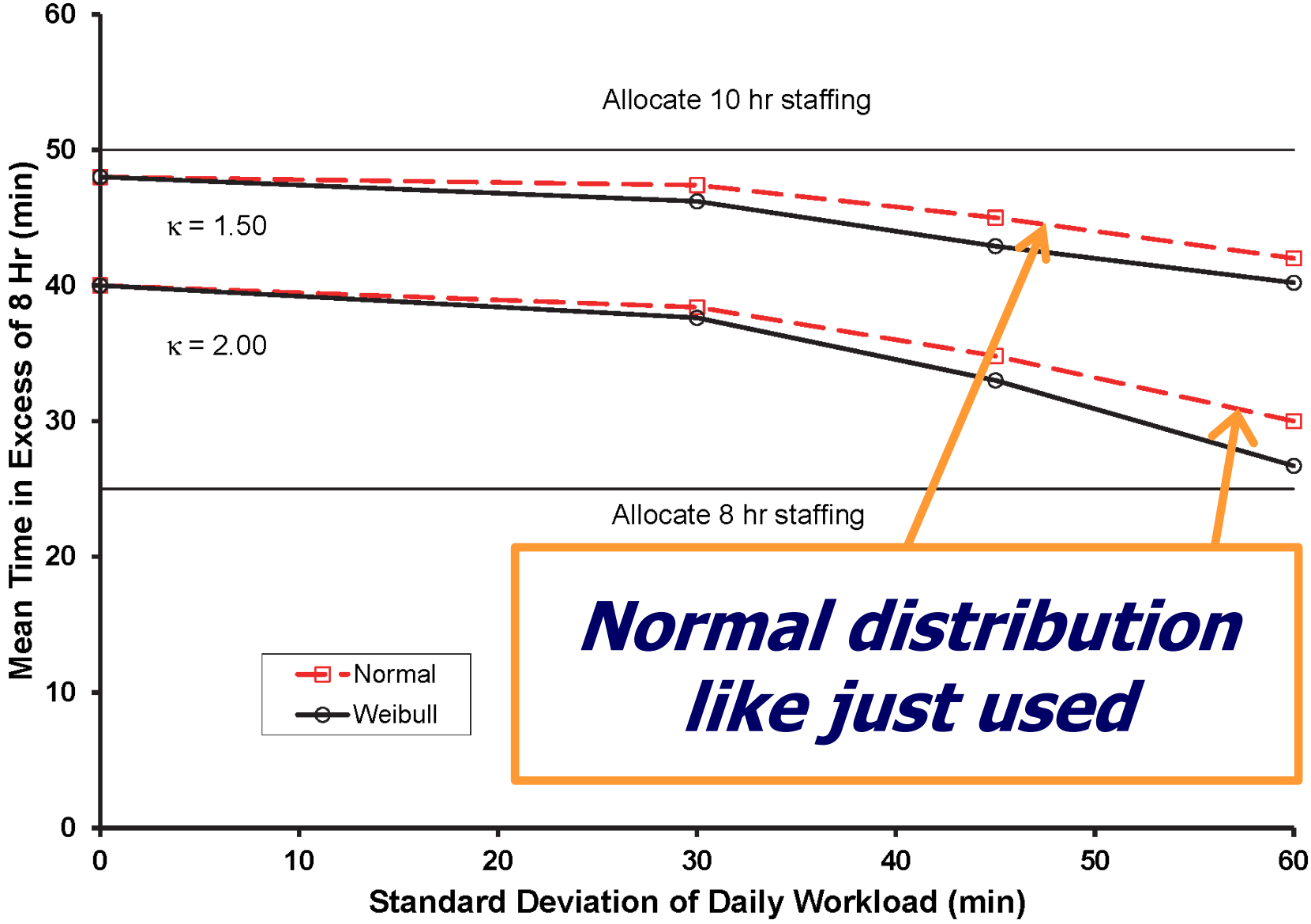
Allocated Times for Single ORs From Pandit & Dexter 2009

- 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 et al. Am J Vet Res 2024

Allocated Times for Single ORs From Pandit & Dexter 2009



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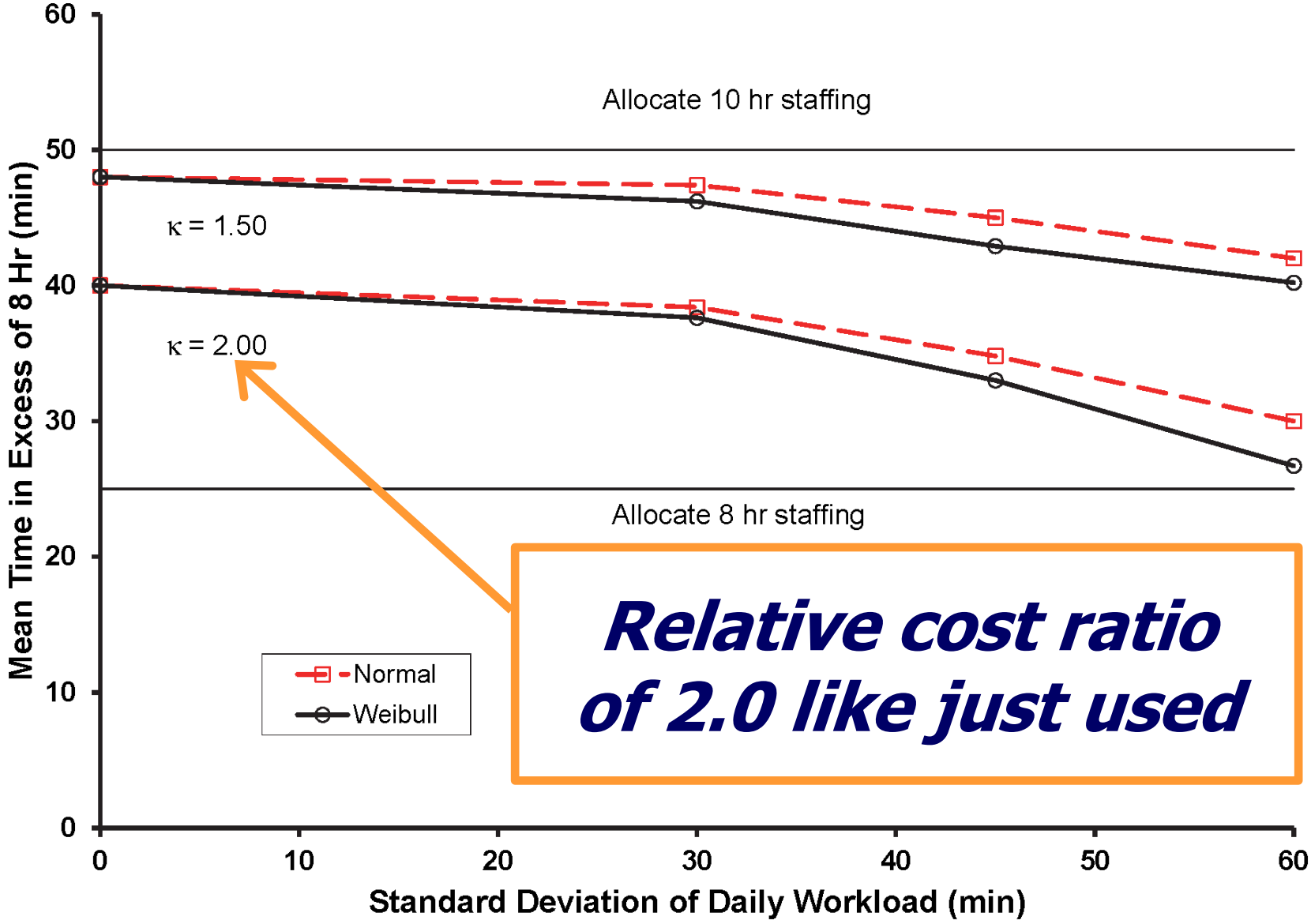

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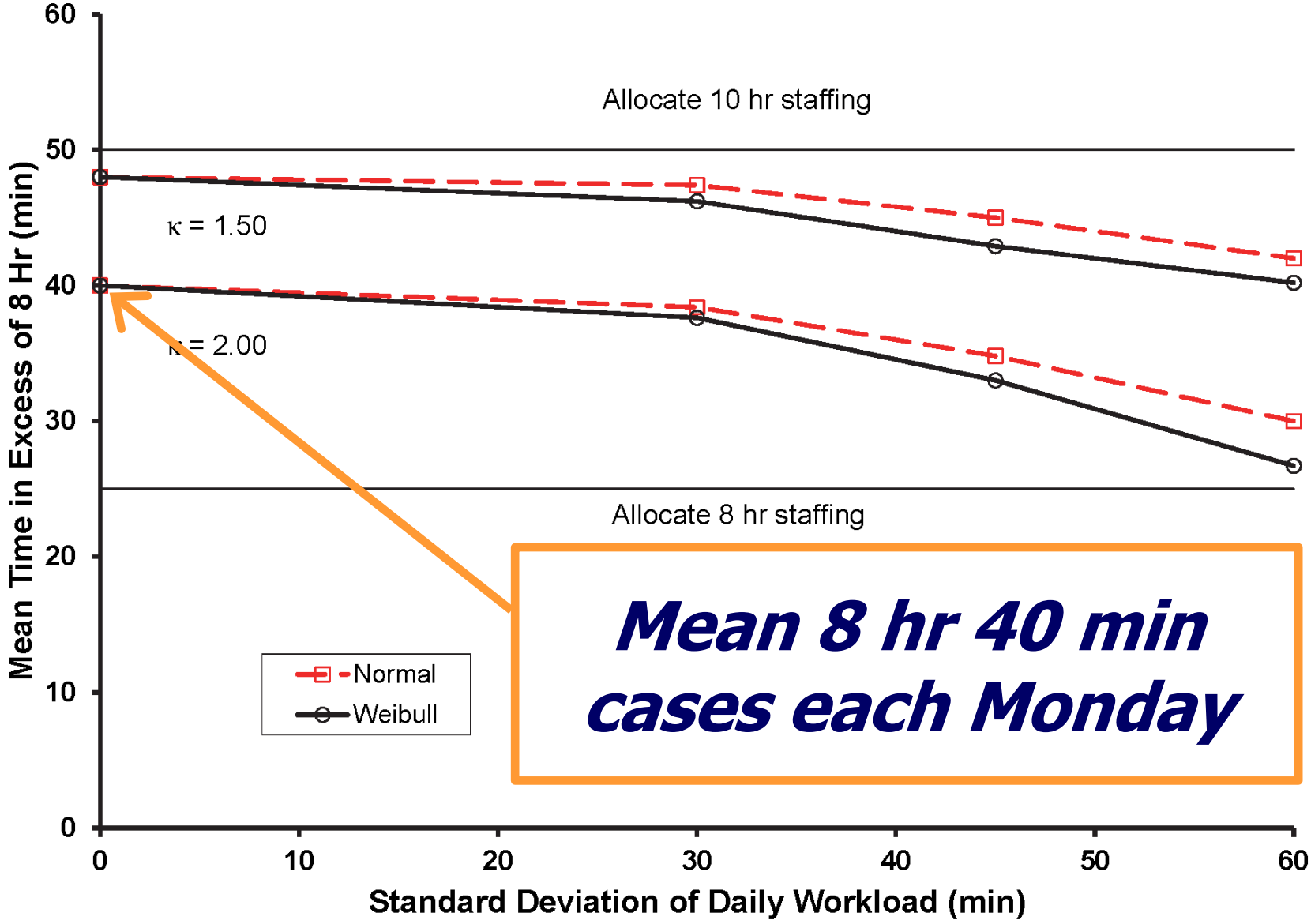

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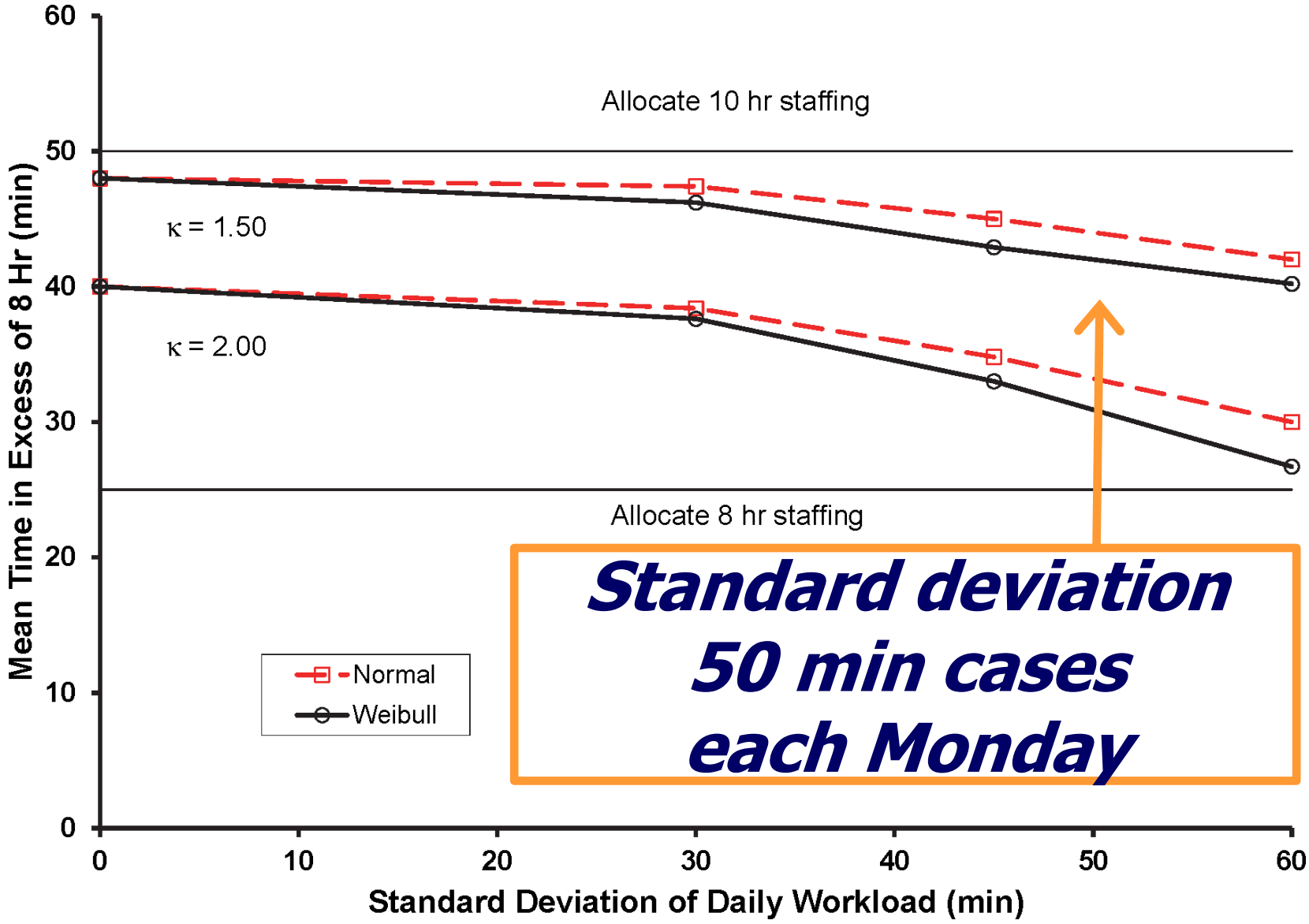

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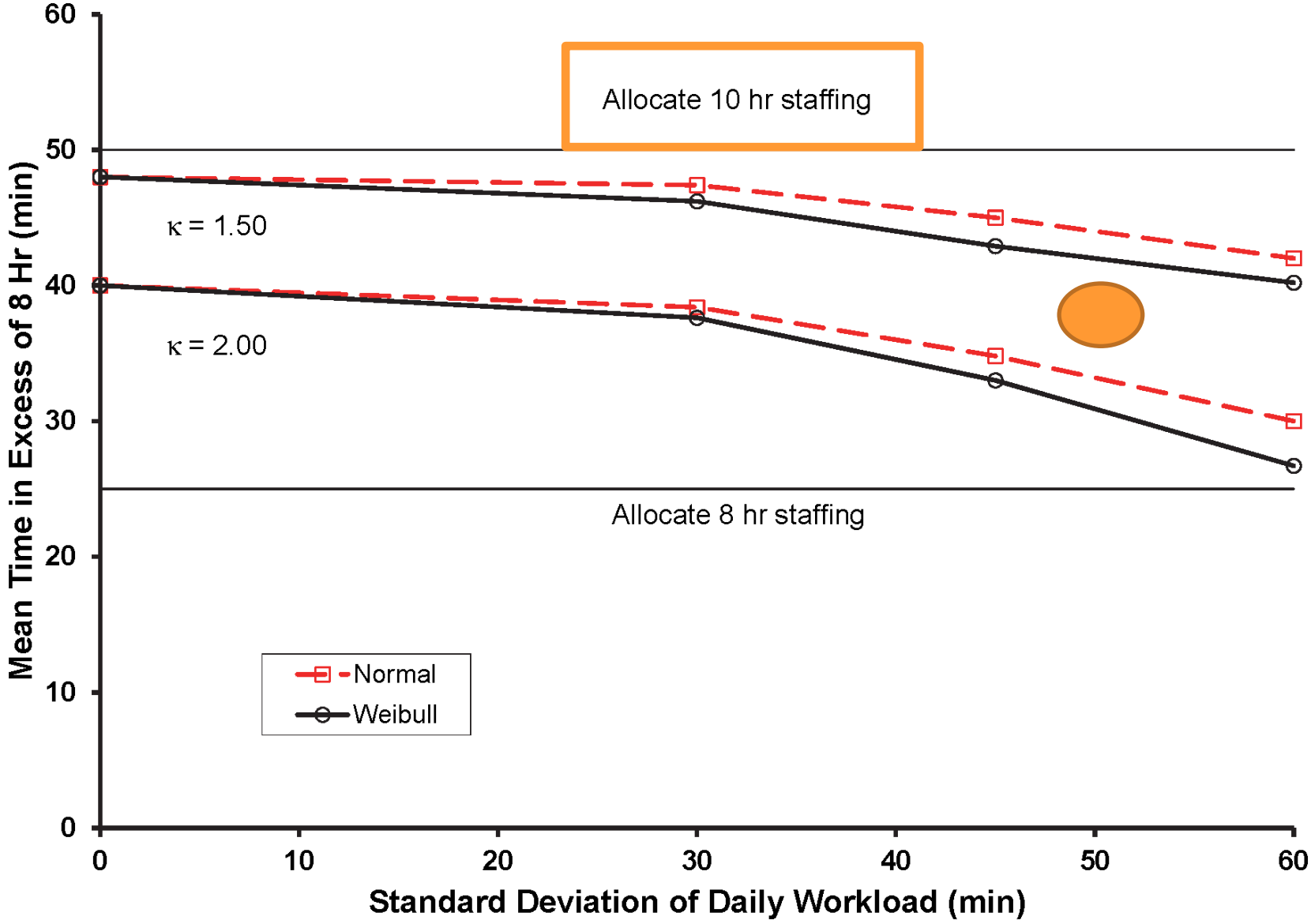

Reducing Variability

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

Reducing Variability

- Vertical axis relates to mean
  - Commonly used to report adjusted utilization
- Horizontal axis relates to standard deviation
- Since objective is to reduce ***variability*** in work hours, focus includes both mean and the standard deviation, principally the latter

Topics of Talk on Reducing Variability

- Review of principles in calculating allocated OR time for use in reducing over-utilized time
  - Decision-making on the day of surgery to reduce over-utilized time
- Review of why use displays to guide decision-making on the day of surgery
- Monitoring reduced variability in work hours

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 are 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 ($) ≅

~~(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

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Constant

Meaning of Maximizing OR Efficiency on Day of Surgery

Inefficiency of use of OR time ($) ≅

~~(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 ($) ≅

~~(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 are 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 OR management operational decision-making is highly sensitive to the OR allocations, which is why those values used on the day of surgery need to be calculated appropriately

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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- Which OR should anesthesiologist start next?

Scenario 2 – Anesthesiologist Reduces Turnover Times

- *OR efficiency* is unaffected by the decision
  - OR 3 expected 0 over-utilized hours
  - OR 4 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 time planned for each OR
    - Calculated based on minimizing the inefficiency of use of OR time

Scenario 3 – Which OR Should Housekeeper Clean First?

- Right when two ORs are finishing their first cases of the day on time, only one person is free to clean the two ORs
- Last case of the day in OR 12 is expected to end at 2 PM
- Last case of the day in OR 14 is expected to end at 4:30 PM
- Allocated hours are from 7 AM to 3:30 PM
- Which OR should housekeeper clean first?
  - Follow the ordered priorities

Scenario 3 – Which OR Should Housekeeper Clean First?

- Safely performing the cases today will not be affected by the decision
- *OR efficiency* is affected by the decision
  - OR 12 expected 0 hr of over-utilized OR time
    - Finish 2 PM, but allocated time to 3:30 PM
  - OR 14 expected 1 hr of over-utilized OR time
    - Finish 4:30 PM, but allocated time to 3:30 PM
- Cleaning OR 14 first is likely to increase OR efficiency

Scenario 3 – Which OR Should Housekeeper Clean First?

- Right when two ORs are finishing their first cases of the day on time, only one person is free to clean the two ORs
- Last case of the day in OR 12 is expected to end at 2 PM
- Last case of the day in OR 14 is expected to end at 4:30 PM
- Allocated time is from 7 AM to ~~3:30~~ ***6*** PM
- Which OR should housekeeper clean first?

Scenario 3 – Which OR Should Housekeeper Clean First?

- *OR efficiency* is unaffected by the decision
  - OR 12 expected 0 over-utilized hours
  - OR 14 expected ~~1.5~~ ***0*** over-utilized hours
- *Patient waiting* is unaffected by the decision
  - Last case of the day in each OR
- *Personal satisfaction* is basis for decision

Scenario 4 – Calling For the Next Patient

- Two ORs call for their next cases, but only one person is free to prepare the patients
- Both ORs are 10 min behind schedule
- The four remaining cases in OR-A are estimated to end at 2 PM
- The one remaining case in OR-B is estimated to end at 4 PM
- Allocated time is from 7 AM to 6 PM
- Prepare which patient first?

Scenario 4 – Calling For the Next Patient

- Safely performing all of these cases today will not be affected by the decision
- *OR efficiency* is unaffected by the decision
  - OR-A expected 0 over-utilized hours
  - OR-B expected 0 over-utilized hours
- *Patient waiting* is affected by decision
  - OR-A expected total tardiness is 40 min
  - OR-B expected total tardiness is 10 min
- Prepare the patient for OR-A first

Scenario 4 – Calling For the Next Patient

- Two ORs call for their next cases, but only one person is free to prepare the patients
- Both ORs are currently on schedule
- The four remaining cases in OR-A are estimated to end at 2 PM
- The one remaining case in OR-B is estimated to end at 4 PM
- Allocated time is from 7 AM to ~~6 PM~~ ***3*** PM
- Prepare which patient first?

Scenario 4 – Calling For the Next Patient

- *OR efficiency* is affected by the decision
  - OR-A expected 0 over-utilized hours
  - OR-B expected 1 over-utilized hours
- Prepare the patient for OR-B first

Scenario 4 – Calling For the Next Patient

- *OR efficiency* is affected by the decision
  - OR-A expected 0 over-utilized hours
  - OR-B expected 1 over-utilized hours
- Prepare the patient for OR-B first

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

Topics of Talk on Reducing Variability

- Review of principles in calculating allocated OR time for use in reducing over-utilized time
- Decision-making on the day of surgery to reduce over-utilized time
- ➢ Review of why use displays to guide decision-making on the day of surgery
- Monitoring reduced variability in work hours

Many Decisions Made on Day of Surgery (or Night Before)

- Add-on cases per OR per day, 0.247 ± 0.052
- OR date combinations with at least one add-on case, 24.1% ± 0.3%
- Change in a case 0.59 ± 0.02 events per hour per 10 first case start locations
- OR date combinations with at least one change at private UK hospital, 37.3%

Dexter F et al. Anesthesiology 1999

Dexter F et al. Anesth Analg 2012

Epstein RH et al. Anesth Analg 2015

Walmsley T et al. J Perioper Pract 2018

Managerial Behavior on the Day of Surgery

- Common behavior is to keep each provider busy during her assigned hours
  - Same as optimal behavior 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 on the Day of Surgery

- 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 Before the Day of Surgery

- Choice of OR allocations used in the display calculations also are not typically made well
  - Reason is cognitive biases
    - Not politics, culture, lack of buy in, personalities, or organizational inertia
  - Simply, stochastic optimization is not intuitive and what seems intuitive is sub-optimal

Wachtel RE, Dexter F. Anesth Analg 2010

Managerial Behavior Before the Day of Surgery

- Implications
  - 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

Managerial Behavior Before the Day of Surgery

- 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 Before the Day of Surgery

- 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

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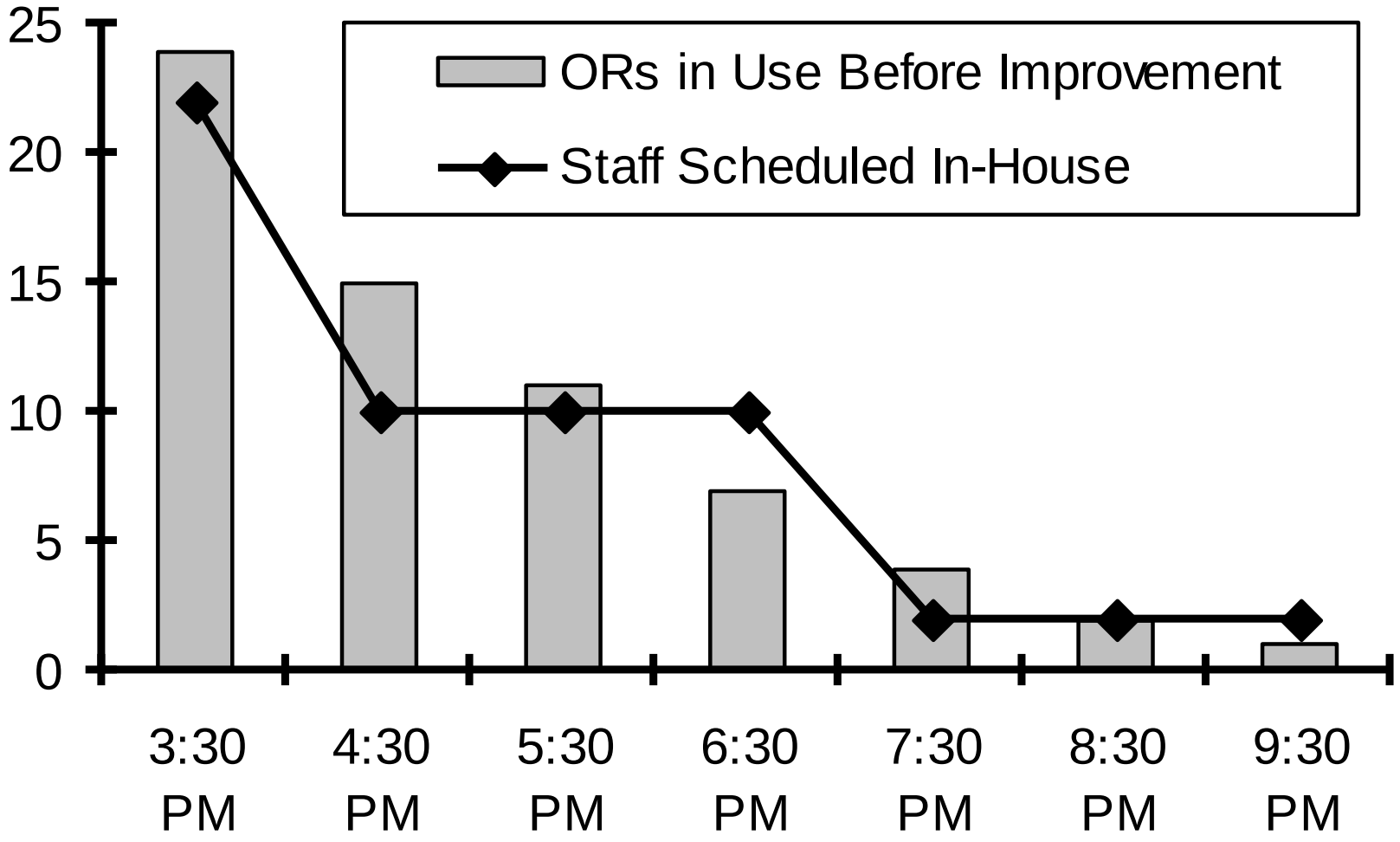
- ➢ Monitoring reduced variability in work hours

Reducing Variability Reduces the Variability

- Reducing total hours of cases including turnovers while performing all of the cases
  - May be good economically, or not
  - May be good clinically, or not
  - Regardless, finishing the day earlier on average is a different topic

Example of Reduced Variability



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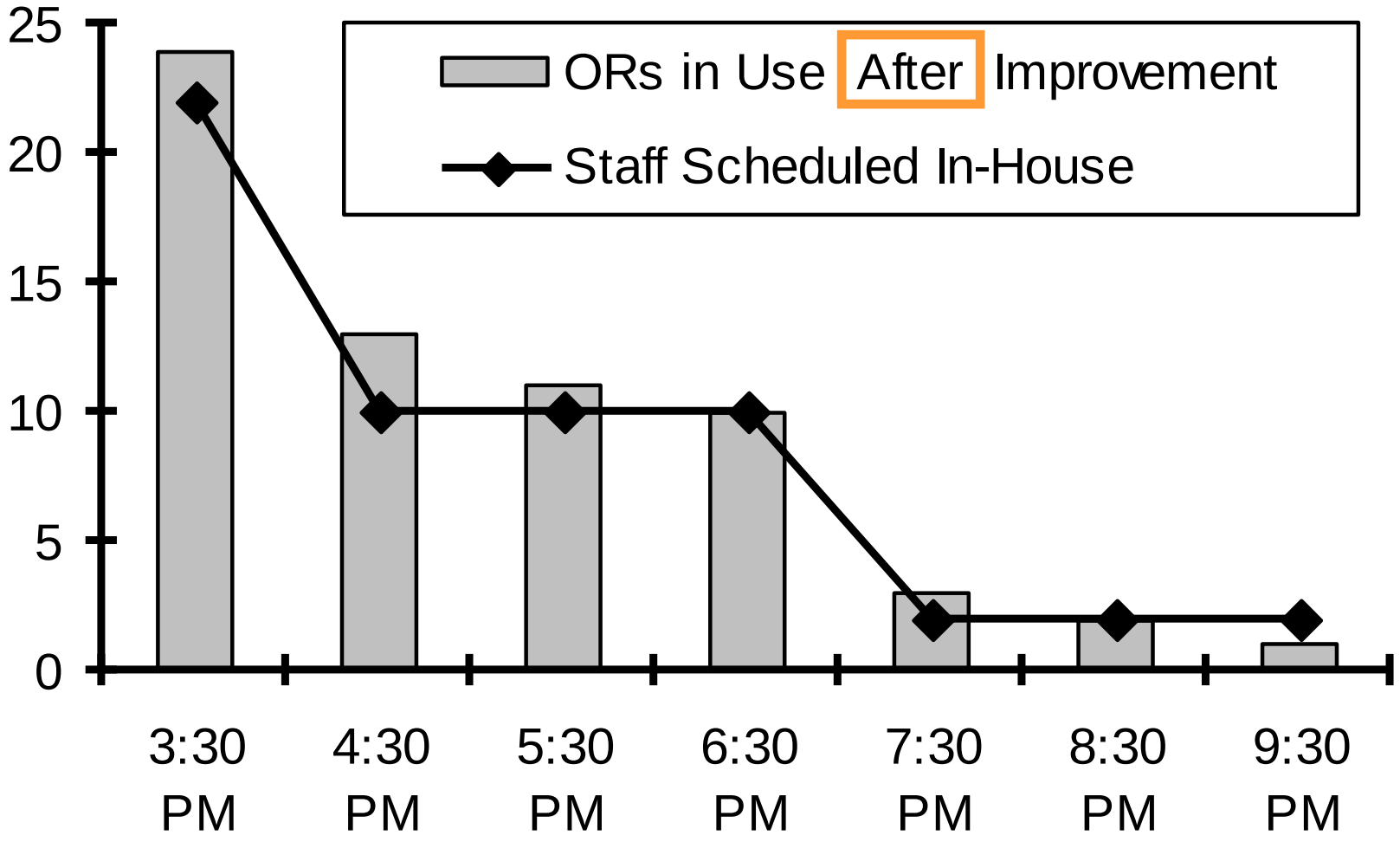

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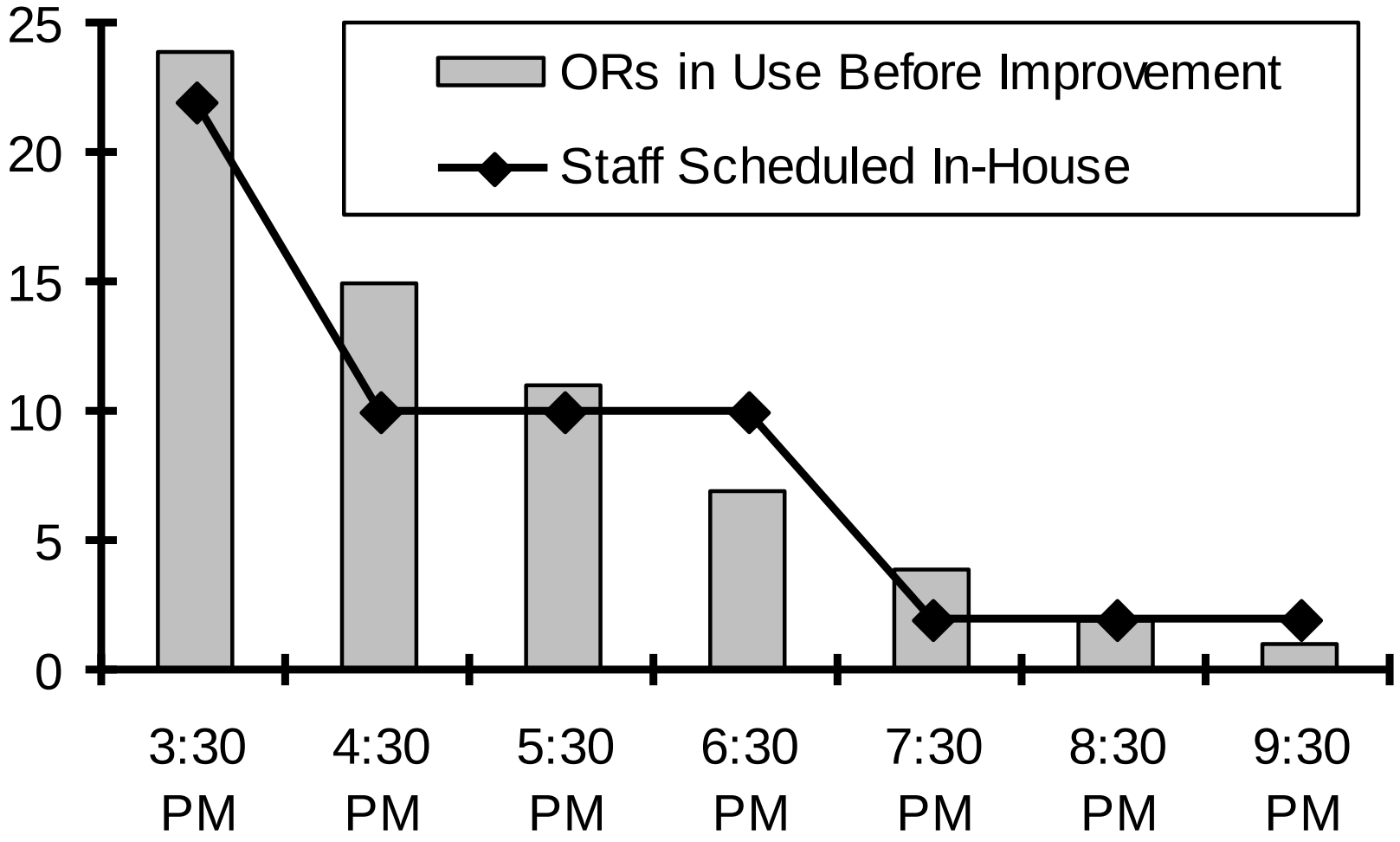

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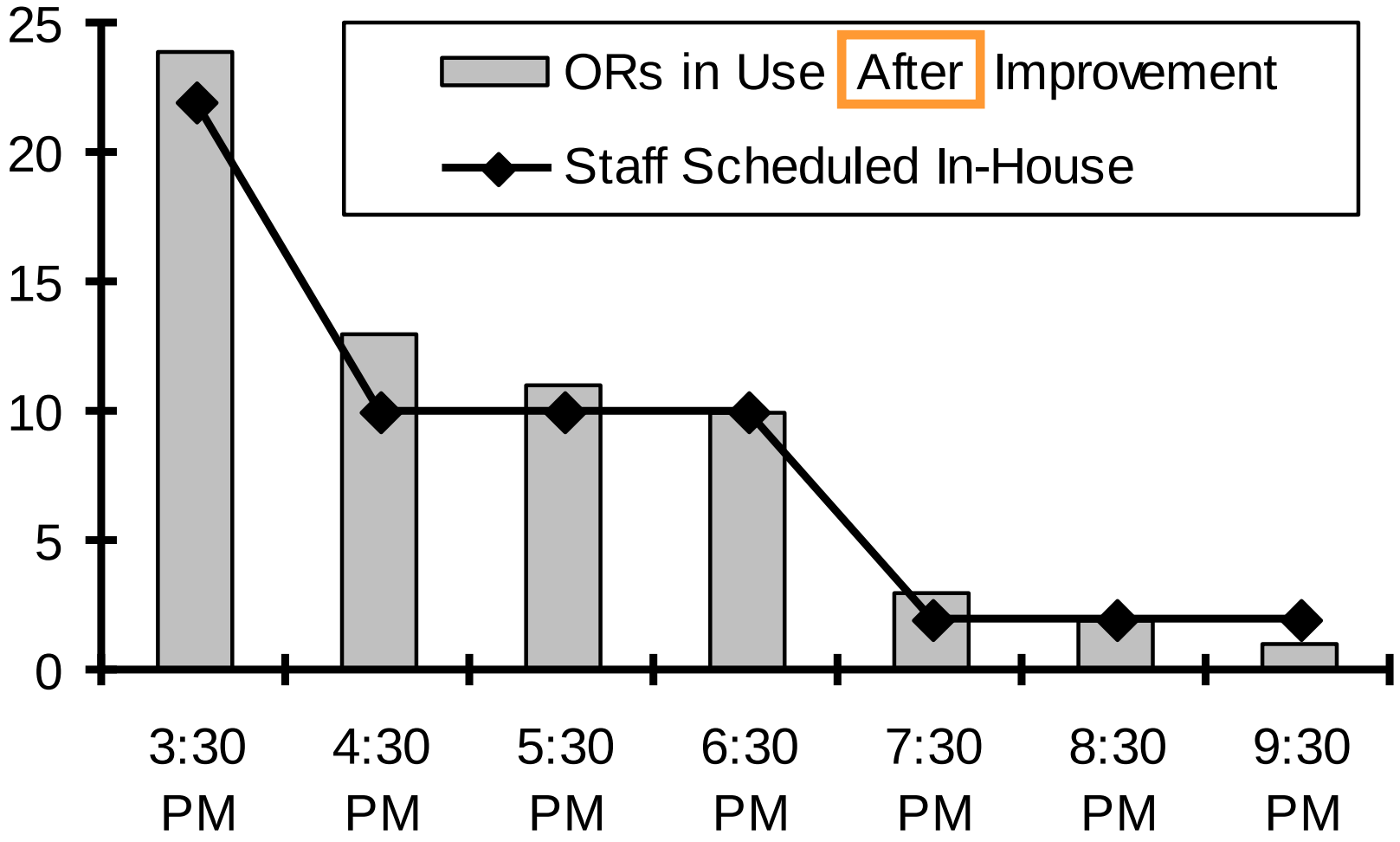

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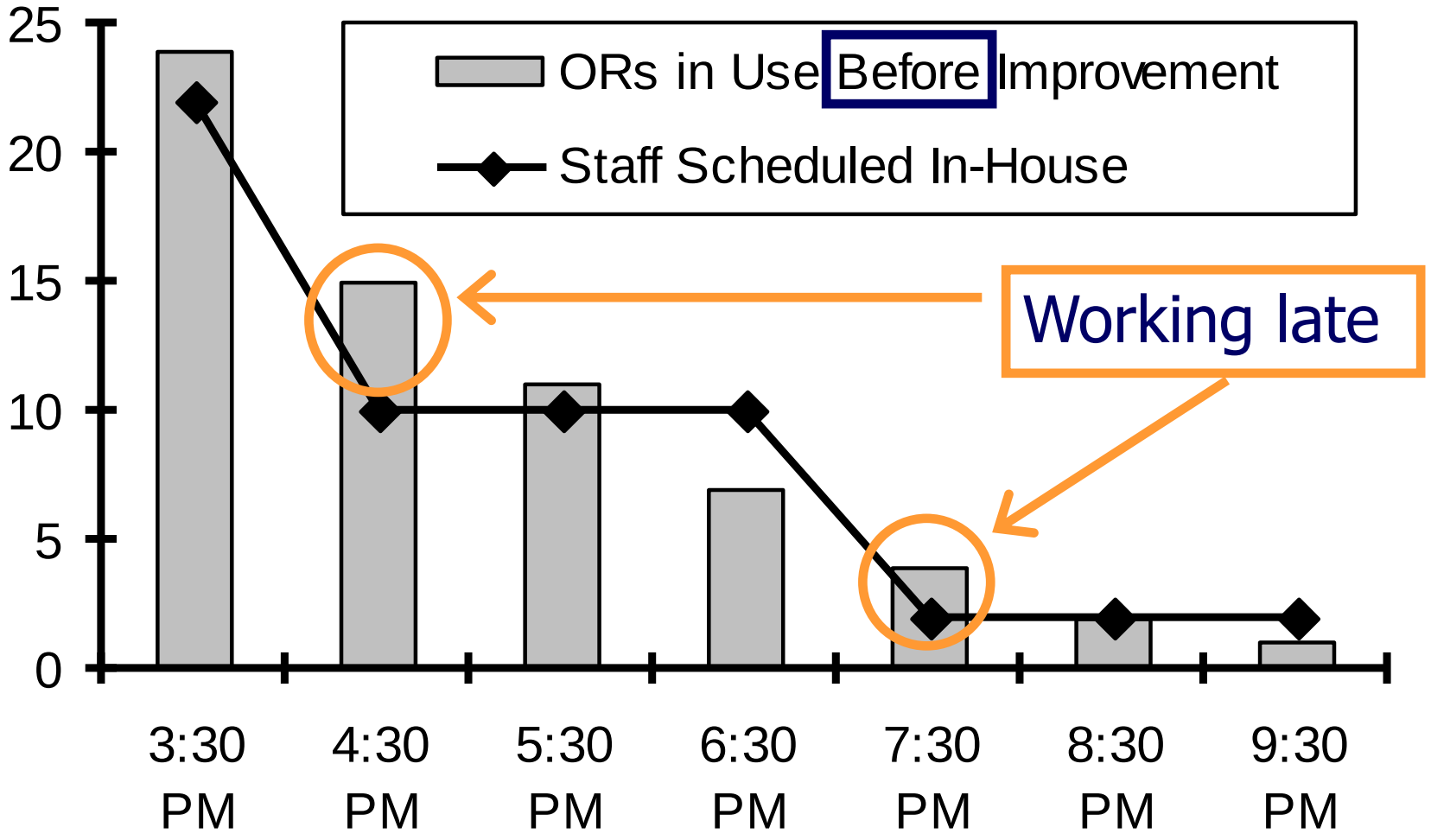

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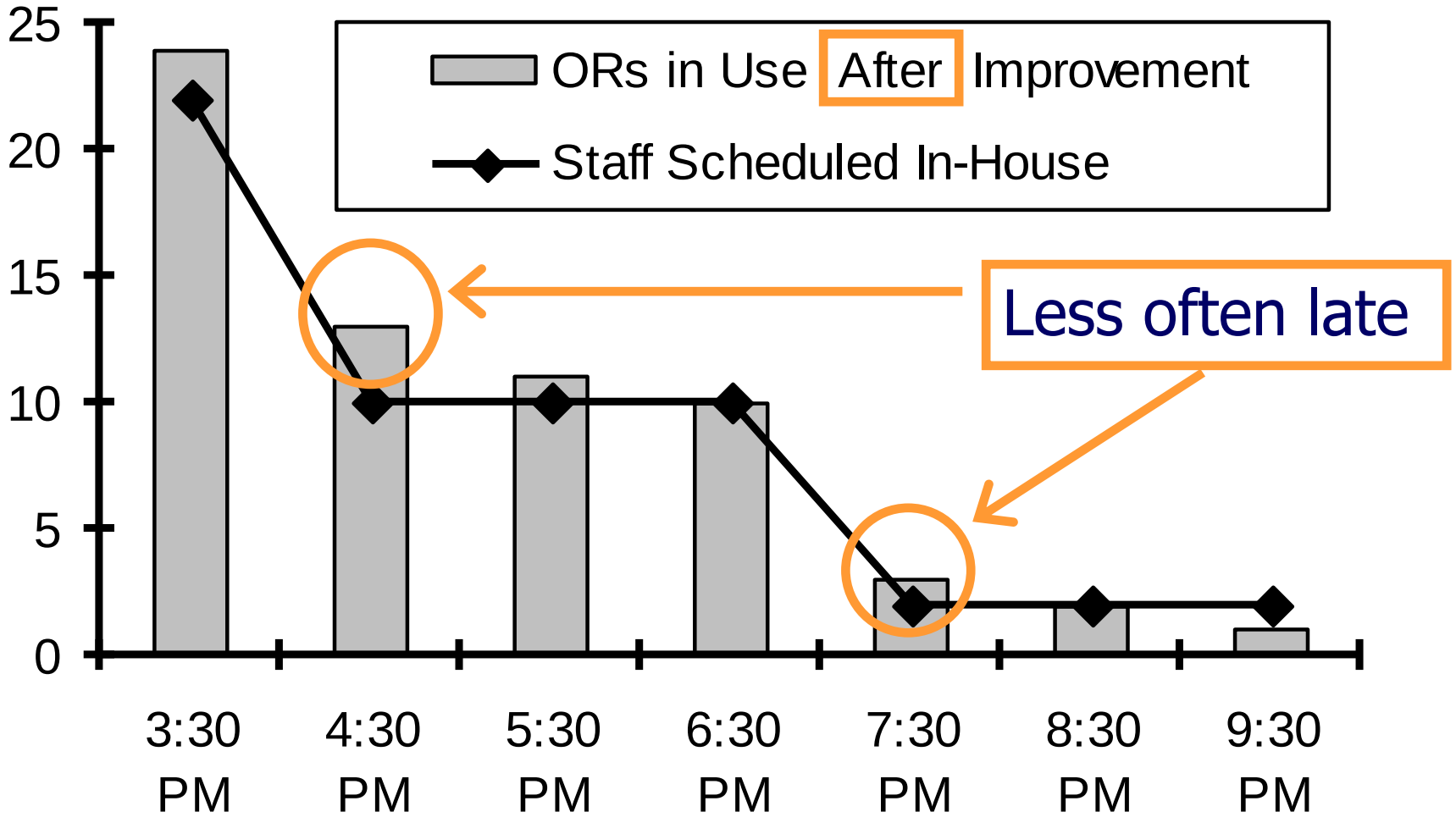

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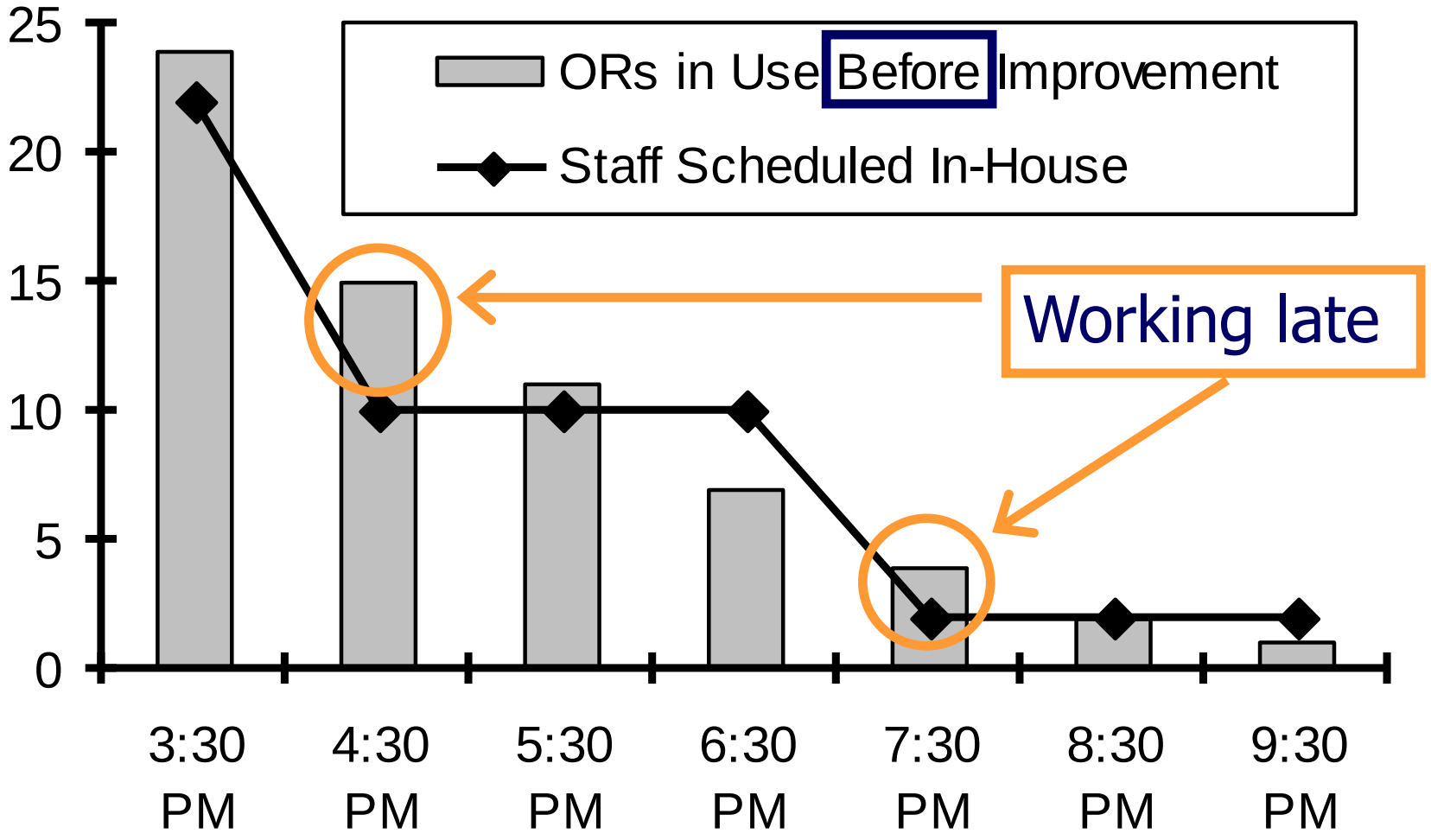

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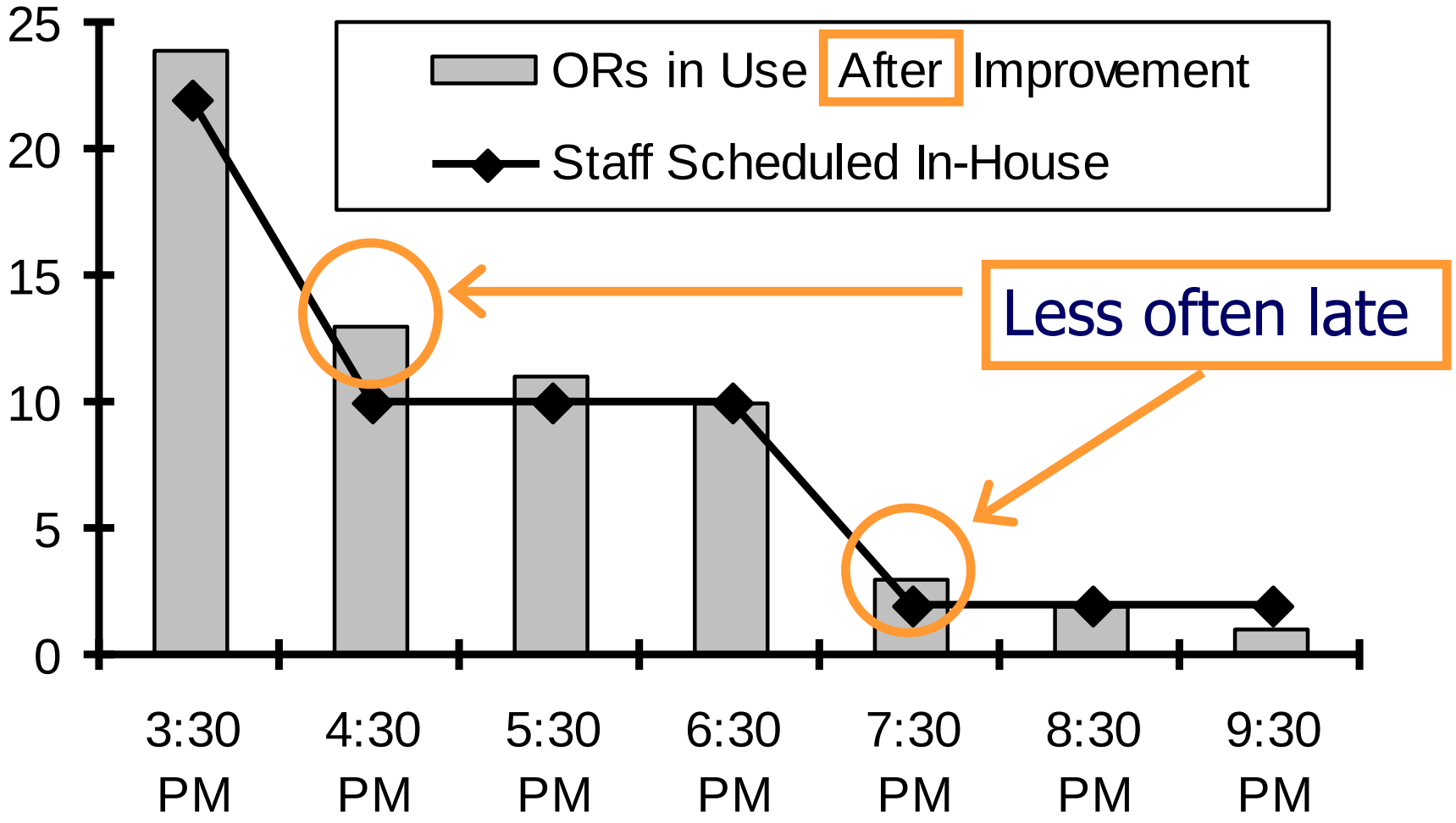

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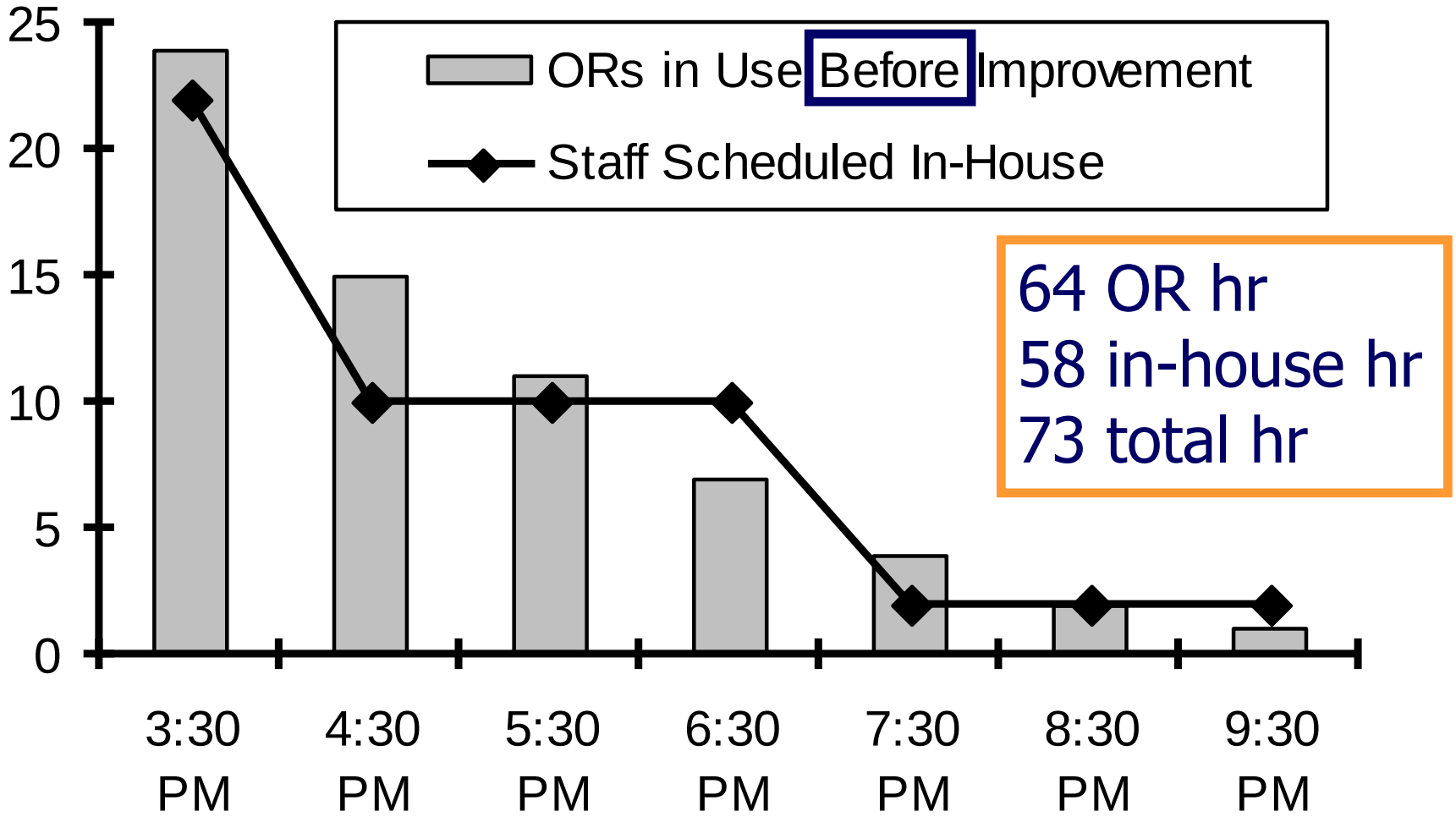

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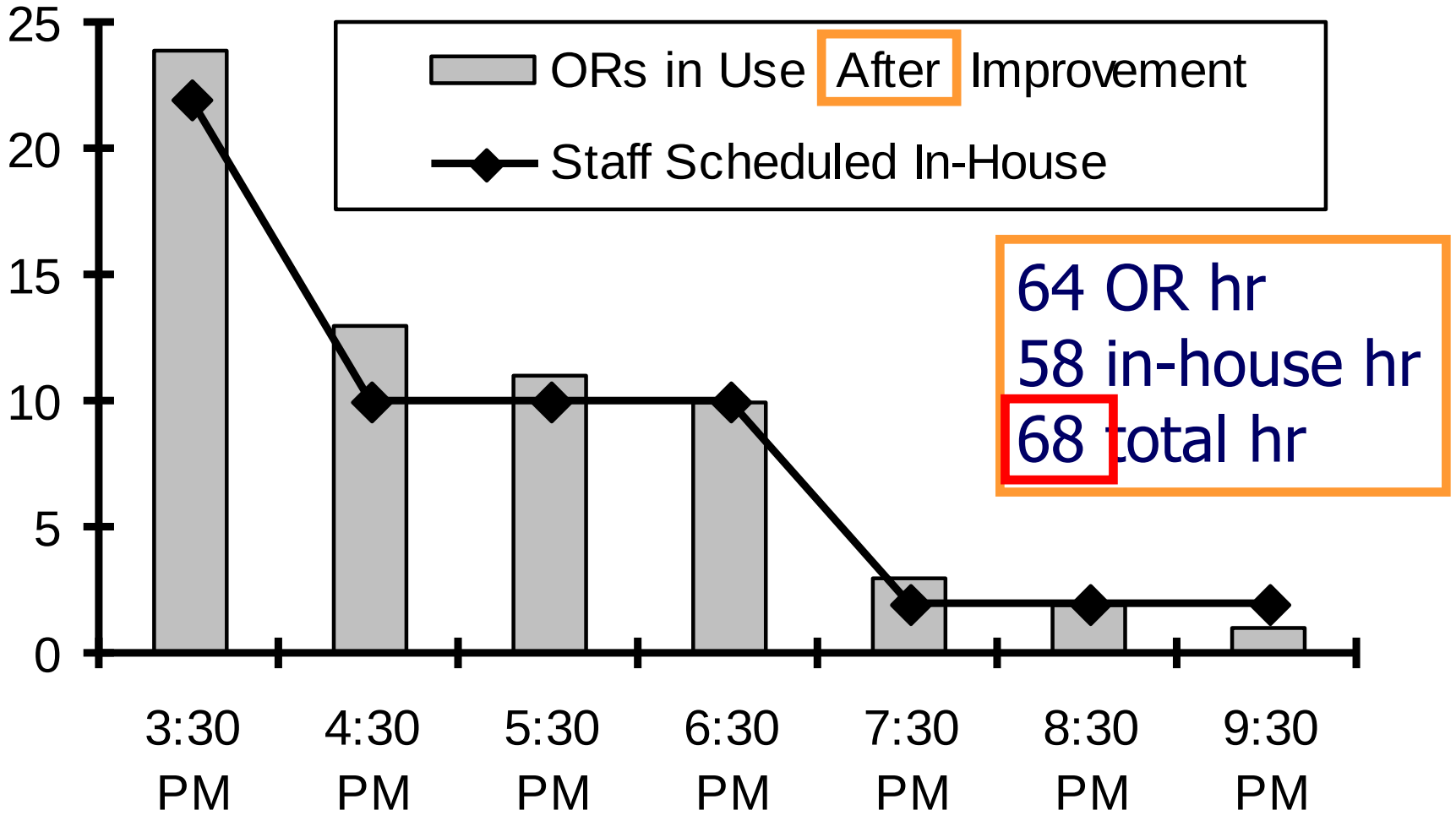

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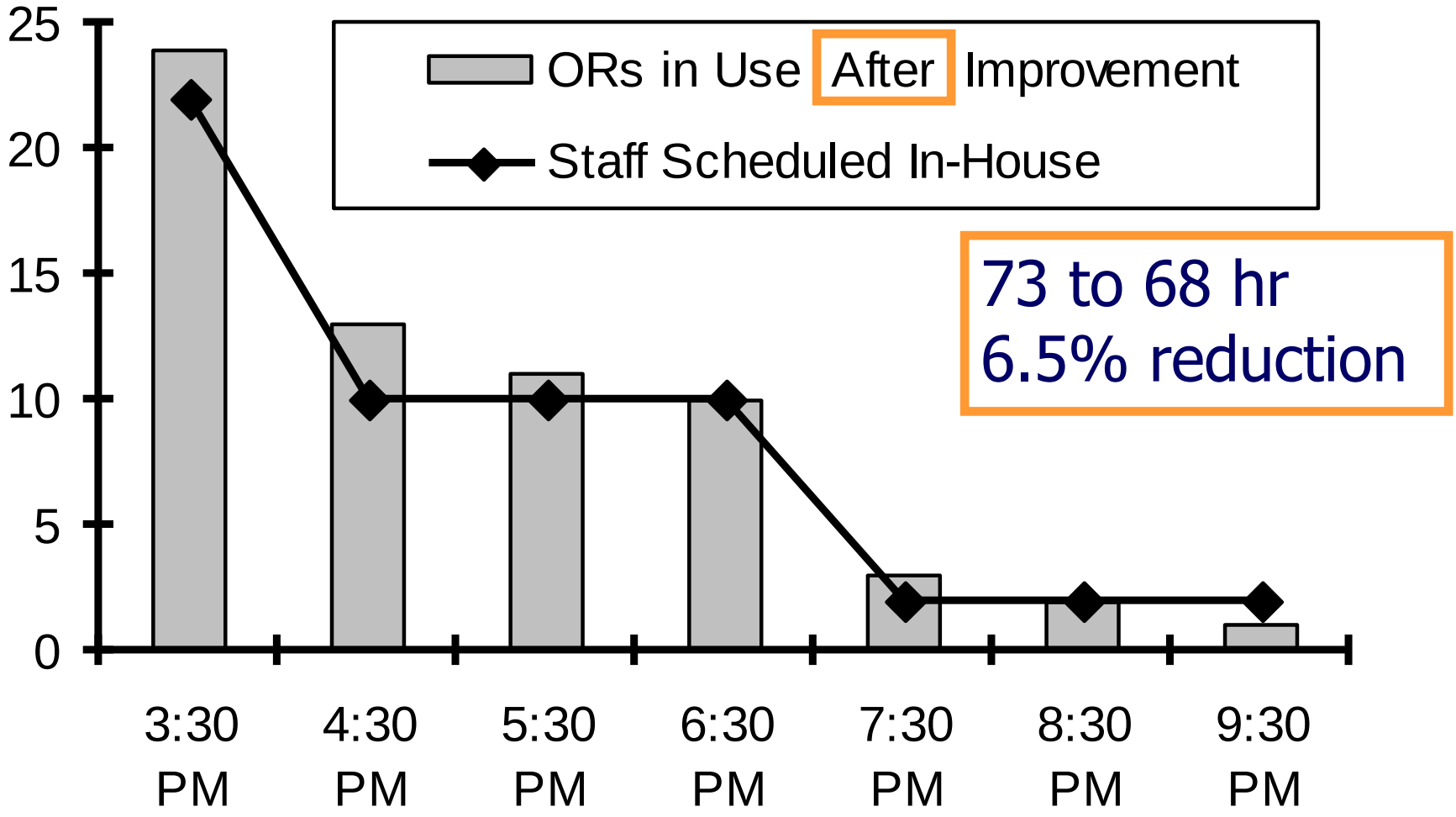

Topics of Talk on Reducing Variability

- Review of principles in calculating allocated OR time for use in reducing over-utilized time
- Decision-making on the day of surgery to reduce over-utilized time
- Review of why use displays to guide decision-making on the day of surgery
- Monitoring reduced variability in work hours

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, increasing anesthesia productivity, financial analysis, and strategic decision-making
- www.FranklinDexter.net
  - Comprehensive bibliography of peer reviewed articles in operating room and anesthesia group management
    - Sign-up for notifications of new articles

Pretest Question #1

- 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?

Pretest Question #2

- Two healthy patients arrive for elective (scheduled) surgery
- Each of their ORs likely will be ready for the patients in 30 minutes, but having both ready so soon will be hard to accomplish
- How decide which of the two patients should be ready soonest?

Pretest Question #3

- 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?

Pretest Question #4

- A facility achieved a 5% reduction in labor costs by reducing variability in work hours in afternoons after 3:00 PM
- The mean hours of cases being performed after 3:00 PM likely changed approximately how much?

Answers to Pretest Questions

1. 10 hr maximizes efficiency of use of OR time
2. Prepare patient for whichever OR has the most (if any) hours of over-utilized OR time
3. No, information alone does not significantly improve the quality of decisions
4. 0% reduction in mean hours, because it is reduction in variability in those hours that has been accomplished, the same amount of surgery is being done