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
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
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)

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?
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 ($\$) \approx (\text{Cost per hour of under-utilized OR time}) \times (\text{hours of under-utilized OR time}) + (\text{Cost per hour of over-utilized OR time}) \times (\text{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

Inefficiency of use of OR time ($) \approx (\text{Cost per hour of over-utilized OR time}) \times (\text{hours of over-utilized OR time})
Meaning of Maximizing OR Efficiency on Day of Surgery

Inefficiency of use of OR time ($) \approx \frac{(\text{Cost per hour of over-utilized OR time}) \times (\text{hours of over-utilized OR time})}{\text{Constant}}
Meaning of Maximizing OR Efficiency on Day of Surgery

Inefficiency of use of OR time ($) \approx \text{(Cost per hour of over-utilized OR time)} \times \text{(hours of over-utilized OR time)}$

**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 ($\approx$)

$(\text{Cost per hour of over-utilized OR time}) \times (\text{hours of over-utilized OR time})$

- 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
• 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?

- Scenario
  - Allocated time is from 8 AM to 3:30 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 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

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- 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
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- 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 over-utilized hours
- **Patient waiting** is unaffected by the decision
  - Last case of the day in both ORs
- **Personal satisfaction** may be affected
  - Whichever anesthesiologist thinks best
Scenario 2 – Anesthesiologist Reduces Turnover Times

• Moral
  – To make good (rational) OR management operational decisions, you need to know the allocated hours for each OR
  • Calculated based on minimizing the inefficiency of use of OR time
Scenario 2 – Anesthesiologist Reduces Turnover Times

- Moral
  - To make good (rational) OR management operational decisions, you need to know the allocated hours for each OR
  - Calculated based on minimizing the inefficiency of use of OR time
  - Will discuss later in the talk
Scenario 3 – Moving Cases

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

- The case will be performed safely regardless of the decision, thus not influencing decision

- **OR efficiency** is affected by the decision
  - Case performed entirely in over-utilized OR time if case is not moved
  - Over-utilized OR time likely reduced by at least 1.5 hr if case is moved
  - Move the case into the add-on case room
    - Even though not an add-on case, doing so achieves organizational priorities
Scenario 4 – When Scheduled Hours Exceed Allocated Time

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

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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• **OR efficiency**
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➢ “Allocated” ≠ maximum ORs at same time
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Bin Packing Surgical Cases

Dexter F et al. Anesthesiology 1999
Dexter F, Traub RD. Anesth Analg 2002
Dexter F et al. Anesthesiology 2004
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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Reason for Add-on Surgical Case Scheduling Result

- Sort the cases based on estimated duration from longest to shortest
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- 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
Reason for Add-on Surgical Case Scheduling Result

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

Dexter F et al. Anesthesiology 1999
Reason for Add-on Surgical Case Scheduling Result

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

➢ Because 0 or 1 add-on cases per OR not designated for add-on cases.
Bin Packing Surgical Cases

• Sort the cases based on estimated duration from longest to shortest
  – Consider the cases in this descending order
  – Longest add-on case is assigned first

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• Assign each case to OR meeting two criteria
  – Has no restrictions on equipment or personnel preventing the case from being put into the OR
  – Sufficient extra time available for the new case

➢ Reduces the hours of over-utilized OR time!
Scenario 5 – Applying Bin Packing Principles

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

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

Epstein RH, Dexter F. Anesth Analg 2015
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
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  ➢ 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

Stepaniak PS et al. Anesth Analg 2009
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)

• 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, a 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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- Decision-making to reduce over-utilized time
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- Allocating OR time based on maximizing the efficiency of use of OR time
- Behavior before and on day of surgery without evidence-based displays
Calculating Allocated OR Time

• On Mondays, hospital currently plans 3 ORs for orthopedics, each OR for 10 hr
  • $3 \text{ ORs} \times 10 \text{ hr} = 30 \text{ hr}$

• On Mondays, total hours of orthopedic cases including turnovers follows a normal distribution with a mean of 30 hr

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

McIntosh C et al. Anesth Analg 2006
Pandit JJ, Dexter F. Anesth Analg 2009
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

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- 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
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 staffing plan maximizes efficiency of use of OR time?

1) 3 ORs: 2 × 8 hr, 1 × 10 hr
2) 3 ORs: 1 × 8 hr, 2 × 10 hr
3) 3 ORs: 0 × 8 hr, 3 × 10 hr
4) 4 ORs: 4 × 8 hr, 0 × 10 hr
5) 4 ORs: 3 × 8 hr, 1 × 10 hr
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Calculating Allocated OR Time

• Consider standard deviation of orthopedics’ workload on Mondays = 10 hr, a large value
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1) 3 ORs: 2 × 8 hr, 1 × 10 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
Allocated Times for Single ORs
From Pandit & Dexter 2009

Allocate 10 hr staffing

$\kappa = 1.50$

$\kappa = 2.00$

Allocate 8 hr staffing

Normal distribution
like just used
Allocated Times for Single ORs
From Pandit & Dexter 2009

Allocate 10 hr staffing

$k = 1.50$

$k = 2.00$

Allocate 8 hr staffing

Relative cost ratio of 2.0 like just used

Mean Time in Excess of 8 Hr (min)

Standard Deviation of Daily Workload (min)
Allocated Times for Single ORs
From Pandit & Dexter 2009

Allocate 10 hr staffing

Allocate 8 hr staffing

Mean 8 hr 40 min cases each Monday
Allocated Times for Single ORs
From Pandit & Dexter 2009

Allocate 10 hr staffing

Allocate 8 hr staffing

Standard deviation
50 min cases each Monday

\[\kappa = 1.50\]

\[\kappa = 2.00\]
Allocated Times for Single ORs
From Pandit & Dexter 2009

\[ \kappa = 1.50 \]
\[ \kappa = 2.00 \]

Allocate 10 hr staffing

Allocate 8 hr staffing

Mean Time in Excess of 8 Hr (min)

Standard Deviation of Daily Workload (min)

- Normal
- Weibull
Topics of Talk on Add-on Case Rooms

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• 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

Wachtel RE, Dexter F. J Grad Med Educ 2010
Topics of Talk on Add-on Case Rooms

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• Behavior before and on day of surgery without evidence-based displays
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?
• OR nurses, nurse anesthetists, and anesthesiologists are full-time employees
• Allocated time is from 8 AM to 6:00 PM
• There is estimated to be 8.5 hr of cases
• Turnover and extubation times are brief
• OR finishes at 3:30 PM, instead of 4:30 PM
• Has OR efficiency been increased?

➢ No
Question and Answer #2

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

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

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

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

- OR managers make decisions on scheduling add-on cases and moving cases among ORs using electronic displays.
- One group gets displays that include calculation of expected hours of over-utilized OR time in each OR and one group does not.
- Are the quality of the decisions made better with the calculated information provided?
Question and Answer #4

• OR managers make decisions on scheduling add-on cases and moving cases among ORs using electronic displays
• One group gets displays that include calculation of expected hours of over-utilized OR time in each OR and one group does not
• Are the quality of the decisions made better with the calculated information provided?
  ➢ No
Question and Answer #5

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

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

- [www.FranklinDexter.net](http://www.FranklinDexter.net)
  - Comprehensive bibliography of peer reviewed articles in operating room and anesthesia group management