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

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

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### **Financial Disclosure**

- I am employed by the University of Iowa, in part, to consult and analyze data for hospitals, anesthesia groups, and companies
- Department of Anesthesia bills for my time, and the income is used to fund our research
  - I receive no funds personally other than my salary and allowable expense reimbursements from the University of Iowa, and have tenure with no incentive program
  - I own no healthcare stocks (other than indirectly through mutual funds)

# Topics of Talk on Add-on Case Rooms

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



### Example of Under-Utilized OR Time

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

McIntosh C et al. Anesth Analg 2006 Dexter F, Epstein RH. Periop Care Oper Room Manag 2024

### Example of Over-Utilized OR Time

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



# Precise Meaning of "Maximize OR Efficiency"

Inefficiency of use of OR time (\$) =
 (Cost per hour of under-utilized OR time)
 × (hours of under-utilized OR time)
 + (Cost per hour of over-utilized OR time)
 × (hours of over-utilized OR time)

Strum DP et al. J Med Syst 1997



- 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



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

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

Dexter F, Traub RD. Anesth Analg 2002 Dexter F et al. Anesthesiology 2004



Inefficiency of use of OR time (\$) ≅
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Inefficiency of use of OR time (\$) ≅ (Cost per hour of over-utilized OR time) × (hours of over-utilized OR time)

# Implication

Constant

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



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

- 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

- 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 6 PM
- There is estimated to be 8.5 hr of cases
- Turnover and extubation times are brief
- OR finishes at 3:30 PM, instead of 4:30 PM
- Has OR efficiency been increased?



### Scenario

- 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

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

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

# Topics of Talk on Add-on Case Rooms

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- 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?



- 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



- 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
- 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?



 OR efficiency is unaffected by the decision - OR 1 expected 0 over-utilized hours - OR 2 expected + 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



### 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



### 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

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

Dexter F et al. Anesth Analg 2016



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



### • Patient safety

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



### • Patient safety

- With three ORs, a case could not reliably start by when the surgeon says it needs to start
- Access to OR time
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  - Never open 4<sup>th</sup> OR other than for safety reasons, because would first fully fill the 3 ORs, which has never happened

"Allocated" ≠ maximum ORs at same time

# Topics of Talk on Add-on Case Rooms

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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 Shi P et al. Anesth Analg 2016



### **Bin Packing Surgical Cases**

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

### **Bin Packing Surgical Cases**

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


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

Dexter F et al. Anesthesiology 1999



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- Average 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**

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- Assign each case to OR meeting two criteria
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  - Sufficient extra time available for the new case

Reduces the hours of over-utilized OR time!



## Scenario 5 – Applying Bin Packing Principles

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

## Scenario 5 – Applying Bin Packing Principles

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

Epstein RH, Dexter F. Anesth Analg 2015 Shi P et al. Anesth Analg 2016

## Scenario 5 – Applying Bin Packing Principles

• How use the add-on case OR if keep it empty?

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

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

Dexter F et al. Anesth Analg 2007 Stepaniak PS et al. Anesth Analg 2009 Wang J et al. Anesth Analg 2013



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

Dexter F et al. Anesth Analg 2007



- 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



- When monitoring managers' performance, good criterion is use by their facility of either:
   – Displays providing recommendations
  - 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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- On Mondays, hospital currently plans 3 ORs for orthopedics, each OR for 10 hr
  - 3 ORs × 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 × 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

- Consider standard deviation of orthopedics' workload on Mondays = 5 hr, a typical value
- Since workload follows a normal distribution, need inverse of normal distribution function
  - Ratio of 2.0:1.0 over-utilized: under-utilized
  - Excel "= NORMINV( 2/3, 30, 5)"
- The 66<sup>th</sup> percentile of the normal distribution function with mean 30 hr and standard deviation 5 hr equals *32 hr*



- 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:  $2 \times 8$  hr,  $1 \times 10$  hr
  - 2) 3 ORs:  $1 \times 8$  hr,  $2 \times 10$  hr
  - 3) 3 ORs:  $0 \times 8$  hr,  $3 \times 10$  hr
  - 4) 4 ORs: 4  $\times$  8 hr, 0  $\times$  10 hr
  - 5) 4 ORs:  $3 \times 8$  hr,  $1 \times 10$  hr
  - 6) 4 ORs:  $2 \times 8$  hr,  $2 \times 10$  hr

- 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  $\times$  8 hr, 1  $\times$  10 hr
  - 2) 3 ORs:  $1 \times 8$  hr,  $2 \times 10$  hr
  - 3) 3 ORs:  $0 \times 8$  hr,  $3 \times 10$  hr
  - 4) 4 ORs:  $4 \times 8$  hr,  $0 \times 10$  hr
  - 5) 4 ORs:  $3 \times 8$  hr,  $1 \times 10$  hr
  - 6) 4 ORs: 2  $\times$  8 hr, 2  $\times$  10 hr

- Consider standard deviation of orthopedics' workload on Mondays = 10 hr, a large value
- Since workload follows a normal distribution, need inverse of normal distribution function
  - Ratio of 2.0:1.0 over-utilized: under-utilized
  - Excel "= NORMINV( 2/3, 30, 10)"
- The 66<sup>th</sup> percentile of the normal distribution function with mean 30 hr and standard deviation *10* hr equals *34 hr*



- 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:  $2 \times 8$  hr,  $1 \times 10$  hr
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  - 3) 3 ORs:  $0 \times 8$  hr,  $3 \times 10$  hr
  - 4) 4 ORs: 4  $\times$  8 hr, 0  $\times$  10 hr
  - 5) 4 ORs:  $3 \times 8$  hr,  $1 \times 10$  hr
  - 6) 4 ORs:  $2 \times 8$  hr,  $2 \times 10$  hr

- 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:  $0 \times 8$  hr,  $3 \times 10$  hr
- 4) 4 ORs:  $4 \times 8$  hr,  $0 \times 10$  hr

5) 4 ORs:  $3 \times 8$  hr,  $1 \times 10$  hr

6) 4 ORs:  $2 \times 8$  hr,  $2 \times 10$  hr



- 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













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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



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

Dexter F et al. Anesth Analg 2007 Wachtel RE, Dexter F. J Grad Med Educ 2010



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#### **Question and Answer #1**

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


- 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



- 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?



- 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

- 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?



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

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



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- Are the quality of the decisions made better with the calculated information provided?
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- 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

- Full course (e.g., medical directors and analysts)
- Lectures on day of surgery decision making, case duration prediction, allocating OR time, anesthesia staffing, financial analysis, and strategic decision-making

#### www.FranklinDexter.net

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

