

# Economics of Reducing Turnover Times

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# Economics of Reducing Turnover Times

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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)

# Why Focus on Turnover Times (Cleanup Time + Setup Time)?

- Lean manufacturing principles
  - Value added time when labor is “touching” product, changing its form or function
  - Non-value added activity is the opposite
- Times when patients are in or out of an OR
  - No reliable and valid instrument and process to record times of the start and stop of value-added activity for most procedures
  - Turnover times can be measured reliably

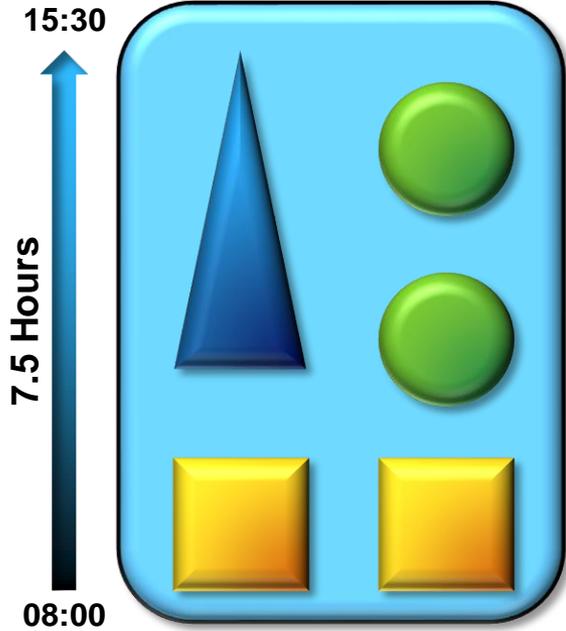


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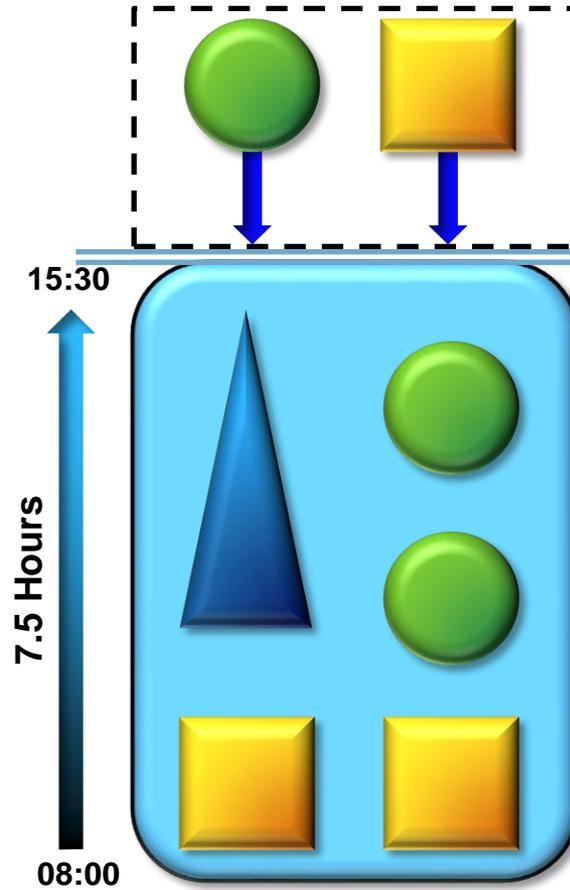


**Regular  
OR Schedule**



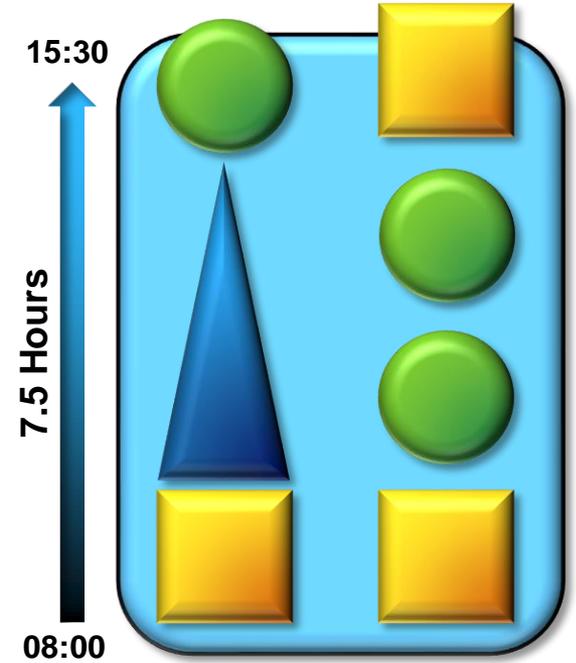
**Baseline**

**Extended  
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**Baseline**

**Regular  
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**Intervention**

**Regular  
OR Schedule**

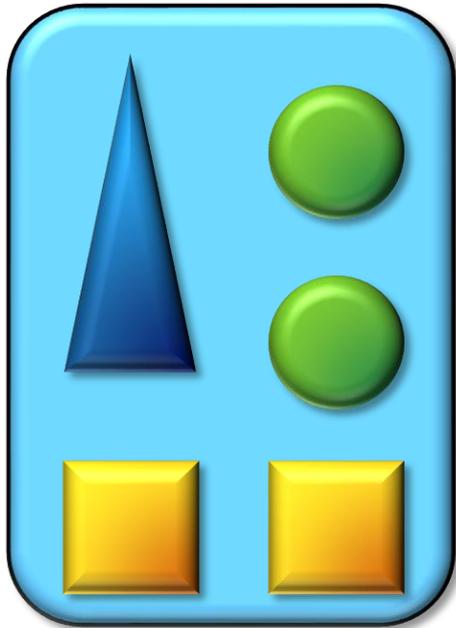
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**Regular  
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15:30

7.5 Hours

08:00

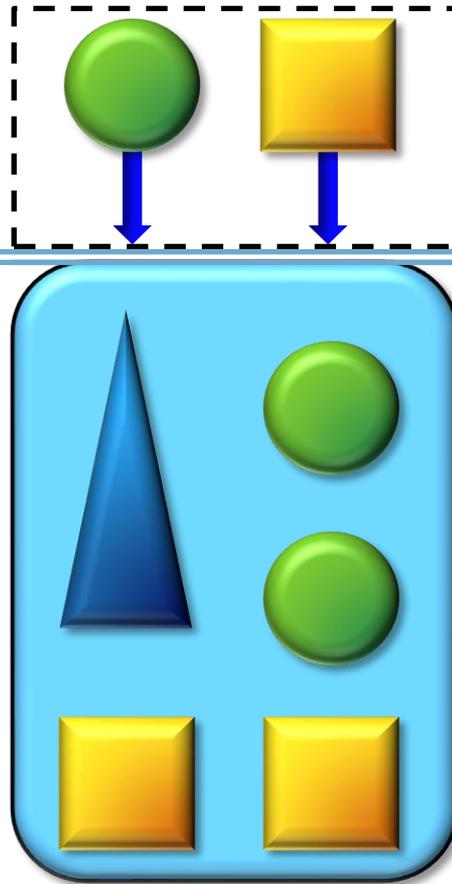


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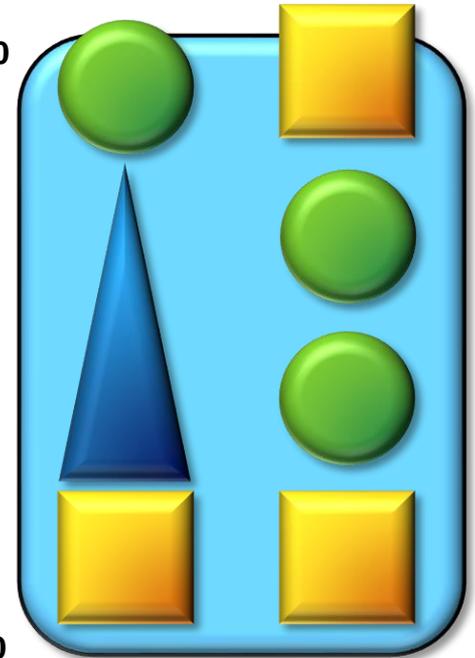


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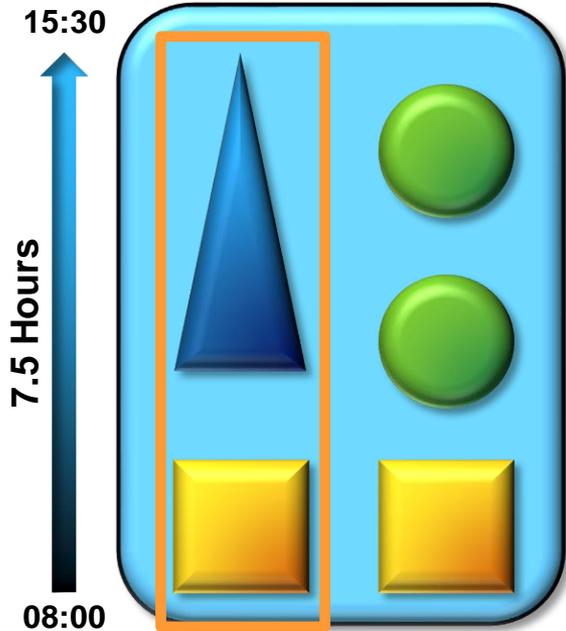
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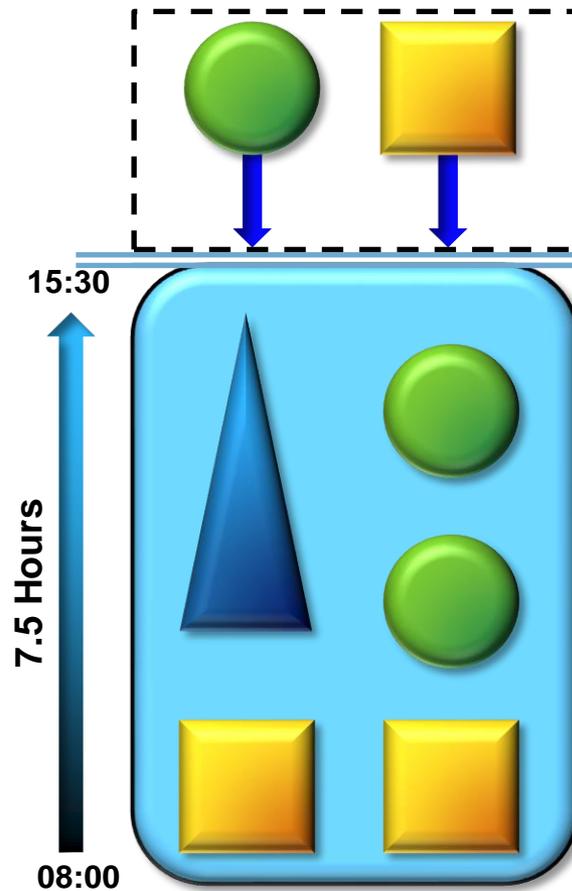
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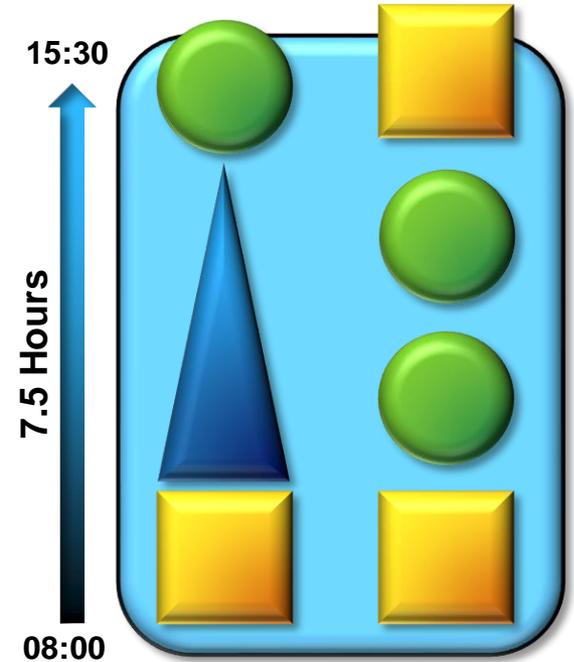
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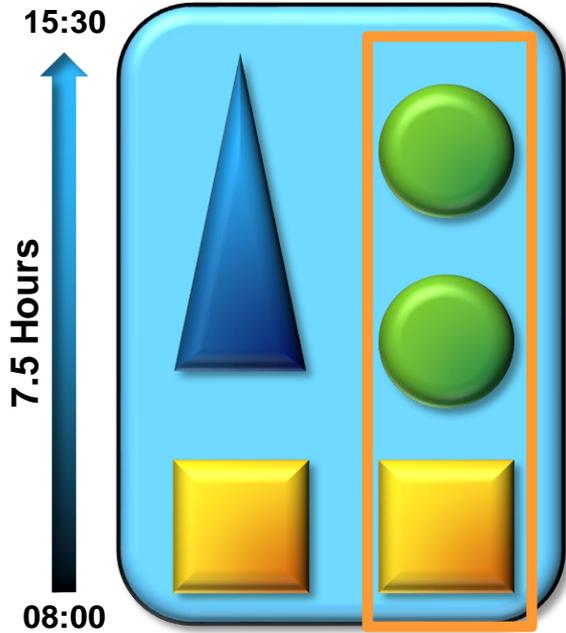
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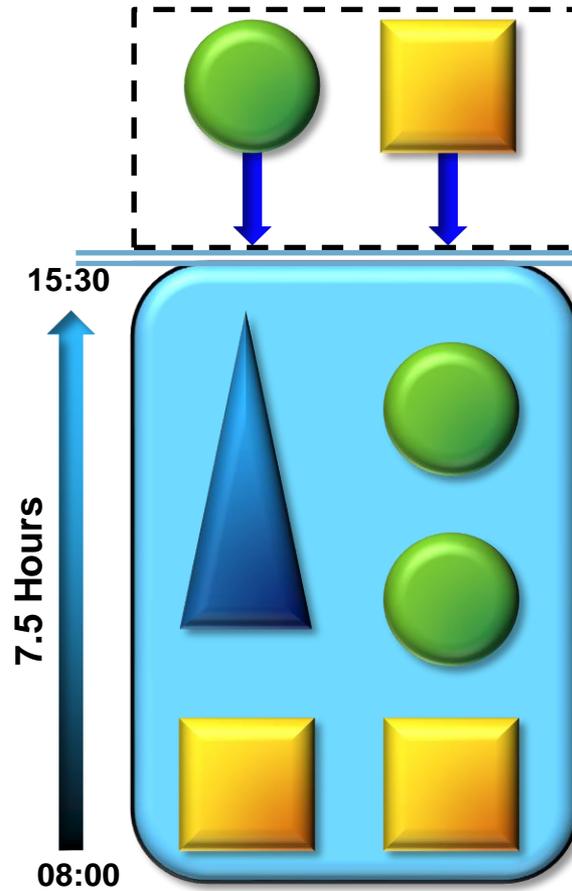
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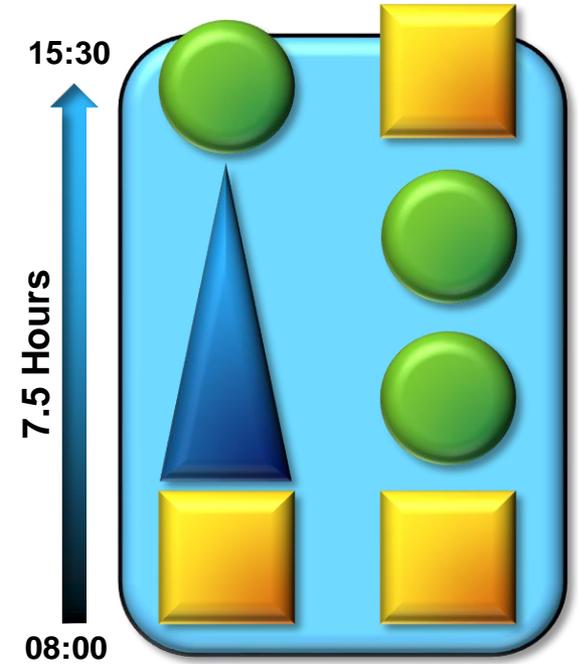
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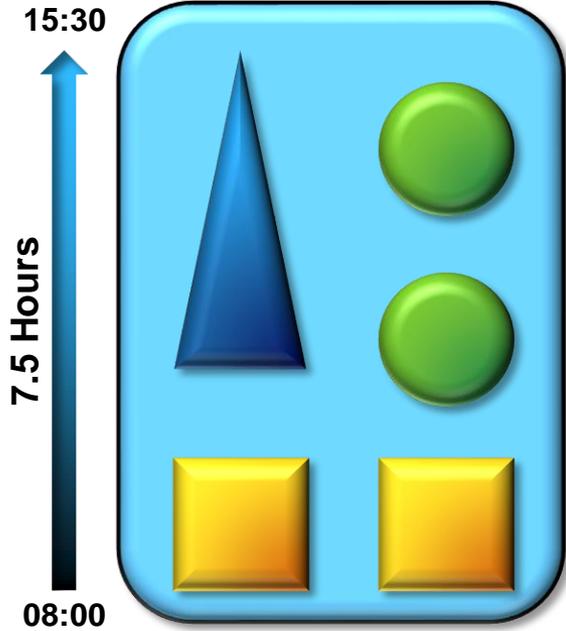
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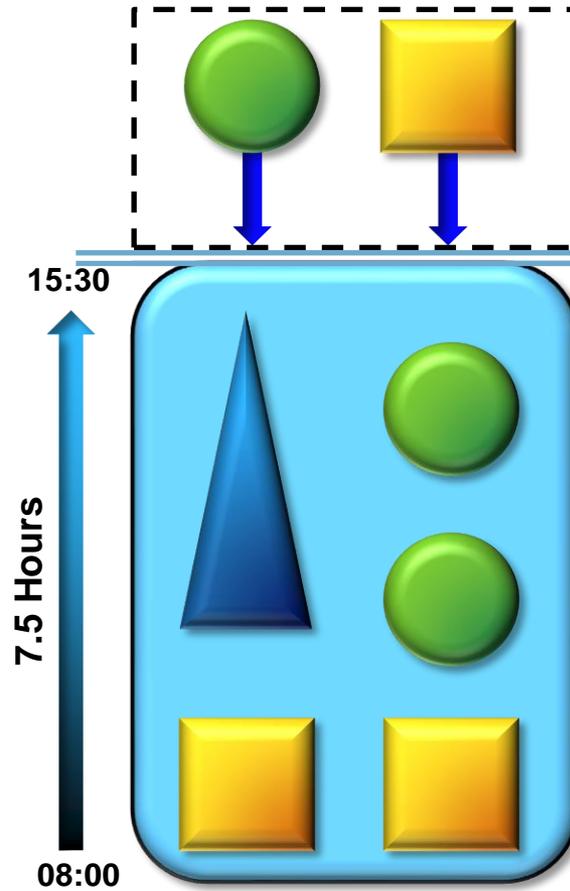
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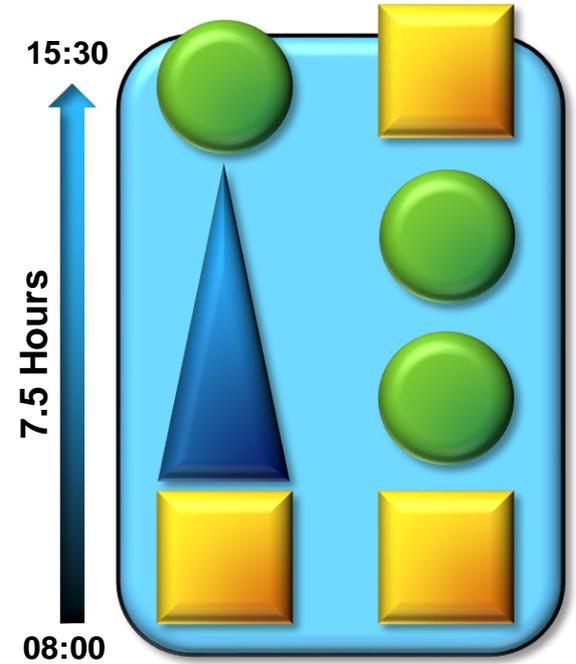
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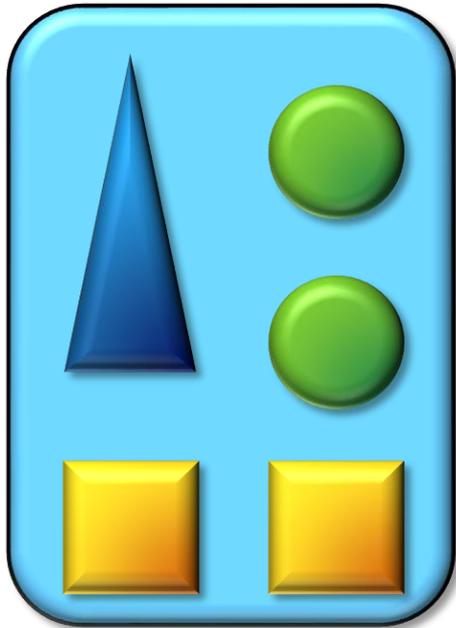
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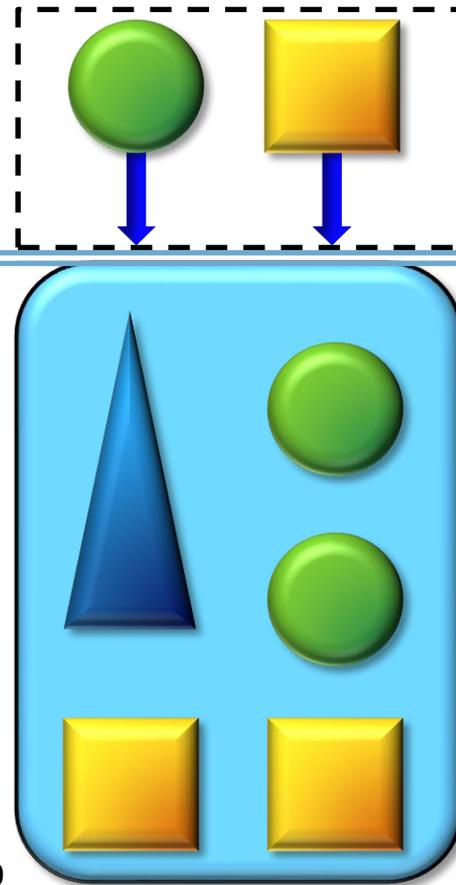
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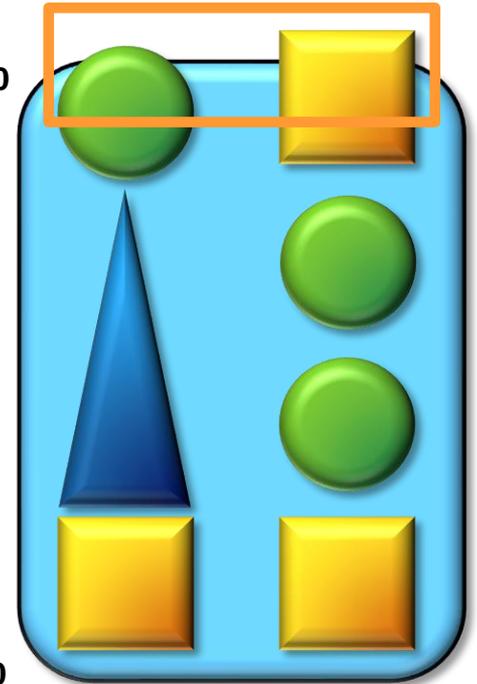
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**Intervention**

# Economics of Reducing Turnover Times

- Potential benefits of reducing turnover times
  - Increase OR efficiency on the day of surgery by reducing over-utilized OR time
  - Increase OR productivity by reducing staffing, even if have under-utilized OR time each day
  - Increase number of cases
- Focus not just on setup and cleanup times, but also the frustrating prolonged turnovers



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  - Increase OR efficiency on the day of surgery by reducing over-utilized OR time
    - Increase OR productivity by reducing staffing, even if have under-utilized OR time each day
    - Increase number of cases
- Focus not just on setup and cleanup times, but also the frustrating prolonged turnovers



# Example of *Under-Utilized OR Time*

- OR staffing is planned from 7 AM to 3 PM
- Yesterday, the last case of the day in OR 1 ended at 1 PM
- There were 2 hours of under-utilized OR time
  - Under-utilized time was from 1 PM to 3 PM

Strum DP et al. Anesthesiology 1999



# Example of *Over-Utilized OR Time*

- OR staffing is planned from 7 AM to 3 PM
- Two days ago, the last case of the day in OR 1 ended at 5 PM
- There were 2 hr of *over-utilized OR time*
  - Over-utilized OR time was from 3 PM to 5 PM



# Precise Meaning of "Maximize Efficiency of Use of OR Time"

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



# Reducing Turnover Times on Day of Surgery

- OR nurses & anesthesiologists full-time, hourly employees scheduled months ahead
- Staffing is planned from 7 AM to 3 PM
- There is estimated to be 9 hr of cases including turnover times
- Because of quick setup and cleanup times, OR finishes at 3 PM, instead of at 4 PM
- Has ↓ turnover times ↑ OR efficiency?



# Reducing Turnover Times on Day of Surgery

- OR nurses & anesthesiologists full-time, hourly employees scheduled months ahead
- 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)  
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Dexter F, Traub RD. Anesth Analg 2002

McIntosh C et al. Anesth Analg 2006

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



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



# Meaning of Maximizing OR Efficiency on Day of Surgery

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



# Reducing Turnover Times on Day of Surgery

- Scenario
  - Staffing is planned from 7 AM to 3 PM
  - By reducing turnover times, cases finished in 8 hr instead of in the expected 9 hr
    - Finished at 3 PM instead of at 4 PM



# Reducing Turnover Times on Day of Surgery

- Scenario
  - Staffing is planned from 7 AM to 3 PM
  - By reducing turnover times, cases finished in 8 hr instead of in the expected 9 hr
    - Finished at 3 PM instead of at 4 PM
  - Reducing turnover times ***increased*** OR efficiency by preventing 1 hr of over-utilized OR time



# Reducing Turnover Times on Day of Surgery

- OR nurses & anesthesiologists full-time, hourly employees scheduled months ahead
- Staffing is planned from 7 AM to ~~3~~ **5** PM
- There is estimated to be 9 hr of cases including turnover times
- Because of quick setup and cleanup times, OR finishes at 3 PM, instead of at 4 PM
- Has ↓ turnover times ↑ OR efficiency?



# Reducing Turnover Times on Day of Surgery

- Scenario
  - Staffing is planned from 7 AM to ~~3~~ **5** PM
  - By reducing turnover times, cases finished in 8 hr instead of in the expected 9 hr
    - Finished at 3 PM instead of at 4 PM

**Same**



# Reducing Turnover Times on Day of Surgery

- Scenario

- Staffing is planned from **7 AM to ~~3~~ 5 PM**

- By reducing turnover times, cases finished in 8 hr instead of in the expected 9 hr

- Finished at 3 PM instead of at 4 PM

- Reducing turnover times **did not** increase OR efficiency by preventing ~~1~~ **0** hr of over-utilized OR time



# Reducing Turnover Times on Day of Surgery

- Implications of the two scenarios
  - Impact of reductions in turnover times and delays on OR efficiency is highly sensitive to the staffing for each OR
  - Efforts to reduce turnover times should be targeted based on the staffing for each OR

Dexter F et al. Anesth Analg 2003

McIntosh C et al. Anesth Analg 2006

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



# Reducing Turnover Times on Day of Surgery

- Implications of the two scenarios
  - Impact of reductions in turnover times and delays on OR efficiency is highly sensitive to the staffing for each OR
  - Efforts to reduce turnover times should be targeted based on the staffing for each OR
  - Staffing for each OR that minimizes the inefficiency of use of OR time generally are the most important values to be calculated using local OR management data



# Principles Apply to First Case of Day Starts

- If OR has 3 cases and the first case of the day enters the OR 8 min late, that is same as increasing mean turnover time by 4 min
  - Thus same principles apply

McIntosh C et al. Anesth Analg 2006

Dexter F, Epstein RH. Anesth Analg 2009



# Principles Apply to First Case of Day Starts

- If OR has 3 cases and the first case of the day enters the OR 8 min late, that is same as increasing mean turnover time by 4 min
  - Thus same principles apply
- For scenarios involving more than 1 OR, such as anesthesiologist medically directing CRNAs, many decisions that increase % cases with on-time first case start reduce OR efficiency

Dexter F et al. Anesth Analg 2007



# Principles Apply to First Case of Day Starts

- Important for anesthesiologists supervising multiple ORs, because must use staggered starts ( $\cong 20$  min) at first cases of the day for anesthesiologist to be present at inductions
  - Otherwise 1:2 MD:CRNA, lapses  $> 30\%$  of days
  - Otherwise 1:3 MD:CRNA, lapses  $> 96\%$  of days

Epstein RH, Dexter F. Anesth Analg 2012



# Principles Apply to First Case of Day Starts

- Let the surgeons know so that those with the later starts are not waiting in the ORs

Koenig T et al. Anaesthesia 2011



# Principles Apply to First Case of Day Starts

- Let the surgeons know so that those with the later starts are not waiting in the ORs
- Yes, preferentially focusing on ORs with over-utilized time, since ordered priorities are first performing all the cases safely and second reducing expected over-utilized time

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# Principles Apply to First Case of Day Starts

- Let the surgeons know so that those with the later starts are not waiting in the ORs
- Yes, preferentially focusing on ORs with over-utilized time, since ordered priorities are first performing all the cases safely and second reducing expected over-utilized time
- Important to understand since fixation on first case starts is due to cognitive bias that starting late results in all cases being tardy



# Impact of Staffing on Benefit of Turnover Time Reduction

- Outpatient Surgery Center with 6 ORs, all staffed from 7 AM to 5 PM
- Mean ORs in use before intervention
  - 2 PM – 5 ORs
  - 3 PM – 2 ORs
  - 4 PM – 1.4 ORs
  - 5 PM – 0.3 ORs
- Mean ORs in use after intervention
  - 2 PM – 4 ORs
  - 3 PM – 1.2 ORs
  - 4 PM – 0.8 ORs
  - 5 PM – 0.1 ORs
- Increased OR efficiency?



# Impact of Staffing on Benefit of Turnover Time Reduction

- 1) Evaluate the OR allocation (staffing)



# Impact of Staffing on Benefit of Turnover Time Reduction

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# Impact of Staffing on Benefit of Turnover Time Reduction

- Outpatient Surgery Center with 6 ORs,  
all staffed from 7 AM to 5 PM

**Unchanged**

- Mean ORs in use before intervention
  - 2 PM – 5 ORs
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  - 4 PM – 1.4 ORs
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- Mean ORs in use after intervention
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  - 3 PM – 1.2 ORs
  - 4 PM – 0.8 ORs
  - 5 PM – 0.1 ORs

- Increased OR efficiency?



# Impact of Staffing on Benefit of Turnover Time Reduction

- 2) Evaluate the over-utilized OR time assuming (and might be incorrect) that 7 AM to 5 PM allocation minimizes the inefficiency of use of OR time



# Impact of Staffing on Benefit of Turnover Time Reduction

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**Small  
& same**

- Increased OR efficiency?



# Impact of Staffing on Benefit of Turnover Time Reduction

- 1) Evaluate the OR allocation (staffing)
  - 2) Evaluate the over-utilized OR time
- No impact on OR efficiency, because staffing and over-utilized OR time are effectively the same



# Impact of Staffing on Benefit of Turnover Time Reduction

- 1) Evaluate the OR allocation (staffing)
- 2) Evaluate the over-utilized OR time
  - No impact on OR efficiency, because staffing and over-utilized OR time are effectively the same
  - Impact of intervention would be mostly an increase in hours of under-utilized OR time



# Impact of Staffing on Benefit of Turnover Time Reduction

- 1) Evaluate the OR allocation (staffing)
- 2) Evaluate the over-utilized OR time
  - No impact on OR efficiency, because staffing and over-utilized OR time are effectively the same
    - Impact of intervention would be mostly an increase in hours of under-utilized OR time
      - “would” since “over-utilized” and “under-utilized” are relative to OR allocation that minimizes inefficiency of use of OR time

# Impact of Staffing on Benefit of Turnover Time Reduction

- Outpatient Surgery Center with 6 ORs, all staffed from **7 AM to ~~5~~ 3 PM**
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- Increased OR efficiency?



# Impact of Staffing on Benefit of Turnover Time Reduction

- ***Increase*** in OR efficiency by reducing hours of over-utilized OR time
  - Reduction from 3.7 hr a day to 2.1 hr a day



# Impact of Staffing on Benefit of Turnover Time Reduction

- Which is right?



# Impact of Staffing on Benefit of Turnover Time Reduction

- Which is right? Plan staffing from 7 AM to 3 PM or to 5 PM to maximize OR efficiency?

McIntosh C et al. Anesth Analg 2006

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



# Precise Meaning of "Maximize Efficiency of Use of OR Time"

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# Impact of Staffing on Benefit of Turnover Time Reduction

- Which is right? Plan staffing from 7 AM to 3 PM or to 5 PM to maximize OR efficiency?
  - Suppose that from long-term perspective the relative cost of an hour of over-utilized OR time to hour of under-utilized OR time is 2.0



# Impact of Staffing on Benefit of Turnover Time Reduction

- Which is right? Plan staffing from 7 AM to 3 PM or to 5 PM to maximize OR efficiency?
  - Suppose that from long-term perspective the relative cost of an hour of over-utilized OR time to hour of under-utilized OR time is 2.0
    - Reasonable, as equals time and a half plus increment for intangible cost of working late



# Impact of Staffing on Benefit of Turnover Time Reduction

- Which is right? Plan staffing from 7 AM to 3 PM or to 5 PM to maximize OR efficiency?
  - Suppose that from long-term perspective the relative cost of an hour of over-utilized OR time to hour of under-utilized OR time is 2.0
    - Reasonable, as equals time and a half plus increment for intangible cost of working late
  - Staff so 2/3<sup>rd</sup> ORs finish early, 1/3<sup>rd</sup> finish late



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  - Staff so 2/3<sup>rd</sup> ORs finish early, 1/3<sup>rd</sup> finish late
  - Staffing that minimizes the inefficiency of use of OR time is from 7 AM to 3 PM



# Impact of Staffing on Benefit of Turnover Time Reduction

- Which is right? Plan staffing from 7 AM to 3 PM or to 5 PM to maximize OR efficiency?
  - Suppose that from long-term perspective the relative cost of an hour of over-utilized OR time to hour of under-utilized OR time is 2.0
    - Reasonable, as equals time and a half plus increment for intangible cost of working late
  - Staff so 2/3<sup>rd</sup> ORs finish early, 1/3<sup>rd</sup> finish late
  - Staffing that minimizes the inefficiency of use of OR time is from 7 AM to 3 PM
  - “Over-utilized OR time” is relative to 8 hours

# Impact of Staffing on Benefit of Turnover Time Reduction

- If:
  - Staffing planned and cases scheduled based on maximizing the efficiency of use of OR time
- And:
  - There are more than 8 hr of cases and turnover times in ORs
- Then:
  - Reducing turnover times can increase OR efficiency



# Impact of Staffing on Benefit of Turnover Time Reduction

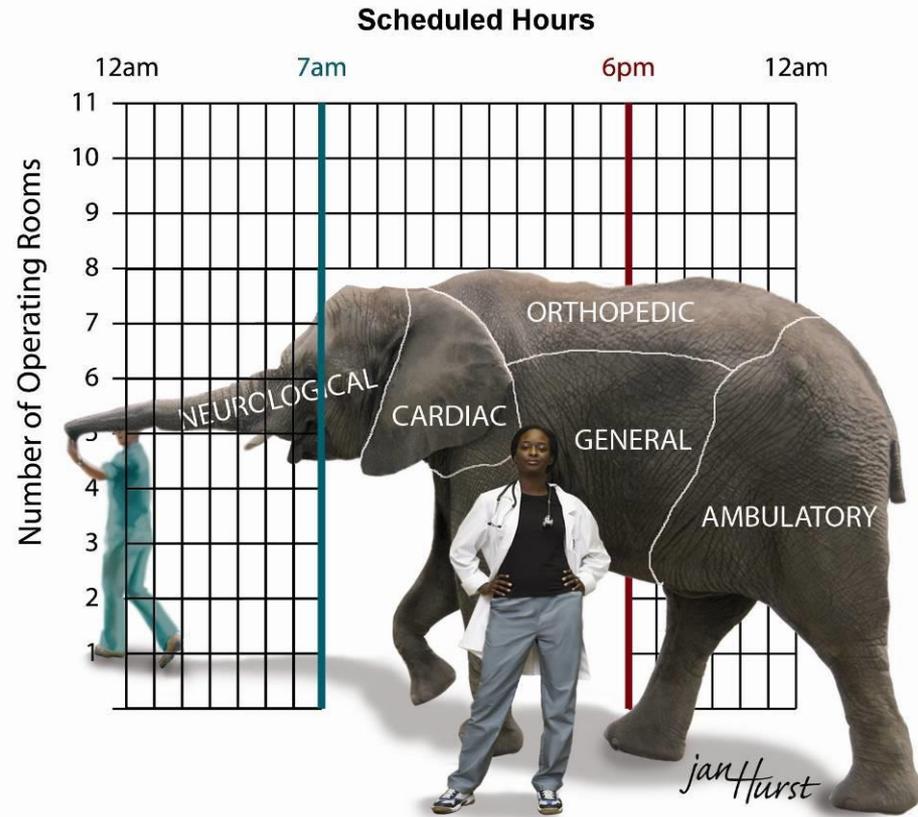
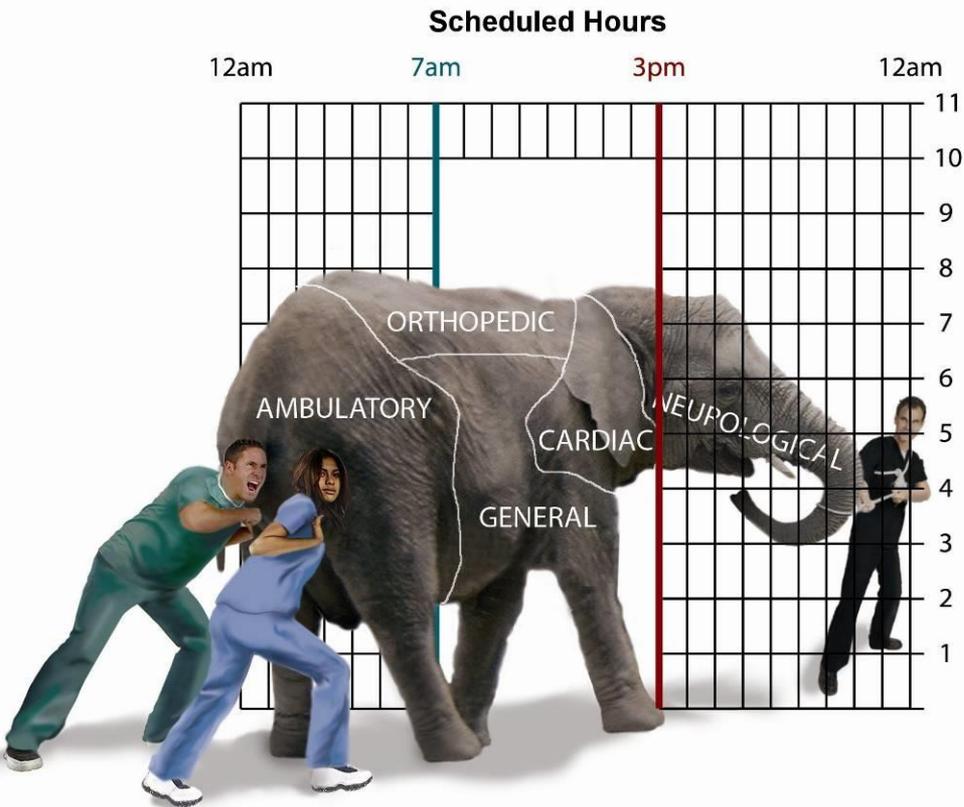
- If:
  - Staffing planned and cases scheduled based on maximizing the efficiency of use of OR time
- And:
  - There are more than 8 hr of cases and turnover times in ORs
- Then:
  - Reducing turnover times ***can increase*** OR efficiency



# Impact of Staffing on Benefit of Turnover Time Reduction

- If: ***Straightforward, with mathematics***
  - ~~Staffing planned and cases scheduled based on maximizing the efficiency of use of OR time~~
- And:
  - There are more than 8 hr of cases and turnover times in ORs
- Then:
  - Reducing turnover times can increase OR efficiency





“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

# Consideration of Appropriate OR Staffing is Useful

- For 12 of 14 suites, staffing plan to maximize OR efficiency had 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

- Pull to center bias
  - Essentially schedule staff as if allocated hours were based on a relative cost ratio of 1.10 instead of 1.75
  - Invariant to demand distribution and to problem context

Wachtel RE, Dexter F. Anesth Analg 2010

Brokesova Z et al. PLoS ONE 2022



# Experimental Studies Explain Why Method Often Unused

- Pull to center bias
  - Essentially schedule staff as if allocated hours were based on a relative cost ratio of 1.10 instead of 1.75
  - Invariant to demand distribution and to problem context
- Issue is psychology, not politics, culture, buy in, personalities, or organizational inertia

Wachtel RE, Dexter F. Anesth Analg 2010



# Impact of Staffing on Benefit of Turnover Time Reduction

- If:
  - Staffing planned and cases scheduled based on maximizing the efficiency of use of OR time
- And: ***Easy Screening Question***
  - There are more than 8 hr of cases and turnover times in ORs
- Then:
  - Reducing turnover times can increase OR efficiency



# Screening Question Useful Since Often Fewer Than 8 Hr of Cases

- Average 6.0 hr of anesthesia time per OR per day at 11 US community anesthesia groups
- Average 5.5 hr of OR time per OR per day at 8 US community hospitals' ORs with knee and hip replacement surgery
- Most ( $\geq 59\%$ ) US facilities complete majority of their weekly anesthesia workload in the mornings of regular workdays

Abouleish AE et al. Anesthesiology 2002

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Dexter F et al. Health Care Manag Sci 2006

Dexter F et al. Anesth Analg 2015



# Screening Question Useful Since Often Fewer Than 8 Hr of Cases

- US national average for ambulatory surgery cases in 2010
  - 64% OR case time completed by 12 noon
    - 77% among pediatric cases (0 to 14 years)
  - 90% OR case time completed by 3:00 PM
    - 94% among pediatric cases

# Impact of Staffing on Benefit of Turnover Time Reduction

- Two screening questions to determine if <option below> can increase OR efficiency by reducing turnover (or even OR) times
    - Reduced delays on day of surgery
    - Product to reduce setup and cleanup times
    - Changes in anesthetic care, drugs, monitors
1. How many ORs have at least 8 hr of cases?
  2. What is the achievable average reduction in total time per OR per day?



# Impact of Staffing on Benefit of Turnover Time Reduction

- Two screening questions to determine if <option below> can increase OR efficiency by reducing turnover (or even OR) times
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    - Changes in anesthetic care, drugs, monitors
1. How many ORs have at least 8 hr of cases?
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***Conclusion***



# Economics of Reducing Turnover Times

- Potential benefits of reducing turnover times
  - Increase OR efficiency on the day of surgery by reducing over-utilized OR time
  - Increase OR productivity by reducing staffing, even if have under-utilized OR time each day
  - Increase number of cases
- Focus not just on setup and cleanup times, but also the frustrating prolonged turnovers



# Increasing OR Productivity Even if Under-Utilized OR Time

- Facility with 6 ORs, all staffed for the same period, calculated based on OR efficiency
- Mean ORs in use before intervention
  - 2 PM – 5 ORs      4 PM – 2.0 ORs
  - 3 PM – 4 ORs      5 PM – 0.6 ORs
- Mean ORs in use after intervention
  - 2 PM – 4 ORs      4 PM – 1.3 ORs
  - 3 PM – 2.0 ORs      5 PM – 0.1 ORs
- Increased OR productivity?



# Increasing OR Productivity Even if Under-Utilized OR Time

- Mean ORs in use *before* intervention
  - 2 PM – 5 ORs
  - 3 PM – 4 ORs
  - 4 PM – 2.0 ORs
  - 5 PM – 0.6 ORs
- If staffing options are 7 AM to 3 PM or 7 AM to 5 PM, staff 7 AM to **5** PM to maximize efficiency of use of OR time
  - Excess over-utilized OR time if 7 AM to 3 PM



# Increasing OR Productivity Even if Under-Utilized OR Time

- Mean ORs in use *after* intervention
  - 2 PM – 4 ORs      4 PM – 1.3 ORs
  - 3 PM – 2.0 ORs      5 PM – 0.1 ORs
- If staffing options are 7 AM to 3 PM or 7 AM to 5 PM, staff 7 AM to **3** PM to maximize efficiency of use of OR time
  - Excess under-utilized OR time if 7 AM to 5 PM



# Increasing OR Productivity Even if Under-Utilized OR Time

- Facility with 6 ORs, all staffed for the same period, calculated based on OR efficiency
- Mean ORs in use before intervention **7 AM – 5 PM**

2 PM – 5 ORs	4 PM – 2.0 ORs
3 PM – 4 ORs	5 PM – 0.6 ORs
- Mean ORs in use after intervention **7 AM – 3 PM**

2 PM – 4 ORs	4 PM – 1.3 ORs
3 PM – 2.0 ORs	5 PM – 0.1 ORs
- Increased OR productivity?



# Increasing OR Productivity Even if Under-Utilized OR Time

- On day of surgery, no impact of intervention on OR efficiency, because staff scheduled to 5 PM have no less over-utilized OR time
- On long-term basis, if staffing were changed from 7 AM – 5 PM to 7 AM – 3 PM, then intervention would increase OR productivity



# Caution: Need to Consider Also the Labor Cost per OR in Use

- Reduced productivity from 3 versus 2 anesthesia providers assigned to 2 ORs
- Increased productivity from 4 versus 3 anesthesia teams assigned to 3 ORs
- Increased productivity from 5 versus 4 anesthesia & nursing teams assigned to 4 ORs

Williams BA et al. Am J Anesthesiol 1998

Hanss R et al. Anesthesiology 2005

Torkki PM et al. Anesthesiology 2005



# Caution: Need to Consider Also the Labor Cost per OR in Use

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- Reduced productivity from 3 versus 2 anesthesia providers assigned to 2 ORs
- Increased productivity from 4 versus 3 anesthesia teams assigned to 3 ORs
- Increased productivity from 5 versus 4 anesthesia & nursing teams assigned to 4 ORs
- Results insensitive to specific workflow

Marjamaa RA et al. Health Care Manag Sci 2009



# Caution: Need to Consider Also the Labor Cost per OR in Use

- Reduced productivity from 3 versus 2 anesthesia providers assigned to 2 ORs
- Increased productivity from 4 versus 3 anesthesia teams assigned to 3 ORs
- Increased productivity from 5 versus 4 anesthesia & nursing teams assigned to 4 ORs
- Results insensitive to specific workflow
- Facilitate by coordinating dates surgeons operate (“blocks”) to best use the shared OR(s)



# Caution: Need to Consider Also the Labor Cost per OR in Use

- For 1 surgeon and a 2<sup>nd</sup> adjacent OR or anesthesia induction area, and with a member of the surgical team that can leave when skin closure begins, mean reduction in turnover time was 8.5 minutes

Mizumoto R et al. Int J Surg 2016



# Service, Day of Week, and Procedure Specific Analysis

- Orthopedics' staffing is 3 OR each day for 8 hr
- Mean 6.8 hr (SD 0.8 hr) cases per OR per day
- Even if reduce turnover times, would still have 3 ORs for 8 hr
  - No increase in OR productivity
    - No resulting reduction in staffing cost



# Service, Day of Week, and Procedure Specific Analysis

- ENT's staffing is 3 OR each day for 10 hr
- Mean 11 hr (SD 0.8 hr) cases per OR per day
- If reduce turnover time, would reduce over-utilized OR time, and perhaps also reduce some OR's staffing to 8 hr
  - Increase in OR productivity
    - Resulting reduction in staffing cost



# Monitor Impact of Reducing Turnover Times by Service

1. Calculate current service-specific staffing
2. Reduce all turnovers that are longer than a collective maximum value to the maximum
3. Recalculate service-specific staffing
4. Report reduction in staffing costs, if any, in units of minutes per 8 hr of staffed OR time

Dexter F et al. Anesth Analg 2003

Abouleish AE et al. Anesthesiology 2004

McIntosh C et al. Anesth Analg 2006

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

# Monitor Impact of Reducing Turnover Times by Service

Service	Mon	Tue	Wed	Thu	Fri
BURN		7			
ENT	<b>44</b>	<b>14</b>	7	6	<b>11</b>
GEN	4				8
GU	6		8		9
NEURO			<b>11</b>	<b>11</b>	
OPTH		2			
ORTH	6	7	7	8	6
URGENT	<b>24</b>	9	<b>13</b>	<b>55</b>	<b>24</b>
<b>TOTAL</b>	14	8	10	14	13

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$$(44 - 2) / 2 = 2100\%$$

# Monitor Impact of Reducing Turnover Times by Service

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BURN		7			
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<b>TOTAL</b>	14	8	10	14	13

# Service, Day of Week, and Procedure Specific Analysis

- Factors to consider about each service:
  - Mean turnover time
    - Opportunity if mean is long
  - Turnover times per OR each day
    - Opportunity if many turnovers per OR
  - Hours of cases including turnovers each day
    - Hours of under- and over-utilized OR time
  - Variability in workload among weeks
    - Benefit if less variability



# Operational Implications for *Benchmarking*

- Factors to consider about each service:
  - Mean turnover time
    - Not simply overall turnover time for suite
  - Turnover times per OR each day
    - Not simply overall turnover time by service
  - Hours of cases including turnovers each day
    - Turnover times per se are not useful
  - Variability in workload among weeks
    - Surgeon blocks taken into account



# Review – Summarize the Facts of the Talk



# Prioritize Goals in Reducing Turnover and Anesthesia Times

- 5-minute exercise



# Prioritize Goals in Reducing Turnover and Anesthesia Times

- Hospital daily has 65 anesthesia practitioners (CRNAs and resident physicians) in ORs
  - Unscheduled absence rate 1.81%
- When assessing risk of inconvenient waiting of patients and surgeons, hospitals will accept as high as 5-6% risk (e.g., weekends)

Dexter F et al. Perioper Care Oper Room Manag 2020

Dexter F et al. AANA Journal 2002

Dexter F, Epstein RH. Anesth Analg 2006



# Prioritize Goals in Reducing Turnover and Anesthesia Times

<b>Probabilities of unscheduled absences</b>	<b>Applying absence rate of 1.81%</b>
1 or more among 65 scheduled	69.6%
2 or more among 66 scheduled	33.7%
3 or more among 67 scheduled	12.2%
4 or more among 68 scheduled	3.5%

Dexter F et al. Perioper Care Oper Room Manag 2020



# Prioritize Goals in Reducing Turnover and Anesthesia Times

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Dexter F et al. Perioper Care Oper Room Manag 2020



# Prioritize Goals in Reducing Turnover and Anesthesia Times

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2 or more among 66 scheduled	33.7%
3 or more among 67 scheduled	12.2%
4 or more among 68 scheduled	3.5%

Create an ordered prioritized list of clinical activities of those 3 extra nurse anesthetists scheduled daily



# Economics of Reducing Turnover Times

- Potential benefits of reducing turnover times
  - Increase OR efficiency on the day of surgery by reducing over-utilized OR time
  - Increase OR productivity by reducing staffing, even if have under-utilized OR time each day
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- Focus not just on setup and cleanup times, but also the frustrating prolonged turnovers



# Reducing Turnover Times *Can* Increase Number of Cases

- How does turnover time reduction achieve this?
  - Increase from median of 3 to median of 4 general surgery cases per day per OR
  - Increase from mean of 1.78 to mean of 2.34 general surgery cases per day per OR
  - Increase from mean of 2.6 to mean of 3.4 orthopedic surgery cases per day per OR

Sandberg WS et al. Anesthesiology 2005

Cendán JC, Good M. Arch Surg 2006

Smith MP et al. Anesthesiology 2008



# Irrational: Reduce Turnover Times to Reduce Cancellations

- Reducing non-surgical times of preceding cases can prevent last case of day from being canceled out of concern that it may finish in over-utilized OR time, increasing OR costs
- One fallacy to the argument is that cancelling a case to perform it another day increases overall costs whether analyzed from societal, hospital, physician, or patient perspective

Tessler MJ et al. Can J Anaesth 1997

Stepaniak PS et al. Anesth Analg 2009



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Tessler MJ et al. Can J Anaesth 1997

Stepaniak PS et al. Anesth Analg 2009



# Irrational: Reduce Turnover Times to Reduce Cancellations

- Studied elective cases cancelled after 7:00 AM of the working day before surgery
  - Elective considered those not American Society of Anesthesiologists' Physical Status E or scheduled within 5 hours of start of surgery
- For 90%, the patient underwent the procedure or a similar procedure at the hospital within 2 years

Epstein RH, Dexter F. Anesth Analg 2013



# **Irrational: Reduce Turnover Times to Reduce Cancellations**

- Studied cancellations on the day of surgery at freestanding ambulatory surgical center
- For 87%, the patient underwent the procedure at the surgical center or the organization's hospital within 2 years

# Irrational: Reduce Turnover Times to Reduce Cancellations

- Another fallacy of argument is that, except for very short cases, mean turnover times are less than mean squared difference between estimated and actual case durations
  - Achievable turnover time reductions practically only permit another case to be scheduled if willing to often ( $> 20\%$ ) cancel and keep patient on ward another day waiting for OR

Dexter F et al. Anesth Analg 1995, 2003



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*More in case #12*

Dexter F et al. Anesth Analg 1995, 2003



# Monitor $\Delta$ Cancellation Rates – Expect General Surgery High

Service	Cancellation Rate	95% Confidence Interval			Full Name of Service
Gyn	12.9%	7.5%	to	19.4%	Gynecology Group
Urol	13.2%	11.2%	to	15.3%	Urology
OralS	14.1%	7.9%	to	21.7%	Oral Surgery
Nsurg	14.6%	9.5%	to	20.6%	University Neurosurgeons
Ortho	15.2%	11.3%	to	19.6%	Orthopedics
ENT	16.1%	13.3%	to	19.1%	Otolaryngology
Gen	16.5%	11.8%	to	21.9%	General Surgery
Thor	22.0%	18.3%	to	26.0%	Thoracic Surgery
Wolf	24.0%	14.5%	to	35.0%	Elizabeth Wolf, MD
Vascu	20.4%				Vascular
Waters	35.4%				Rachel Waters, MD

Dexter F et al. Anesth Analg 2005

Schuster M et al. Anesth Analg 2011

# Monitor $\Delta$ Cancellation Rates – Apply Valid Statistical Methods



DEPARTMENT OF ANESTHESIA

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# Monitor $\Delta$ Cancellation Rates – Apply Valid Statistical Methods



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# Irrational: Reduce Turnover Times to Permit Another Case

- Staffing is planned from 7 AM to 5 PM
- Laparoscopic surgeon does 4 cases per day, finishing between 4 PM and 4:30 PM
- Turnover times 40 min, because of ...
  - Cleaning up OR in haphazard manner
  - Setting up poorly organized instruments
  - Wheeling and setting up incompatible video
- “If reduce turnover times, we would not reduce staffing to 8 hr, but do 5<sup>th</sup> case a day to increase revenue.”



# Irrational: Reduce Turnover Times to Permit Another Case

- Argument
  - “If reduce turnover times, we would ~~not reduce staffing to 8 hr, but~~ do 5<sup>th</sup> case a day to increase revenue.”



# Irrational: Reduce Turnover Times to Permit Another Case

- Variable costs
  - Change relative to volume of activity
  - Examples of variable costs
    - Patient-care employees' time
      - Maybe: discussed later
    - Implants
    - Disposable supplies
    - Medications



# Irrational: Reduce Turnover Times to Permit Another Case

- Fixed costs
  - Do not change relative to volume of activity
  - Examples of fixed costs
    - Maintenance of building and grounds
    - Billing office and information systems
    - OR equipment and instruments
  - Since fixed costs are fixed, irrelevant to decisions regarding reducing turnover times



# Irrational: Reduce Turnover Times to Permit Another Case

- Profit =  
revenue – variable costs – fixed costs
- Contribution margin =  
revenue – variable costs
- If contribution margin is positive, case contributes to covering a facility's fixed costs
- Financial goal of tactical decision-making is not to increase revenue, but to increase contribution margin



# Irrational: Reduce Turnover Times to Permit Another Case

- 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

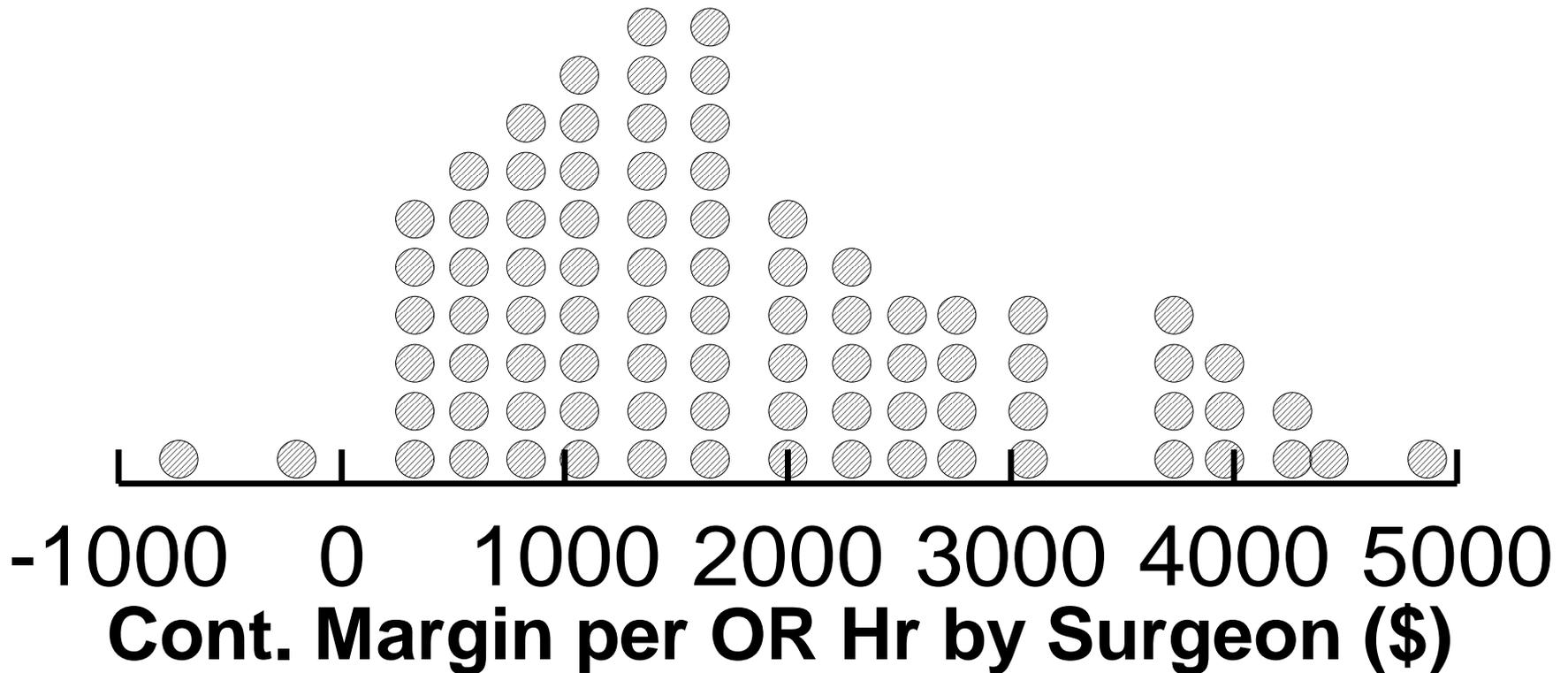


# Irrational: Reduce Turnover Times to Permit Another Case

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

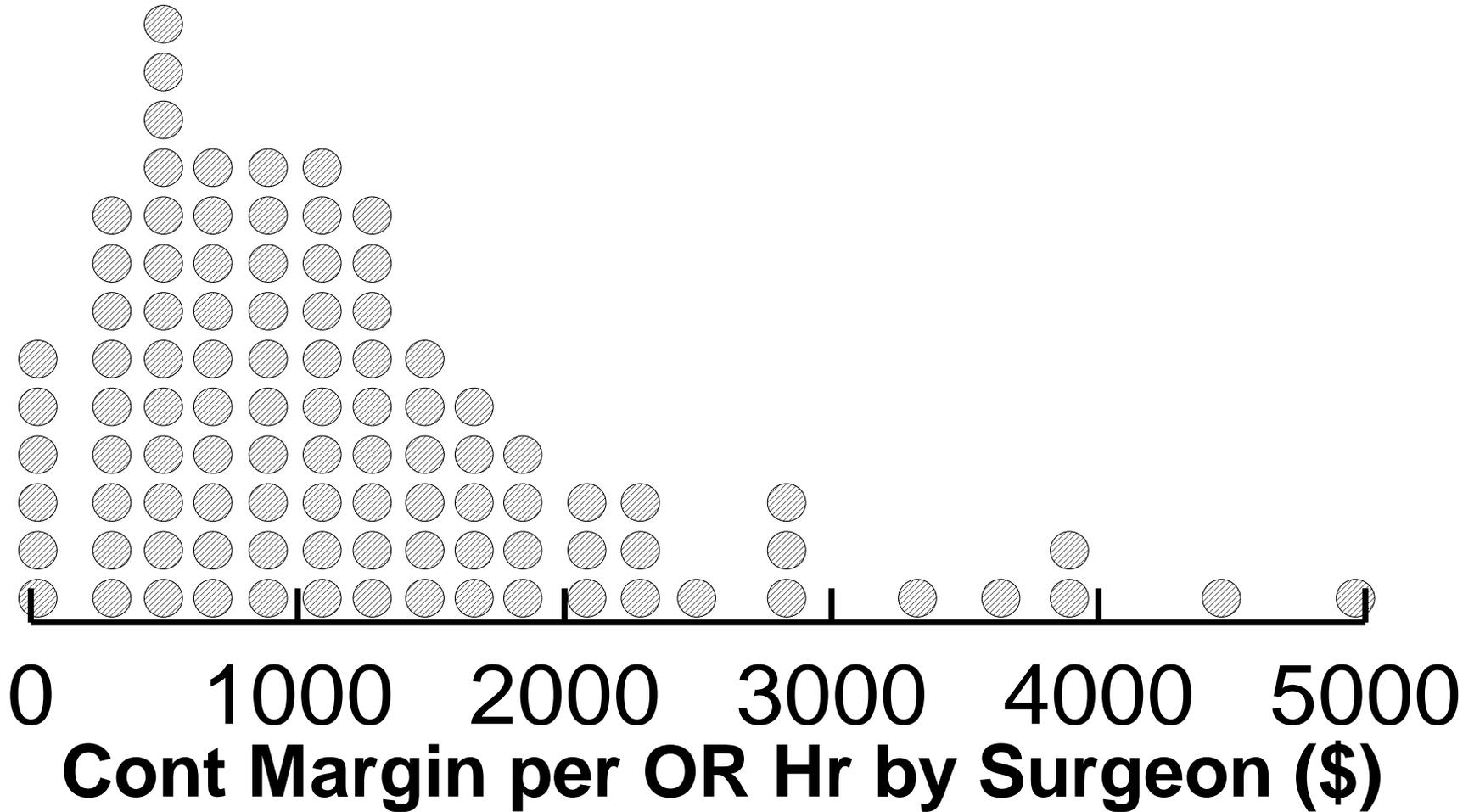


# Hospital Losing Money Has + Cont. Margin For 97% Surgeons



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

# Other Hospital Positive Contribution Margin all Surgeons



# Irrational: Reduce Turnover Times to Permit Another Case

- Summary of contribution margins (FY04 US\$)
  - \$1,864 per OR hour, 97% surgeons > \$0
    - Macario A et al. Anesth Analg 2001
  - \$1,773 per OR hour, 99% surgeons > \$0
    - Dexter F et al. Anesth Analg 2005
  - \$1,530 per OR hour, 100% surgeons > \$0
    - Dexter F et al. Anesth Analg 2002



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- Summary of contribution margins (FY04 US\$)
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    - Dexter F et al. Anesth Analg 2005
  - \$1,530 per OR hour, 100% surgeons > \$0
    - Dexter F et al. Anesth Analg 2002
- Irrational financially not to encourage nurses and anesthesia providers to get cases done regardless of whether reduce turnover time



# Irrational: Reduce Turnover Times to Permit Another Case

- Staffing is planned from 7 AM to 5 PM
- **Laparoscopic surgeon** does 4 cases per day, finishing between 4 PM and 4:30 PM
- Turnover times 40 min, because of ...
  - Cleaning up OR in haphazard manner
  - Setting up poorly organized instruments
  - Wheeling and setting up incompatible video
- “If reduce turnover times, we won’t reduce staffing to 8 hr, but **do 5<sup>th</sup> case a day**”



# Irrational: Reduce Turnover Times to Permit Another Case

- Laparoscopic surgery (e.g., cholecystectomy) consistently achieves a contribution margin around \$1,800 per OR hour
- Even if paid nurses \$300 per hour, revenue far exceeds costs for the case



# Irrational: Reduce Turnover Times to Permit Another Case

- Laparoscopic surgery (e.g., cholecystectomy) consistently achieves a contribution margin around \$1,800 per OR hour
- Even if paid nurses \$300 per hour, revenue far exceeds costs for the case
- Rational manager has case done regardless of whether turnover time is reduced



# Irrational: Reduce Turnover Times to Permit Another Case

- Variable costs
  - Change relative to volume of activity
  - Examples of variable costs
    - Patient-care employees' time
      - Maybe: *discussed later*
      - Conclusion even stronger if were to consider employees' time to be a fixed cost, because then contribution margin is even larger



# Reducing Turnover Times *Can* Increase Number of Cases

- When turnover times are reduced, some surgeons schedule additional cases that could otherwise have been scheduled, but which *the surgeon* otherwise chose not to schedule

Sandberg WS et al. Anesthesiology 2005

Dexter F. Anesthesiology 2005

Cendán JC, Good M. Arch Surg 2006

Smith MP et al. Anesthesiology 2008



# Reducing Turnover Times *Can* Increase Number of Cases

- When turnover times are reduced, some surgeons schedule additional cases that could otherwise have been scheduled, but which *the surgeon* otherwise chose not to schedule
- Reducing turnover times can rationally increase cases and revenue



# Reducing Turnover Times *Can* Increase Number of Cases

- When turnover times are reduced, some surgeons schedule additional cases that could otherwise have been scheduled, but which *the surgeon* otherwise chose not to schedule
- Reducing turnover times can rationally increase cases and revenue *indirectly*



# Reducing Turnover Times *Can* Increase Number of Cases

- When turnover times are reduced, some surgeons schedule additional cases that could otherwise have been scheduled, but which *the surgeon* otherwise chose not to schedule
- Reducing turnover times can rationally increase cases and revenue *indirectly*
  - Small reductions in turnover time are sufficient to increase surgeons' feelings of personal competence and achievement

Stahl JE et al. Surgery 2005



# Reducing Turnover Times *Can* Increase Number of Cases

- How does turnover time reduction achieve this?
  - Increase from median of 3 to median of 4 general surgery cases per day per OR
  - Increase from mean of 1.78 to mean of 2.34 general surgery cases per day per OR
  - Increase from mean of 2.6 to mean of 3.4 orthopedic surgery cases per day per OR

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***Conclusion***



# Economics of Reducing Turnover Times

- Potential benefits of reducing turnover times
  - Increase OR efficiency on the day of surgery by reducing over-utilized OR time
  - Increase OR productivity by reducing staffing, even if have under-utilized OR time each day
  - Increase number of cases
- Focus not just on setup and cleanup times, but also the frustrating prolonged turnovers



# Reducing Turnover Times *Can* Increase Number of Cases

- Focus on these studies as tools to understand behavior, since reductions in turnover times cannot account for much growth in surgery
- Average hospital in Iowa had minority of annual growth in inpatient and outpatient cases amongst surgeons who performed  $N > 2$  cases per *week* in baseline year ( $23.0\% \pm 2.5\%$  [SE])
  - Little growth in outpatient surgery Relative Value Units amongst those surgeons ( $18.1\% \pm 2.2\%$ )

Dexter F et al. J Clin Anesth 2018

Epstein RH et al. J Clin Anesth 2022



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  - Little growth in outpatient surgery Relative Value Units amongst those surgeons ( $18.1\% \pm 2.2\%$ )

Dexter F et al. J Clin Anesth 2018

[Epstein RH et al. J Clin Anesth 2022](#)



# Value of Benchmarking Facilities' Average Turnover

- Benchmarking report of typical turnovers
  - Turnovers longer than 90 min are excluded
    - “Average” assesses setup and cleanup times
- Average turnover times can be reduced
  - For avg. turnovers < 40 min, reductions  $\cong$  7 min
  - For avg. 57 to 65 min, reductions  $\cong$  15 min

Adams R et al. J Nurs Adm 2004

Cendán JC, Good M. Arch Surg 2006

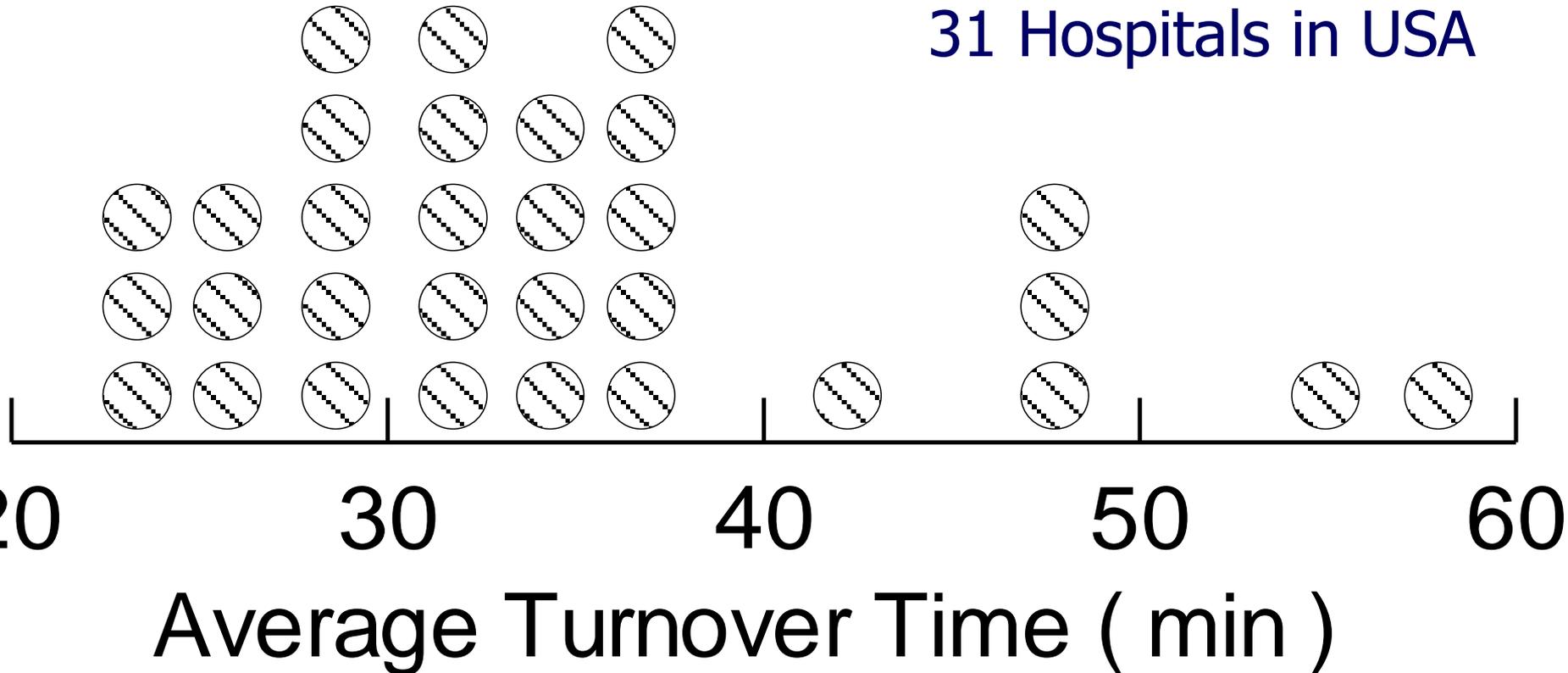
Overdyk FJ et al. Anesth Analg 1998

Sokolovic E et al. Eur J Anaesth 2002



# Value of Benchmarking Facilities' Average Turnover

31 Hospitals in USA



# Value of Benchmarking Facilities' Average Turnover

- Both anesthesiologists & surgeons poor expert judges of their personal (actual) turnover times
- Responses essentially indistinguishable between subjects with many versus very few turnovers
  - Number of complaints (comments)
  - Estimate of personal average turnover time
  - Estimates of incidence of prolonged turnovers

Masursky D et al. Anesth Analg 2011



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  - Estimates of incidence of prolonged turnovers
- Responses influenced by perception of team activity and how contributes to turnover times



# Value of Benchmarking Facilities' Average Turnover

- Example of surgeon “estimate of the percentage of all your turnovers, wheels out to wheels in, which were longer than 45 minutes” in 2009
  - Those with very few turnovers and with many turnovers had same mean response, 54%
    - Actual mean 25%

Masursky D et al. Anesth Analg 2011



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Masursky D et al. Anesth Analg 2011



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  - Those with “very few” turnovers had mean of just 15 turnovers for the entire year
- Not only do the surgeons overestimate turnovers, perception is not literally about turnovers



# Monitor Incidence of Prolonged Turnovers Times by Time of Day

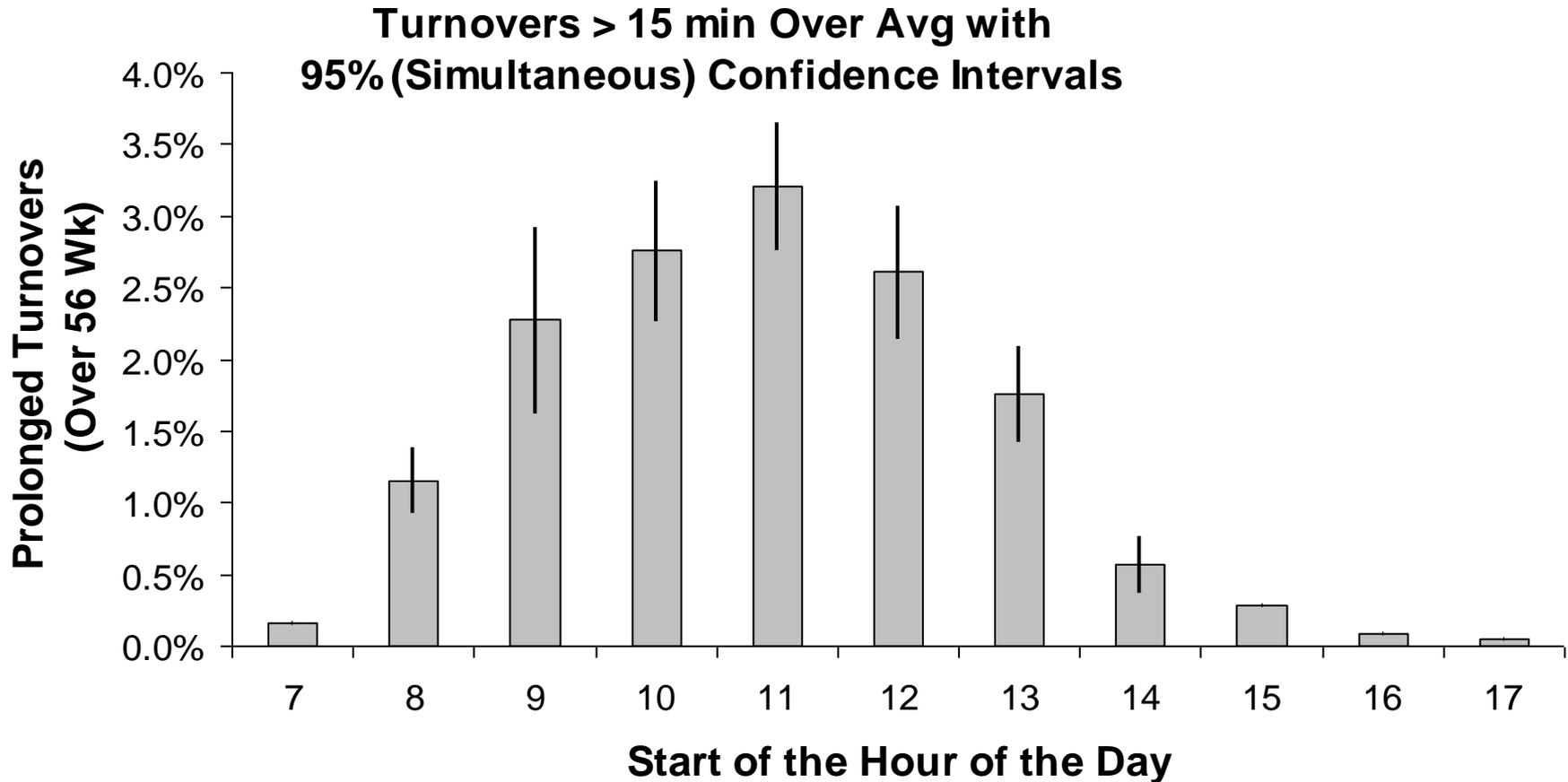
- Turnover “prolonged” if time from one elective case ends until another starts in the same OR is  $> 15$  min longer than the average turnover
  - “Average” includes just setup & cleanup times

Dexter F et al. Anesthesiology 2005

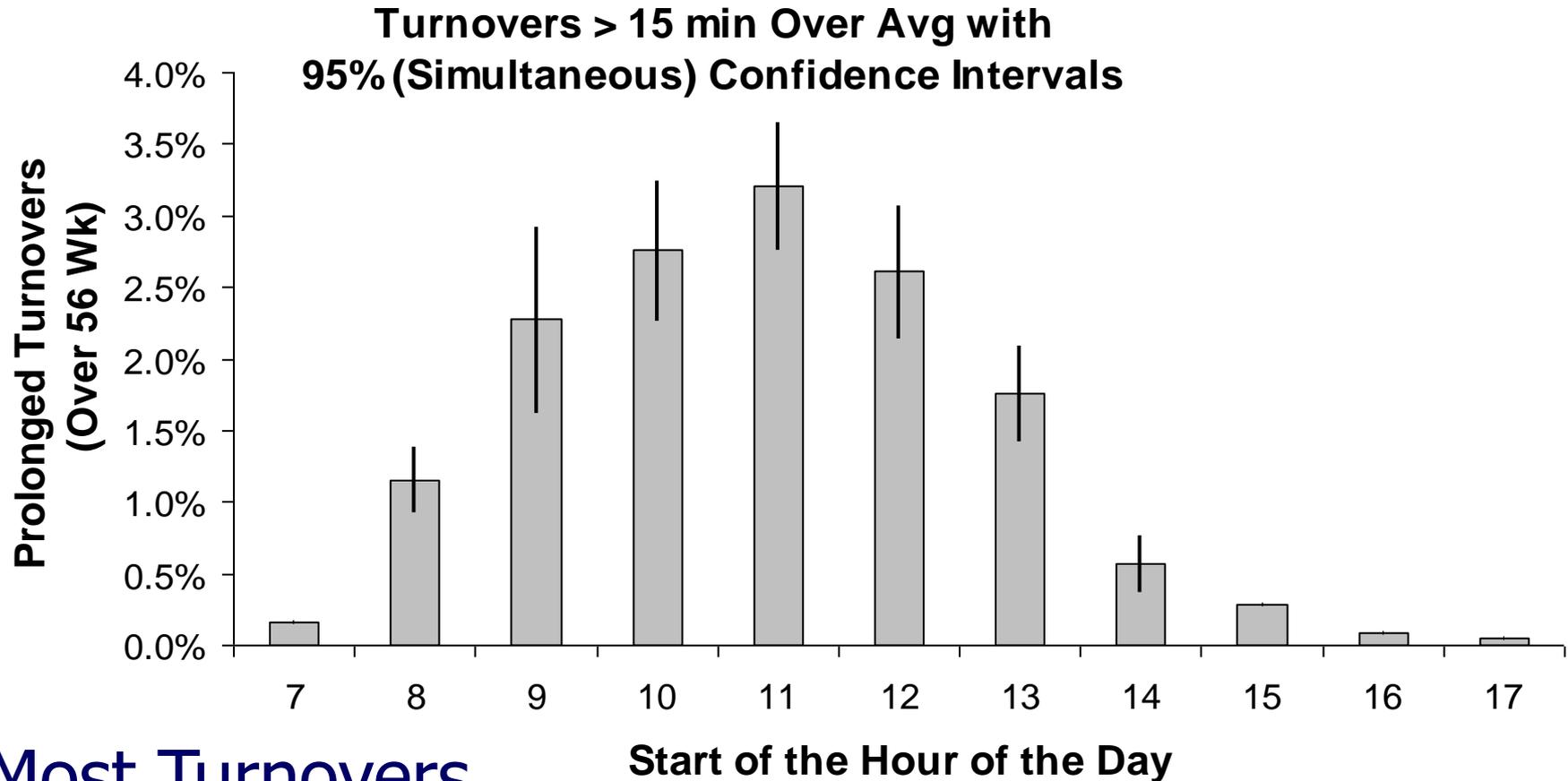
Masursky D et al. Anesth Analg 2010



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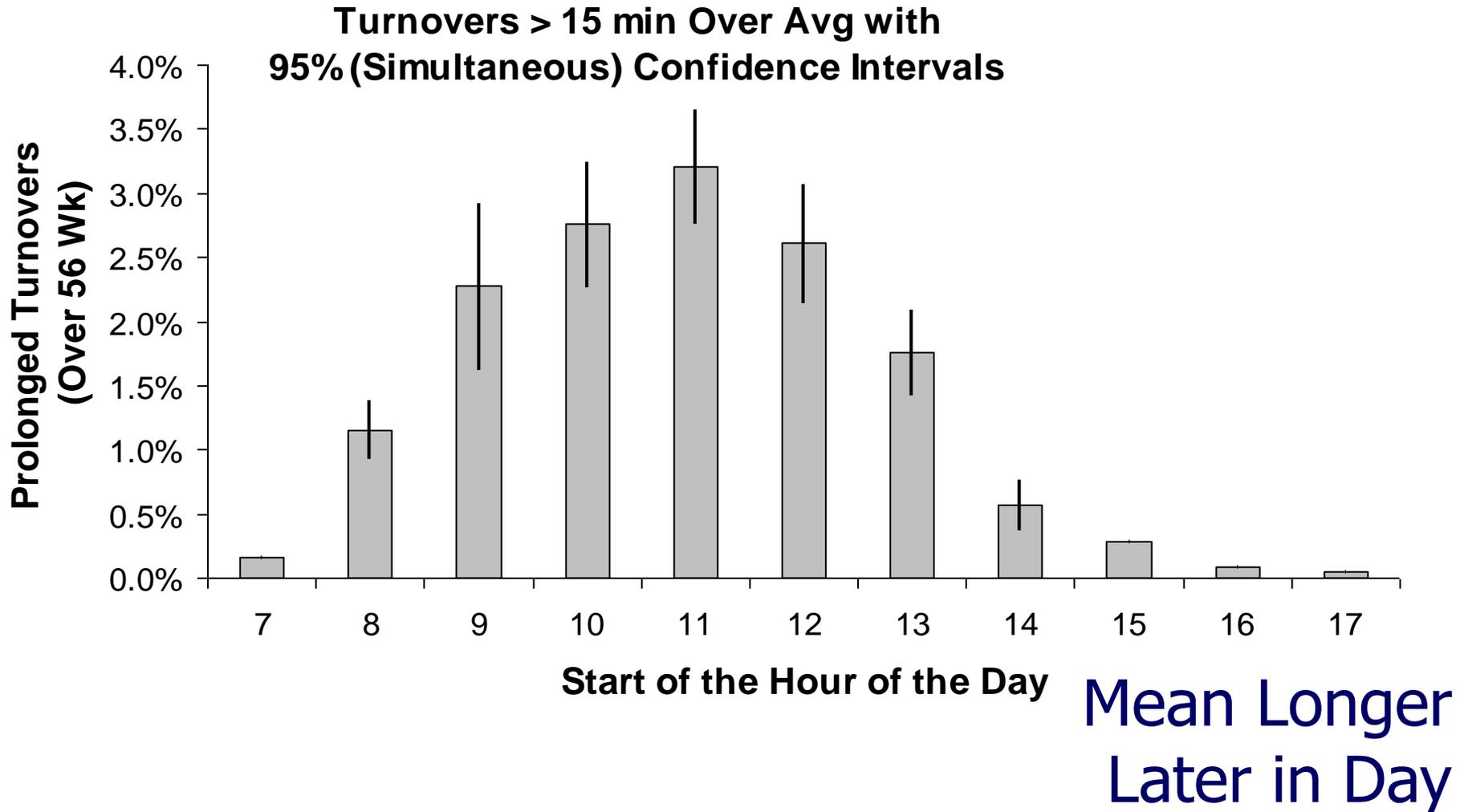


# Monitor Incidence of Prolonged Turnovers Times by Time of Day



Most Turnovers  
Early in Day

# Monitor Incidence of Prolonged Turnovers Times by Time of Day



# Monitor Incidence of Prolonged Turnovers Times by Time of Day

- Balance of incidence (earlier in day) and magnitude (later in day) is for most prolonged turnovers to occur in the middle of the day



# Monitor Incidence of Prolonged Turnovers Times by Time of Day

- Balance of incidence (earlier in day) and magnitude (later in day) is for most prolonged turnovers to occur in the middle of the day
- Most anesthesiologists and surgeons surveyed thought that the time of the day with his or her largest number of prolonged turnovers was at least 2 hr later than actual ( $P < 0.001$ )

Masursky D et al. Anesth Analg 2011



# Perceptions Related to Team Activity

- Balance of incidence (earlier in day) and magnitude (later in day) is for most prolonged turnovers to occur in the middle of the day
- Most anesthesiologists and surgeons surveyed thought that the time of the day with his or her largest number of prolonged turnovers was at least 2 hr later than actual ( $P < 0.001$ )
  - Bias due to mental model of cause as being related to team activity (e.g., shift change)



# Perceptions Related to Team Activity

- Observation in OR, counting annoying or angry tone, specifically “tense communication”
- Triggers of tensions involved teamwork and coordination for 88% of events
- Initiation of tension, 97% surgeons

Keller S et al PLoS ONE 2019



# Reducing Incidence of Prolonged Turnovers Times

- Interventions to reduce prolonged turnovers
  - $\Delta$  schedules of staff (e.g., housekeepers) to focus on those times of day
  - Add 1 or occasionally more turnover teams
  - $\downarrow$  scheduled delays between cases (“holes”)
  - Coordinate using decision-support systems
  - Have sufficient equipment on site to do all cases of the day without reprocessing
  - Enhance equipment standardization



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# Lunch Breaks

- Most prolonged turnovers occur middle of day

Dexter F et al. Anesthesiology 2005



# Lunch Breaks

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- After first cases of day, period of day with the largest numbers of anesthesia providers needed is also middle of day because of lunch breaks (at hospitals with ORs lasting >8 hours)

Epstein RH, Dexter F. Anesthesiology 2012



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Marjamaa RA et al. Health Care Manag Sci 2009

Smallman B et al. Anesth Analg 2013



# Lunch Breaks

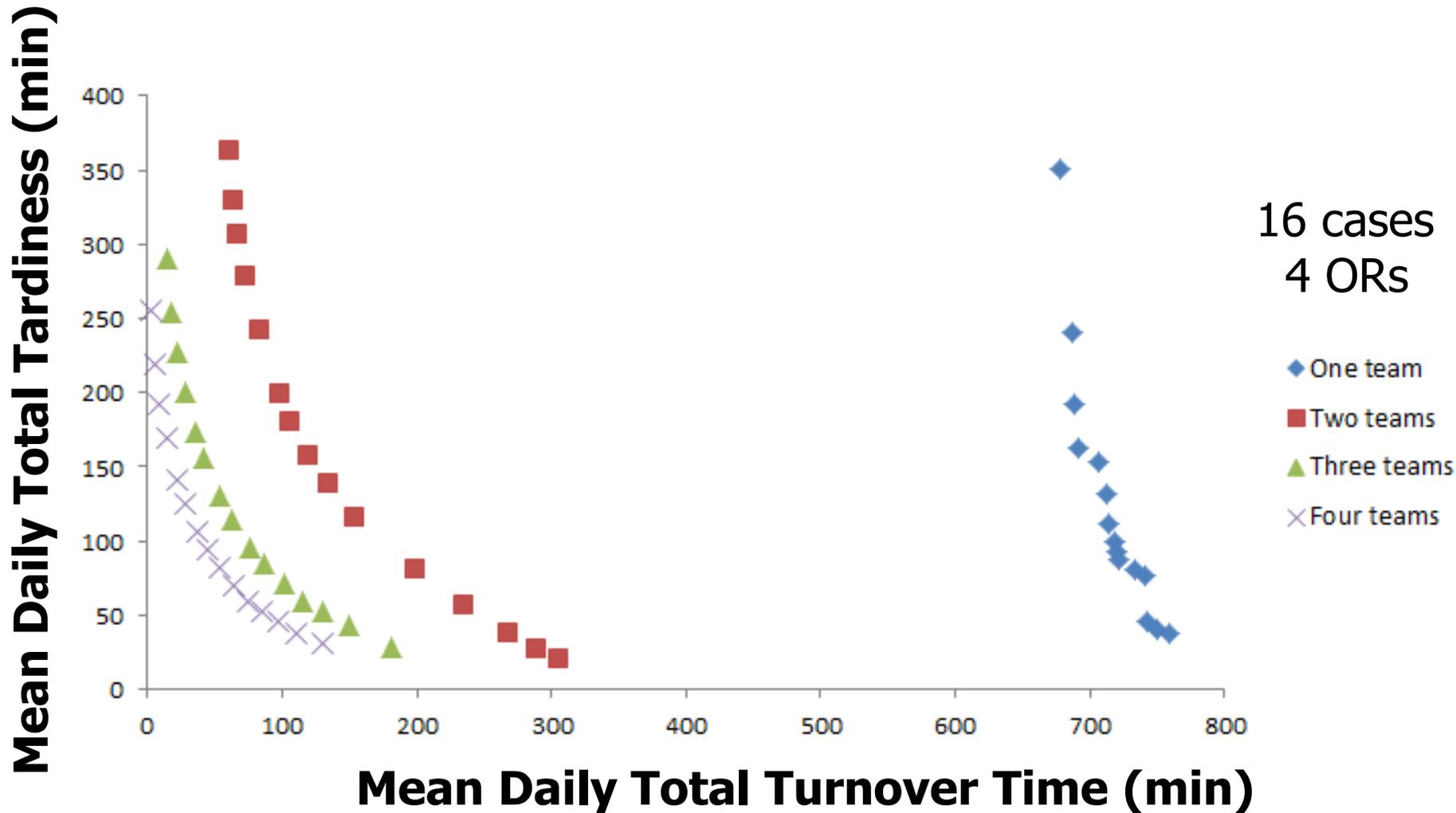
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- Use displays with evidence-based dynamic assignment of providers to ORs for breaks

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# Number of Teams Affects Turnover Times and Tardiness



# Simultaneous Turnovers to Decide If Add Turnover Team

- 5 OR facility has 2 turnover teams
- Turnover times longer when  $>2$  cases were finishing close to simultaneously
  - 50<sup>th</sup> percentile 40 minutes
  - 90<sup>th</sup> percentile 55 minutes
  - Among turnover times 60 minutes or longer, 66% were when there were  $>2$  turnovers

Wang J et al. Anesth Analg 2013



# Simultaneous Turnovers to Decide If Add Turnover Team

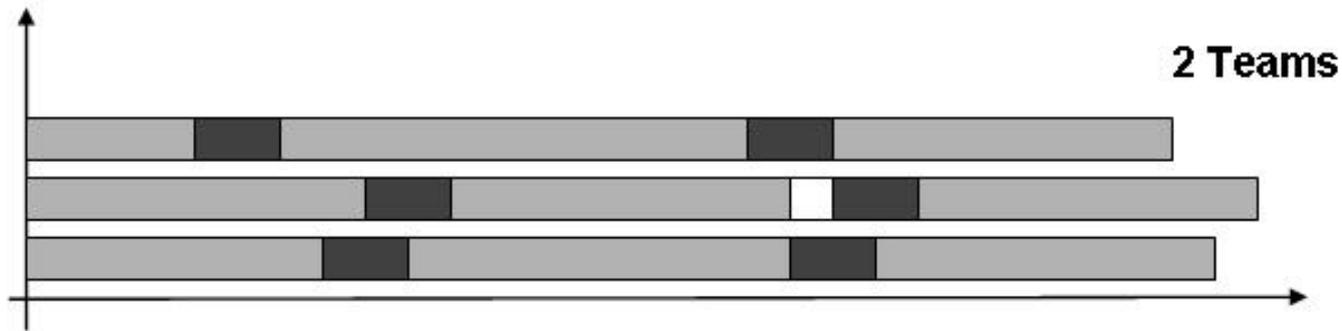
- Analyze minutes of time with simultaneous turnovers exceeding a threshold number of teams

Dexter F et al. Anesth Analg 2009

Wang J et al. Anesth Analg 2013

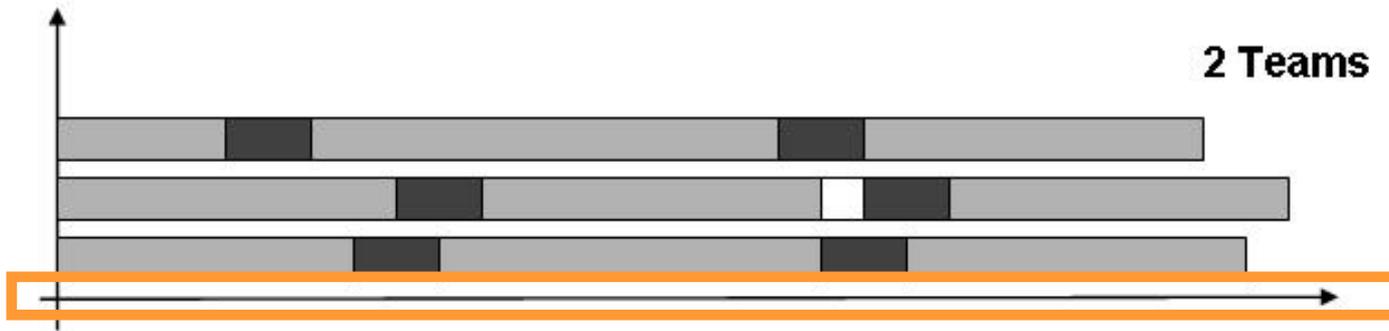


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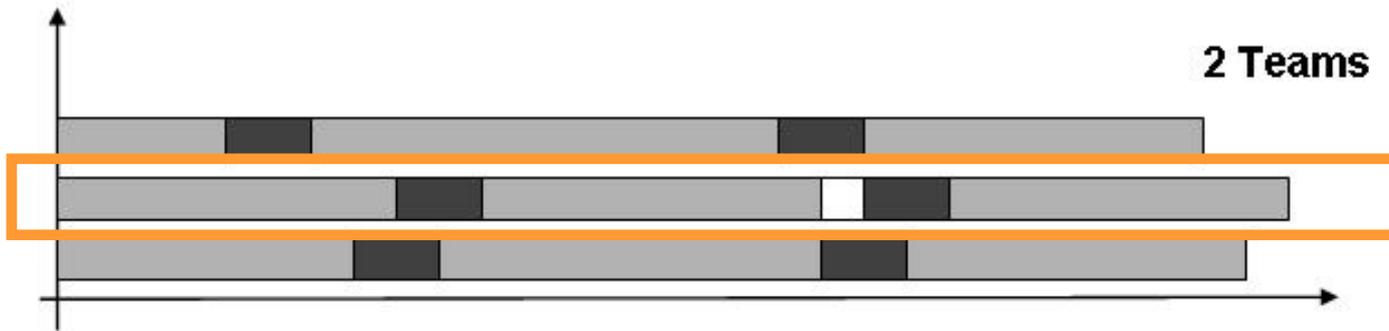
- Time is plotted along the horizontal axis
- Each row represents an OR
- Long light gray bars represent patients in ORs
- Dark gray bars represent cleanup and setup times
- White bar represents 10 min delay in starting cleanup waiting for turnover team from other OR

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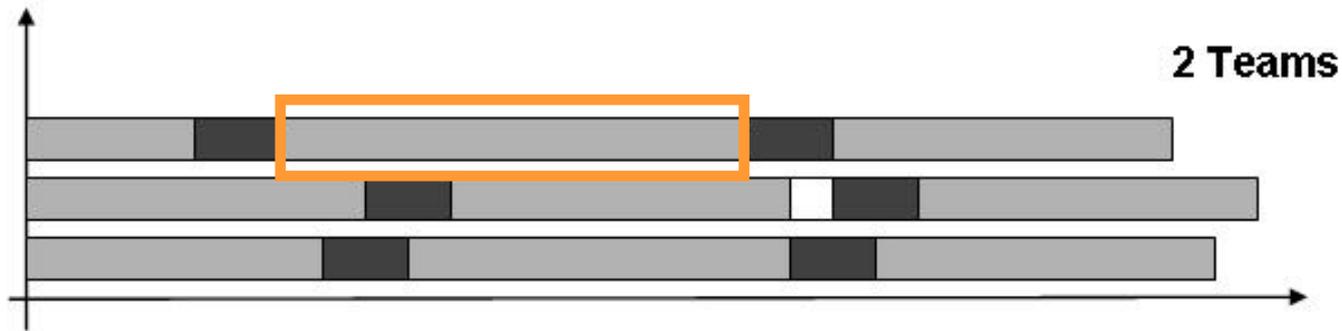
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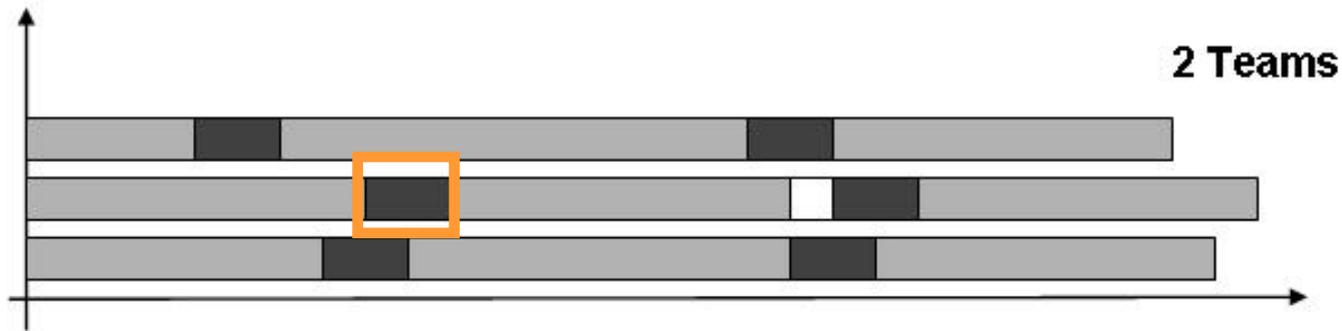
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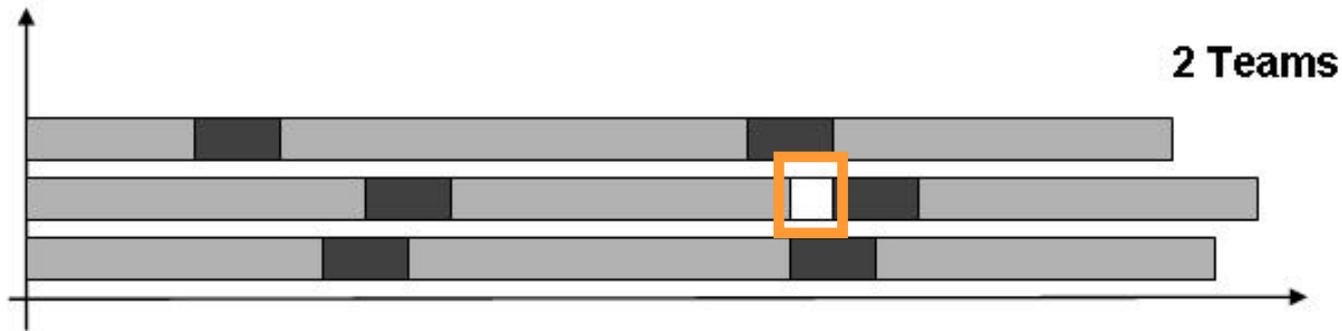
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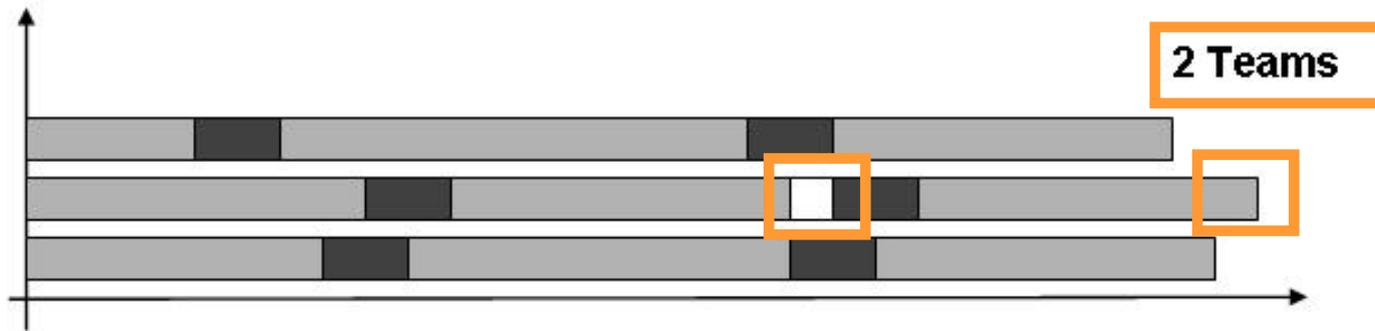
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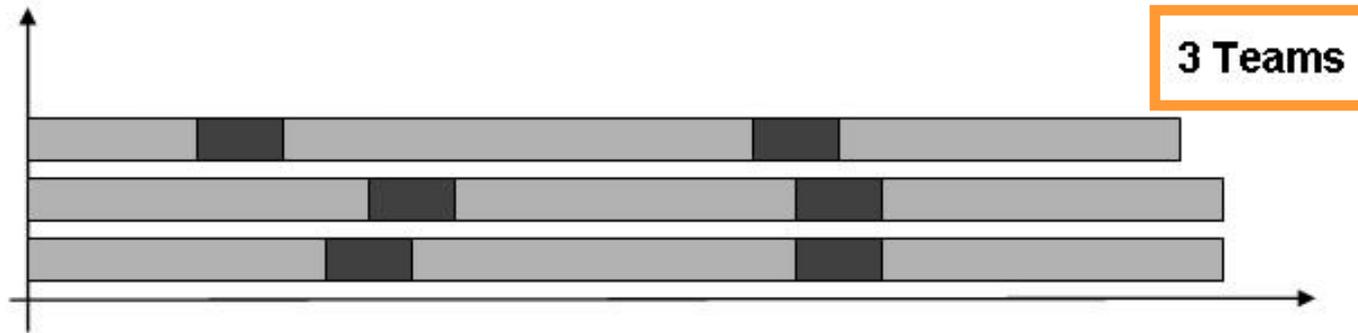
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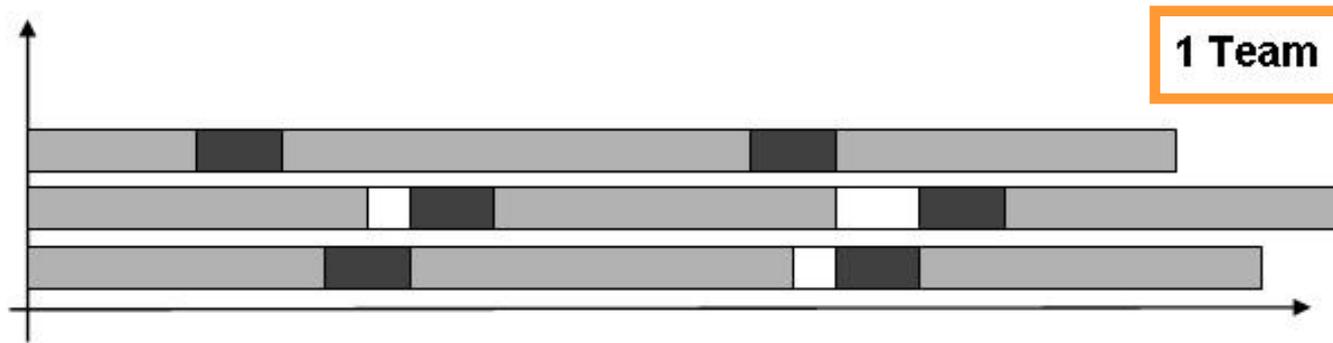
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# Simultaneous Turnovers to Decide If Add Turnover Team



- Adding 1 team reduces the minutes of simultaneous turnovers exceeding the threshold of the number of teams from 10 min to 0 min
- Adding the 1 team also reduces the total surgeon experienced turnover time by 10 min

# Simultaneous Turnovers to Decide If Add Turnover Team



- Removing 1 team increases the minutes of simultaneous turnovers exceeding the threshold of the number of teams from 10 min to 40 min
- Removing 1 team also increases the total surgeon experienced turnover time by 30 min

# Mean ↓ Min of Turnovers per Day From Each 1 Increase in # of Teams

- 24 min = (5% of 8 hr) × (60 min per hr)
  - Threshold of 24 min per day is reasonable threshold if hiring for an 8 hr workday
- 12 min = (5% of 4 hr) × (60 min per hr)
  - Threshold of 12 min per day is reasonable threshold if can hire for an extra 4 hr per day

Dexter F, Traub RD. Anesthesiology 2000

Wachtel RE, Dexter F. Anesth Analg 2007



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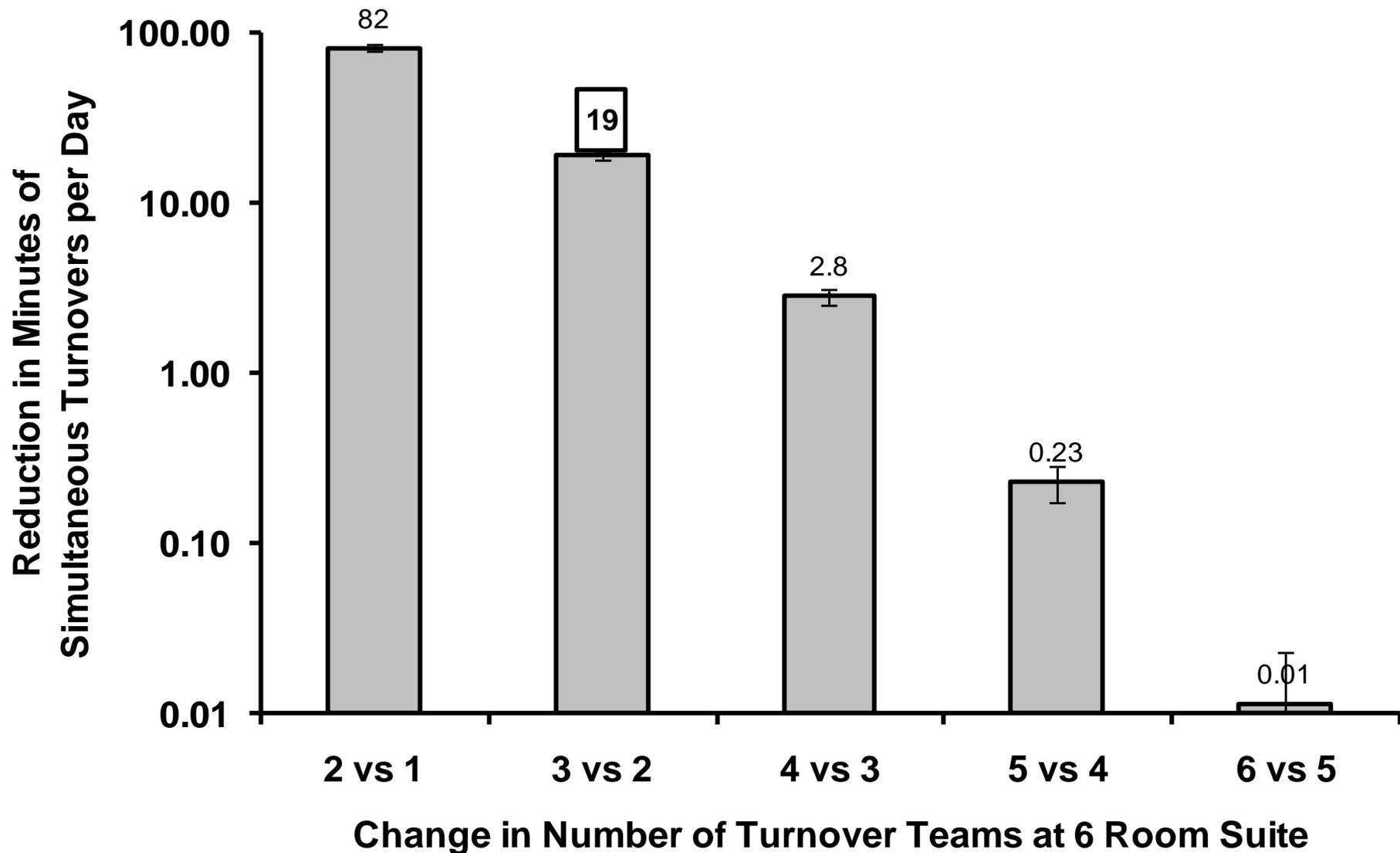
- $P < 0.05$  is common balance in medicine
- 5% is median annual compensation in US of housekeeper divided by that for (one patient + anesthesiologist + general surgeon + two nurses + FTE housekeeper)
- 5% is measured actual % of occurrences ORs waiting for patients at hospital without policy

Dexter F, Traub RD. Anesthesiology 2000

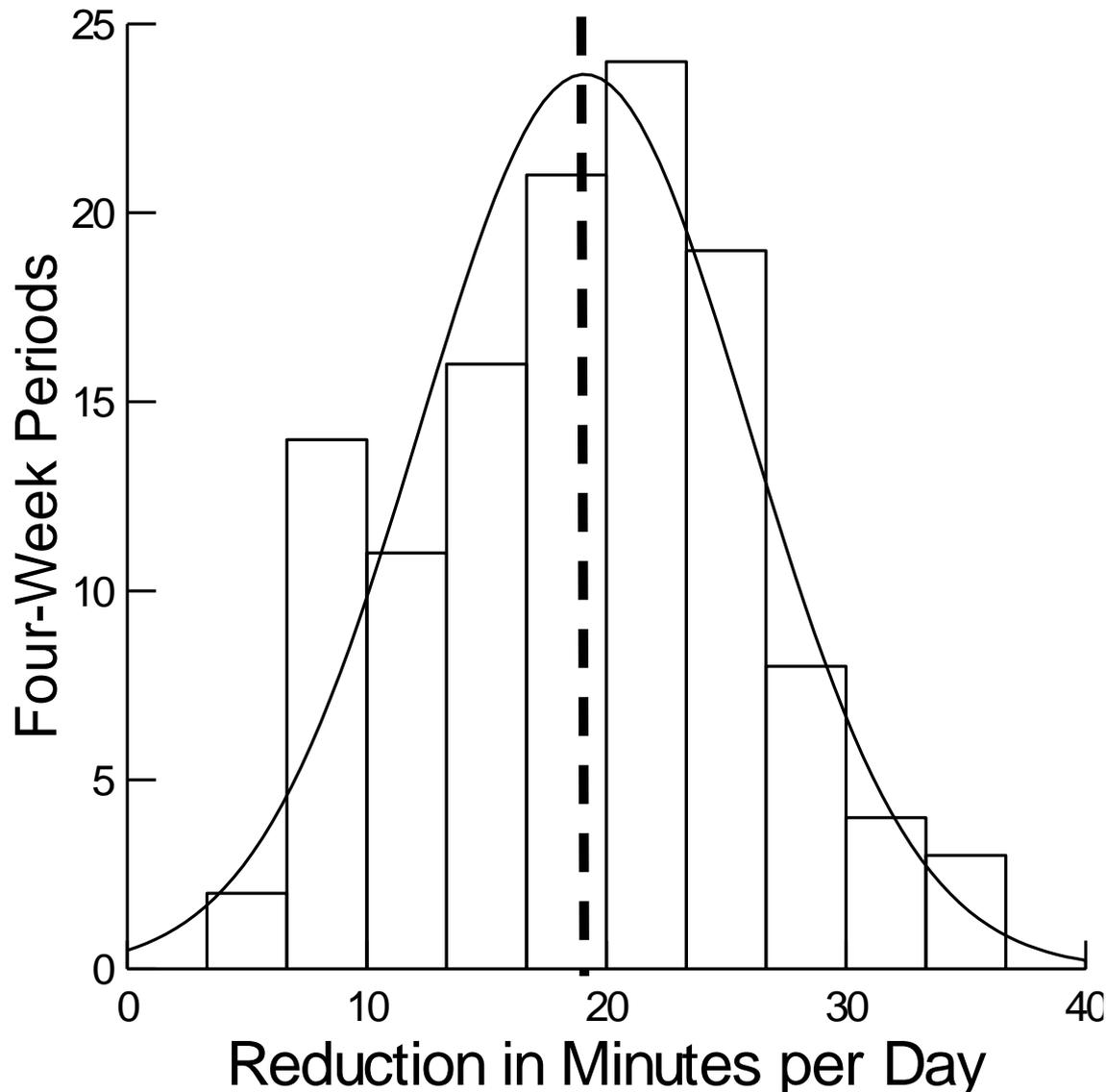
Wachtel RE, Dexter F. Anesth Analg 2007



# Mean ↓ Min of Turnovers per Day From Each 1 Increase in # of Teams



# Confidence Intervals Based on Normal Distribution



- Use 13 four-week periods of results to calculate lower 95% confidence limit for savings with Student's  $t$  distribution

# Reducing Incidence of Prolonged Turnovers Times

- Interventions to reduce prolonged turnovers
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***Conclusion***



# Review – Summarize the Facts of the Talk



# Prioritize Goals in Reducing Turnover and Anesthesia Times



# Prioritize Goals in Reducing Turnover and Anesthesia Times

1. Increase OR efficiency on the day of surgery by reducing over-utilized OR time
2. Increase OR productivity by reducing staffing, even if have under-utilized OR time each day
3. Increase number of cases
4. Reduce frustrating prolonged turnovers
5. Add turnover team(s)



# Additional Information on Operating Room Management

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