MSBA 7004
Operations Analytics

Class 5-1: Process Flow Analysis (IV)

Shouldice Hospital Case

2023

Learning Objectives

- To apply process analysis methods
- To understand how operations analytics can be app lied to healthcare management problems

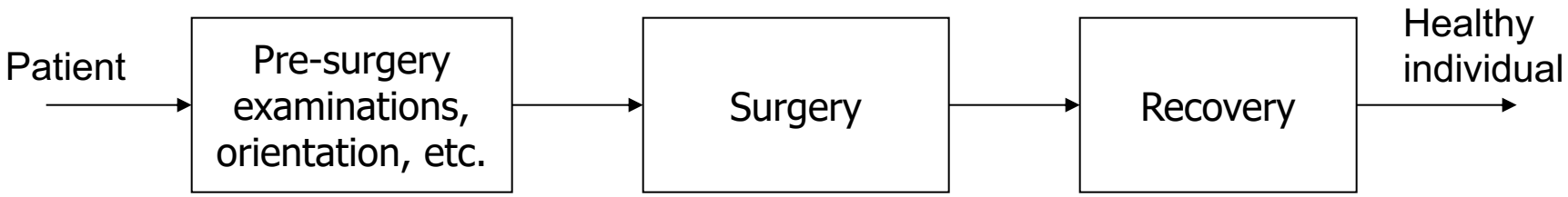
- Purpose of the analysis:
  - To determine the capacity, throughput, *resource utilizati on* of the current practice (*evaluate*) and
  - propose future expansion plans for Shouldice Hospital (*improve*)

Assumptions: For the *current* operations

- No weekend (Sat & Sun) surgeries
- Admits 30 patients/day on Sun-Thurs
- Each surgeon can operate 4 patients/day; total of 12 surgeons
- Each surgery takes 1 hour in the operating room; each of 5 operating rooms is available from 7:30am to 3:30pm (8hr/day)
- Total of 90 beds, and committed to a 3-day process
- **All other resources have sufficient capacity**
  - part-time assistant surgeons
  - laboratory/examination rooms
  - nurses and other staff

- **Flow Units: Patient.**
- **Key Resources: Beds, Operating rooms, Surgeons.**

Q1: **Flow Units,** Resources

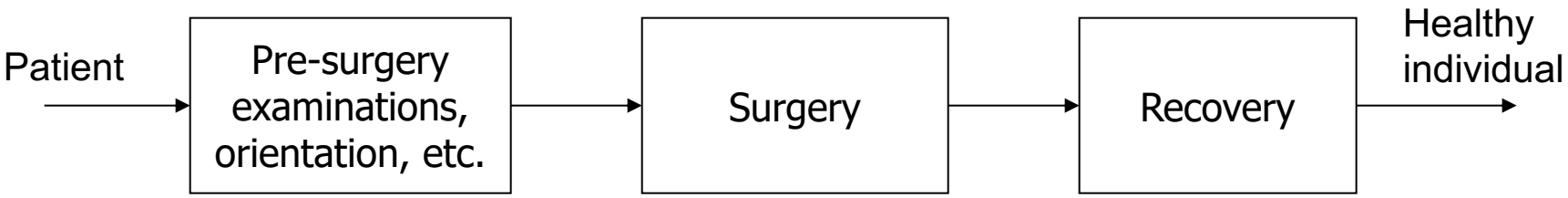


- **Flow Units: Patient.**
- **Key Resources: Beds, Operating rooms, Surgeons.**

Q2: Current operations - bed

	# of beds required each day						
Check-in day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Mon	30	30	30				
Tue		30	30	30			
Wed			30	30	30		
Thu				30	30	30	
Fri							
Sat							
Sun	30	30					30
Total	**60**	**90**	**90**	**90**	**60**	**30**	**30**
Utilization	**66.7%**	**100%**	**100%**	**100%**	**66.7%**	**33.3%**	**33.3%**

Q2: Current operations for weekday (operating day)



Resource	Unit Load (per patient)	Operating hours per day	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity
Bed	3 days	24 hrs	1/3 patient/day	90	30 patients/day
Operating Room	1 hr	8 hrs	8 patients/day	5	40 patients/day
Surgeon	1 hr	4 hrs	4 patients/day	12	48 patients/day

Q2

- 2(a) (Per week) hospital throughput rate (actual output rate)

  = 30 patients/operating day * 5 operating days/week= 150 patients/week

- **2(b) Utilization(bed)**= Throughput Rate/ Capacity Rate (bed)

  =**150/210= 71.4%**

Q2: What is the current bed utilization? (Alternative approach 1)

	# of beds required each day						
Check-in day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Mon	30	30	30				
Tue		30	30	30			
Wed			30	30	30		
Thu				30	30	30	
Fri							
Sat							
Sun	30	30					30
Total	**60**	**90**	**90**	**90**	**60**	**30**	**30**
Utilization	**66.7%**	**100%**	**100%**	**100%**	**66.7%**	**33.3%**	**33.3%**

- Utilization=Average utilization in a week

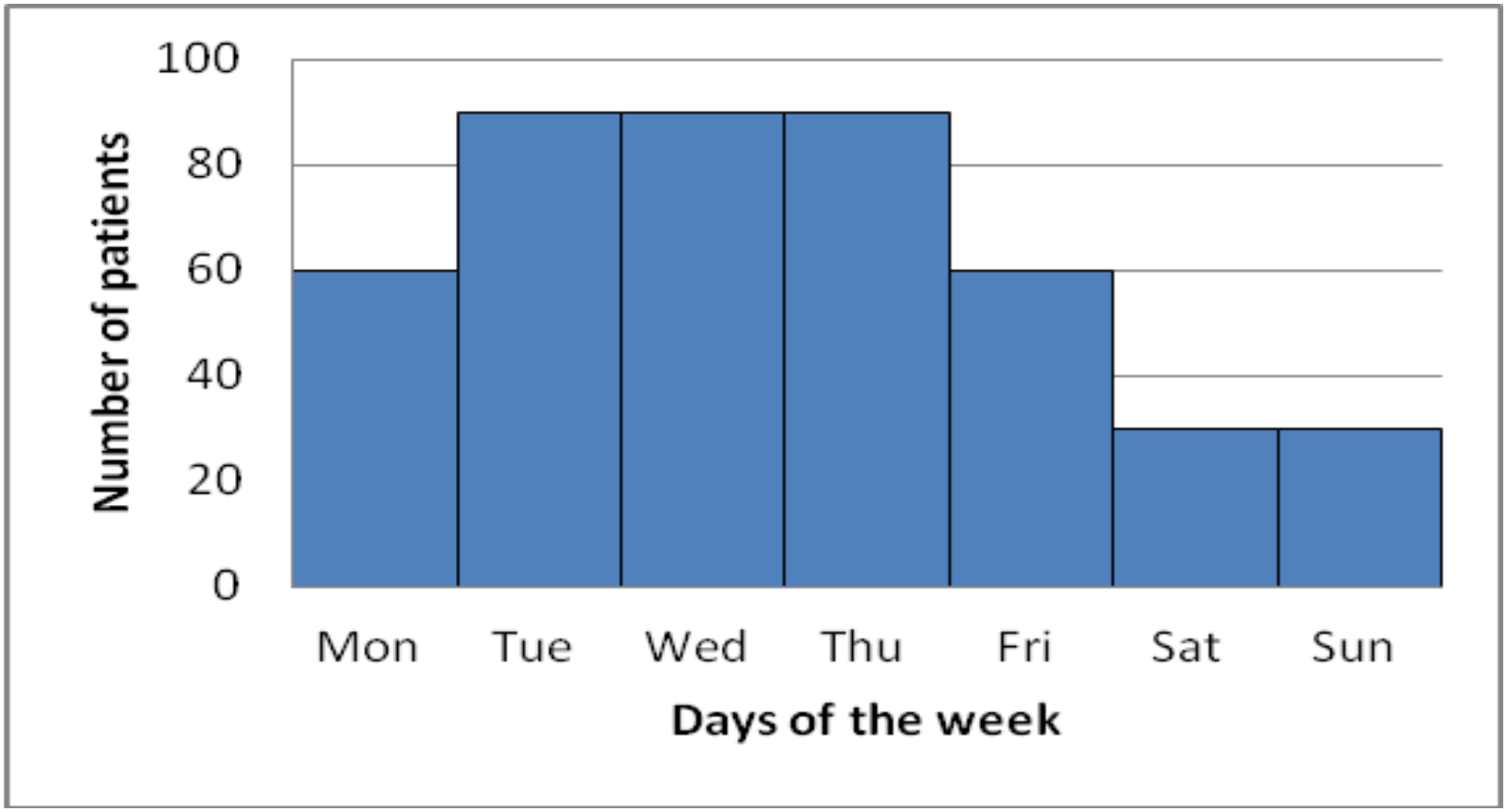
  =(66.7%+100%+100%+100%+66.7%+33.3%+33.3%)/7=71.4%

Q2: What is the current bed utilization? (Alternative approach 2)

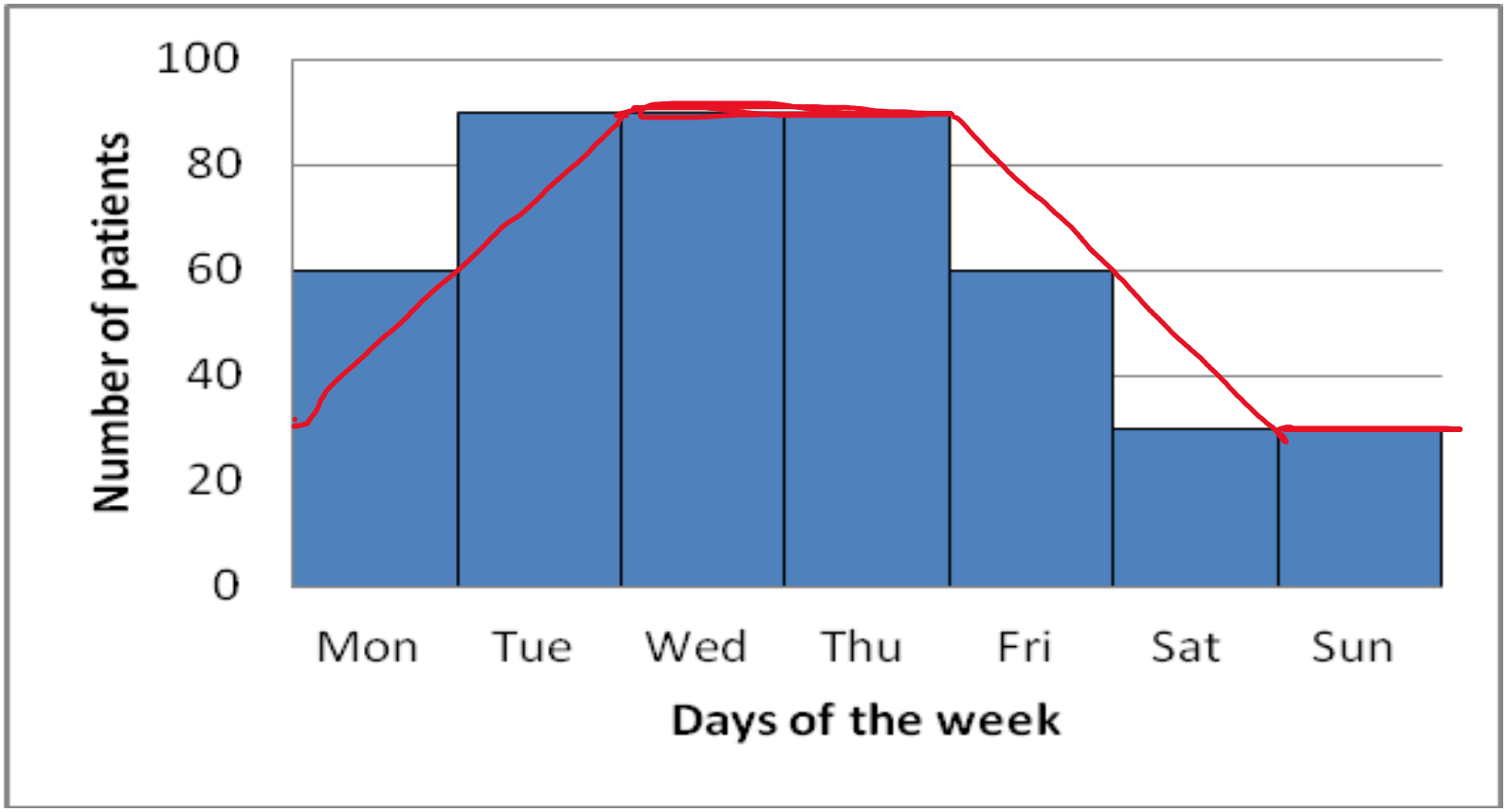
Check-in day	Input	Output	Capacity	Inventory (at the end of day)
Sun	30	30	30	30
Mon	30	0	30	60
Tue	30	0	30	90
Wed	30	30	30	90
Thu	30	30	30	90
Fri	0	30	30	60
Sat	0	30	30	30
Total	**150**	**150**	**210**	**450**
Average				**450/7=64.3**

- Interpretation of Inventory: “A flow unit is either being processed or waiting for process” implies that both “activity” and “buffer” can hold inventory.
- Note: assume patients are discharged on the morning of the 4th day
- Utilization=Average inventory/Total possible inventory
  =64.3/90=71.4%

Q2(c): What is the current bed utilization? Inventory build-up diagram



Q2(c) (red curve is also acceptable) Inventory build-up diagram



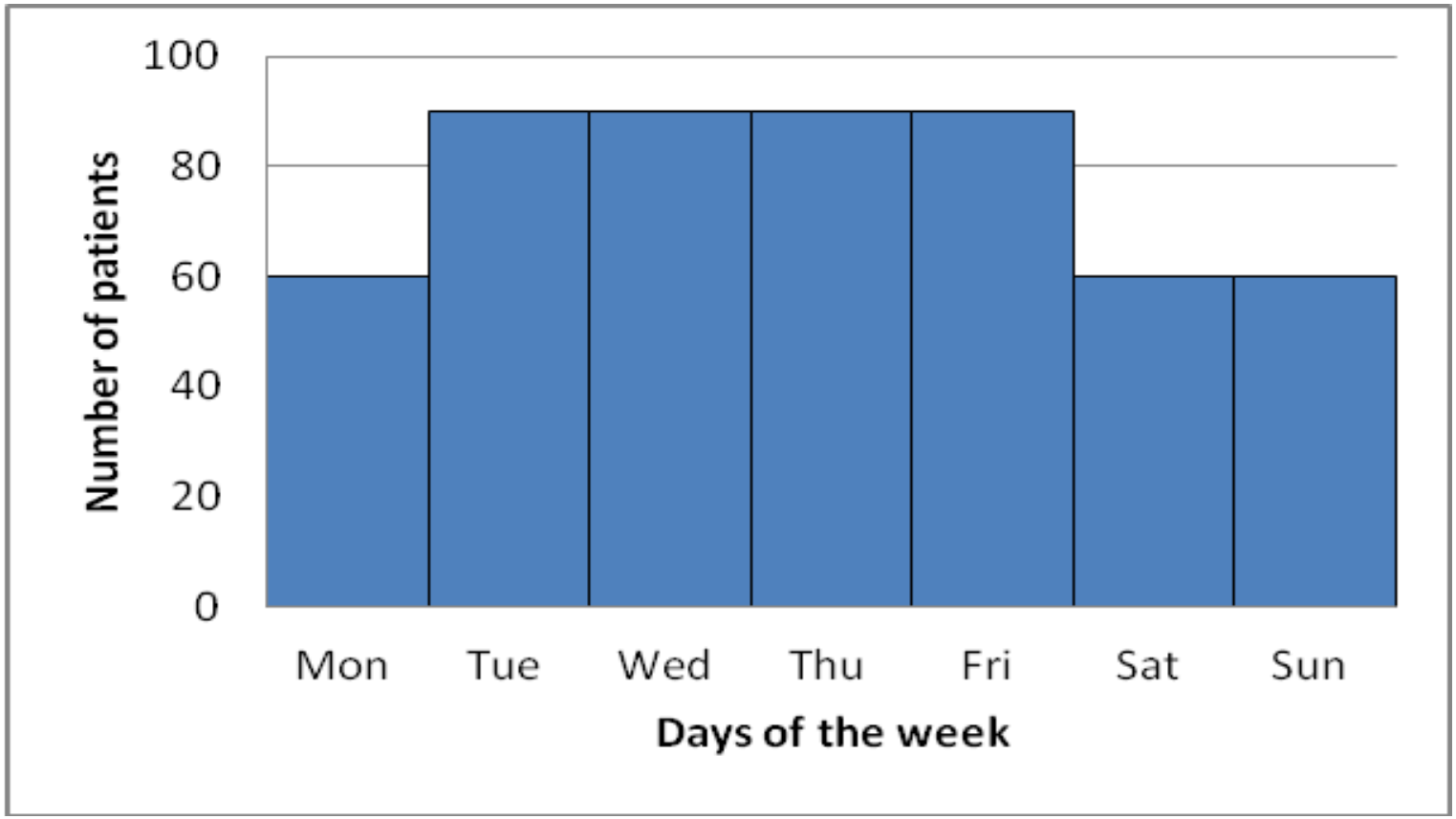
Q3: Adding operations on Saturday

	# of beds required each day						
Check-in day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Mon	30	30	30				
Tue		30	30	30			
Wed			30	30	30		
Thu				30	30	30	
Fri					30	30	30
Sat							
Sun	30	30					30
Total	**60**	**90**	**90**	**90**	**90**	**60**	**60**
Utilization	**66.7%**	**100%**	**100%**	**100%**	**100%**	**66.7%**	**66.7%**

- Utilization=Throughput Rate/Capacity Rate=[30(patients/operating day)*6(operating days/week)]/[30(patient/day)*7(days/week)]=85.7%
- Utilization=Average utilization in a week

  =(66.7%+100%+100%+100%+100%+66.7%+66.7%)/7=85.7%

Q3: Adding operations on Saturday
Inventory build-up diagram



Q3-2 (not a part of the assignment): What if we increase the number of beds by 50%?

Resource	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity (for weekdays)	Utilization (for days used)
Bed	1/3 patient/day	90	30 patients /day	71.4%
Operating Room	8 patients/day	5	40 patients /day	30/40=75%
Surgeon	4 patients/day	12	48 patients /day	30/48=62.5%

Resource	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity (for weekdays)	Utilization (for days used)
Bed	1/3 patient/day	135	45 patients /day	63.5%
Operating Room	8 patients/day	5	40 patients /day	40/40=100%
Surgeon	4 patients/day	12	48 patients /day	40/48=83.3%

- Utilization is for days used: bed 7 days a week, OR and surgeon 5 days a week
- Bed utilization(with 50% more beds)=Throughput Rate/Bed Capacity Rate
  =(40 patients/operating day*5 operating days/week)/(45patients/day*7days/week)
  =63.5%
- Improvement in throughput rate=(40 patients/operating day*5 operating days/week)-(30 patients/operating day*5 operating days/week)=50 patients/week

Q3-2: What if we increase the number of beds by 50%?
Sub Q: Do we need to expand by 50%?

Resource	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity (for weekdays)	Utilization (for days used)
Bed	1/3 patient/day	120	40 patients /day	71.4%
Operating Room	8 patients/day	5	40 patients /day	40/40=100%
Surgeon	4 patients/day	12	48 patients /day	40/48=83.3%

- Can we save in investment cost while achieving the same output rate (40 patients/day=200patients/week)?
- OR is the bottleneck as long as bed daily capacity is at least 40 patients/day
- Required beds=40(patients/day)/(1/3)(patient/day/bed)=120beds
- Required expansion=120beds-90beds=30beds

- **Every day (Sunday – Thursday) admits 40 patients/day.**

Q4: Increasing output by 20% without Saturday operations

- Objective: 20% throughput rate increase
  150 patients/week → 180 patients/week
- Bottleneck resources (beds) need to be added
- # of patients admitted each day
  = 180(patients/week)/5(operating days/week)
  = 36 (patients/day)
- # of additional beds required= 36 (patients/day) / (1/3)(patient/day/bed)-90beds = 18 beds
- Is this feasible? What do we need to check?
  Other resources may become the new bottleneck, if so, ad ding 18 beds might not achieve 20% throughput rate incre ase

Q4: Adding 18 beds

Resource	Unit Load (per patient)	Operating hours per day	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity
Bed	3 days	24 hrs	1/3 patient/day	108	36 patients/day
Operating Room	1 hr	8 hrs	8 patients/day	5	40 patients/day
Surgeon	1 hr	4 hrs	4 patients/day	12	48 patients/day

- Process capacity rate = Bottleneck capacity rate = 36 patients/(operating) day
- We can achieve a 20% increase in throughput by adding 18 more beds
- Is this the most economical way?

Q4: Flexible admission schedule

	# of beds required each day						
Check-in day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Mon	40	40	40				
Tue		20	20	20			
Wed			40	40	40		
Thu				40	40	40	
Fri							
Sat							
Sun	40	40					40
Total	**80**	**100**	**100**	**100**	**80**	**40**	**40**
Utilization	**80%**	**100%**	**100%**	**100%**	**80%**	**40%**	**40%**

- Throughput rate = 180 (patients/week) =40+20+40+40+40
- We need to add 10 more beds (=100-90)

More alternatives for 20% throughput increase

- What if the hospital admits patients only on Monday, Wednesday, Thursday and Sunday, i.e., NO admission on Tuesday and weekend?
- What is the new bottleneck?

More alternatives for 20% throughput increase: 4-day operation

For now let's ignore resource limitation and focus on schedule

	# of beds required each day						
Check-in day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Mon	45	45	45				
Tue							
Wed			45	45	45		
Thu				45	45	45	
Fri							
Sat							
Sun	45	45					45
Total	**90**	**90**	**90**	**90**	**90**	**45**	**45**
Utilization	**100%**	**100%**	**100%**	**100%**	**100%**	**50%**	**50%**

- Throughput rate: 180(patients/week) with no new resources added.
- Now let's consider resources: Not feasible. Let's check the OR. We may nee d to either
  - add one operating room
  - extend operating room hours by 1 hour (from 8 to 9) per day

More alternatives for 20% throughput increase: 4-day operation: Adding 1 OR

Resource	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity	Operating Days per Week	Weekly Capacity
Bed	1/3 patient/day	90	30 patients/day	7 days/week	210 patients/week
Operating Room	8 patients/day	5	40 patients/day	4 days/ week	160 patients/week
Surgeon	4 patients/day	12	48 patients/day	4 days/week	192 patients/week

Resource	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity	Operating Days per Week	Weekly Capacity
Bed	1/3 patient/day	90	30 patients/day	7 days/week	210 patients/week
Operating Room	8 patients/day	6	48 patients/day	4 days/ week	192 patients/week
Surgeon	4 patients/day	12	48 patients/day	4 days/week	192 patients/week

- With the current resources, 4-day operations cannot achieve 20% (30patients/week) increase. Only 10=(160-150) (patients/week)
- If we add 1 more OR, we can handle 180 patients/week

More alternatives for 20% throughput increase: 4-day operation: Increasing OR hour

Resource	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity	Operating Days per Week	Weekly Capacity
Bed	1/3 patient/day	90	30 patients/day	7 days/week	210 patients/week
Operating Room	8 patients/day	5	40 patients/day	4 days/ week	160 patients/week
Surgeon	4 patients/day	12	48 patients/day	4 days/week	192 patients/week

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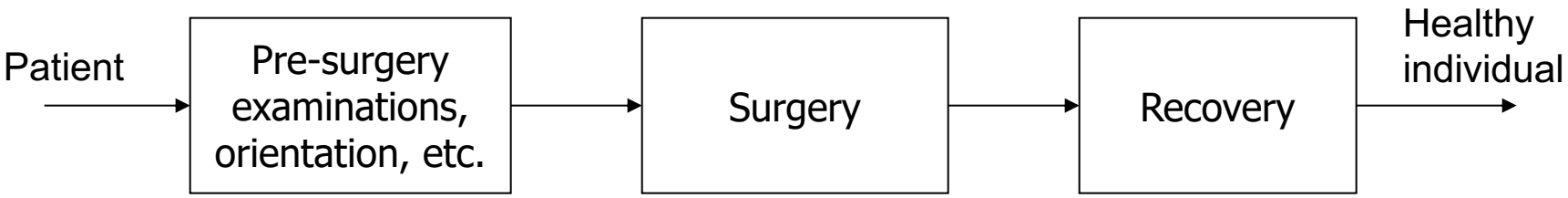
Bed	1/3 patient/day	90	30 patients/day	7 days/week	210 patients/week
Operating Room	9 patients/day	5	45 patients/day	4 days/ week	180 patients/week
Surgeon	4 patients/day	12	48 patients/day	4 days/week	192 patients/week

- ORs are extremely expensive. Then what can we do with our current resources to meet the objective?
- If we operate each OR 1 more hour each day, 9 operations can be performed per OR each day. We can achieve 180 patients/week

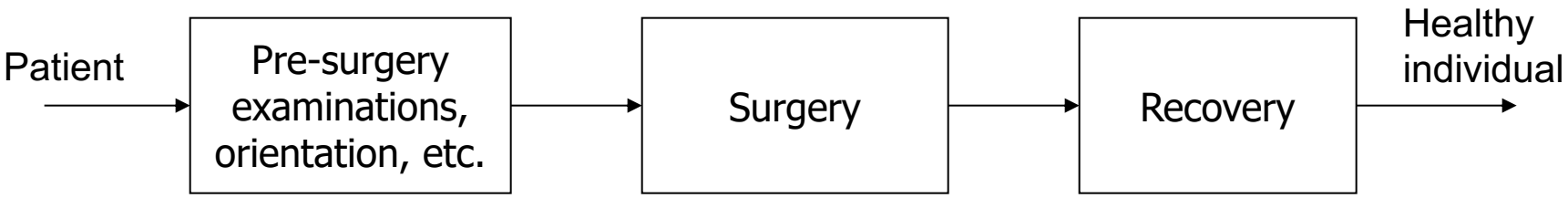
Q4(c): Current operations for weekday (operating day)



Resource	Unit Load (per patient)	Operating hours per day	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity
Bed	3 days	24 hrs	1/3 patient/day	90	30 patients/day
Operating Room	1 hr	8 hrs	8 patients/day	5	40 patients/day
Surgeon	1 hr	4 hrs	4 patients/day	12	48 patients/day

- Process capacity rate = Bottleneck capacity rate
  = 30 patients/(operating) day

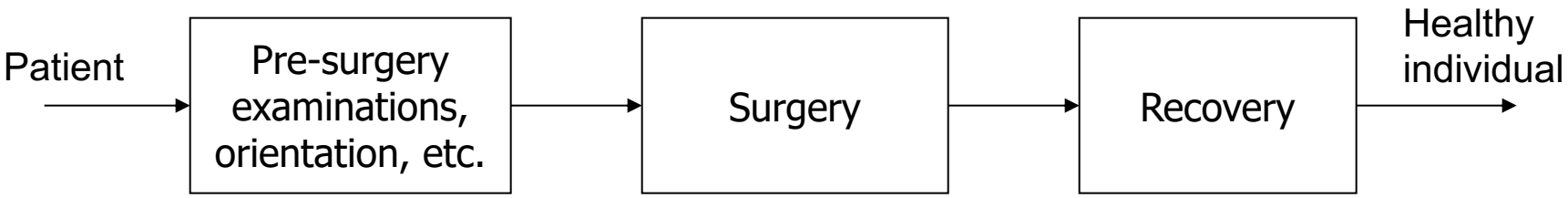
Q4(c): Current operations for weekend (non-operating day)



Resource	Unit Load (per patient)	Operating hours per day	Daily Capacity (per 1 resource)	# of Resources	Daily Capacity
Bed	3 days	24 hrs	1/3 patient/day	90	30 patients/day
Operating Room	1 hr	0 hrs	0 patients/day	5	0 patients/day
Surgeon	1 hr	0 hrs	0 patients/day	12	0 patients/day

- Process capacity rate = Bottleneck capacity rate
  = 0 patients/(non-operating) day

Q4(c): Current operations for a week



Resource	Unit Load (per patient)	Operating hours per operating day	Daily Capacity (per 1 resource per operating day)	# of Resources	# of operating days per week	Weekly Capacity
Bed	3 days	24 hrs	1/3 patient /(operating) day	90	7 (operating) days /week	210 patients /week
Operating Room	1 hr	8 hrs	8 patients /(operating) day	5	5 (operating) days /week	200 patients /week
Surgeon	1 hr	4 hrs	4 patients /(operating) day	12	5 (operating) days /week	240 Patients /week

Q4 (c)

- (Per week) hospital capacity rate

  = Weekly capacity rate of (weekly) bottleneck

  = Weekly capacity rate of operating room

  = 40 patients/(operating) day * 5 (operating) days/week= 200 patients/week ?

Or operating day + (non) operating day: 150 patients/week ?

Q4(c) Maximum throughput without adding re source and changing current practice

- How to formulate the question?
  - Integer programming
  - Objective: weekly throughput
  - Decision variables: daily admissions
  - Constraints: Bed, OR, surgeon capacity

$$max \sum_{i \in DOW} admit_i$$

s.t. $admit_{i-1} + admit_i + admit_{i+1} \leq 90 \; for \; \forall i \in DOW$

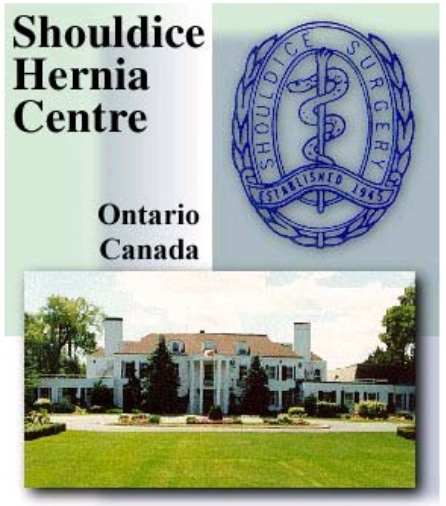
$admit_i \leq 40 \; for \; \forall i \in \{Sun, Mon, Tue, Wed, Thu\}$,
$admit_i = 0 \; for \; \forall i \in \{Fri, Sat\}$.

Q4(c)

	# of beds required each day						
Check-in day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Mon	40	40	40				
Tue		10	10	10			
Wed			40	40	40		
Thu				40	40	40	
Fri							
Sat							
Sun	40	40					40
Total	**80**	**90**	**90**	**90**	**80**	**40**	**40**

Shouldice Hospital

- Video:
  - https://www.shouldice.com/about/

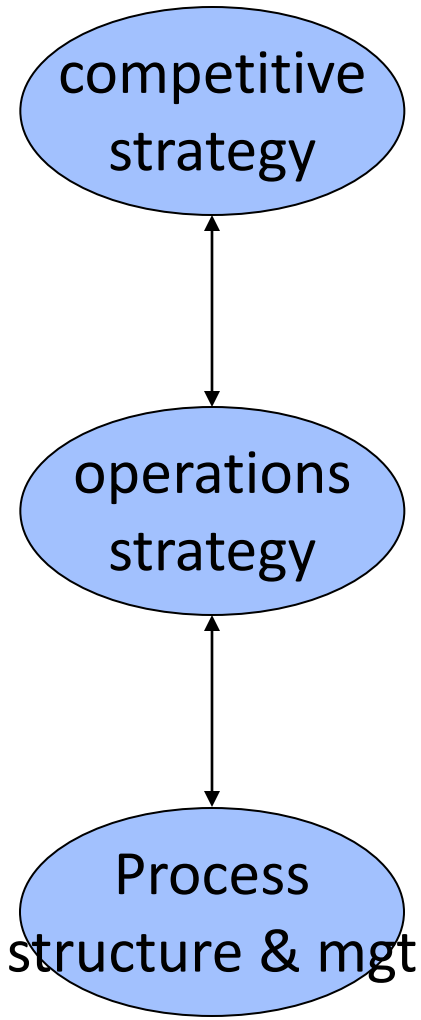


- Background
  - What is the target market?

- Competitive priorities?
  - What do they do to achieve them?
  - Patients' experience?
  - Nurse experience?
  - Doctor experience?

MONDAY, OCTOBER 18
WALK IN CLINIC HAS REACHED CAPACITY
AND IS NOW CLOSED FOR THE DAY.
Walk in Clinic reopens Tuesday
Clinic hours are 9 am to 3 pm on weekdays.
The current wait time for surgery is 12 weeks.

A Strategic Framework for Process Design and Improvement: Three questions



1. What is our strategic position: how do we compete & provide value in the market?
   - What is the value proposition to our customers?
   - ➢ Rank (*p, T, Q, V*)

2. Given our strategic position, what must op erations do particularly well?
   - Which *competencies* must ops develop?
   - ➢ Rank *(c, T, Q, Flex*)

3. Given needed competencies, how should operations processes be structured to dev elop competencies that support strategy?
   - ➢ Process choice (structure) and management

Firms compete on product attributes. This requires process competencies.

Product Attribute (External)	*Process Competency (Internal)*
Price	Cost
Response time	Flow time
Variety	Flexibility
Quality	Quality

Firms compete on product attributes. This requires process competencies.

Product Attribute (External)	*Process Competency (Internal)*
Price	Cost
~~Response time~~	Flow time
~~Variety~~	Flexibility
Quality	Quality

Shouldice Hospital

- Quality
  - Superior technique
  - Specialized surgeons
  - Environment decorated and designed
  - Committed to 3-day process
  - Screen patients (Shouldice accepts only patients with uncomplicated external hernias)

- Cost
  - Standardized services
  - Do not need to hire the best surgeons (work 4 hours a day)
  - Surgeons' turnover rate is low
  - New patients paired with old patients (old patients take nurses' job)
  - Short operating hours

Strategy and Operations of Shouldice Hospital

- Focused strategy
  - Very selective with patient types: certain hernia patients
  - Prioritized product attribute? **P**, ~~T~~, **Q**, ~~V~~
- Operations aligned with strategy
  - Prioritized process attribute? **C**, T, **Q**, F
  - Enables a very specialized process