Department of Industrial and Systems Engineering
IE3100R: Systems Design Project (AY12/13)

Changi General Hospital

NUS National University of Singapore

Lead Time Reduction and Resource Management for Appointment Making in Specialist Outpatient Clinics
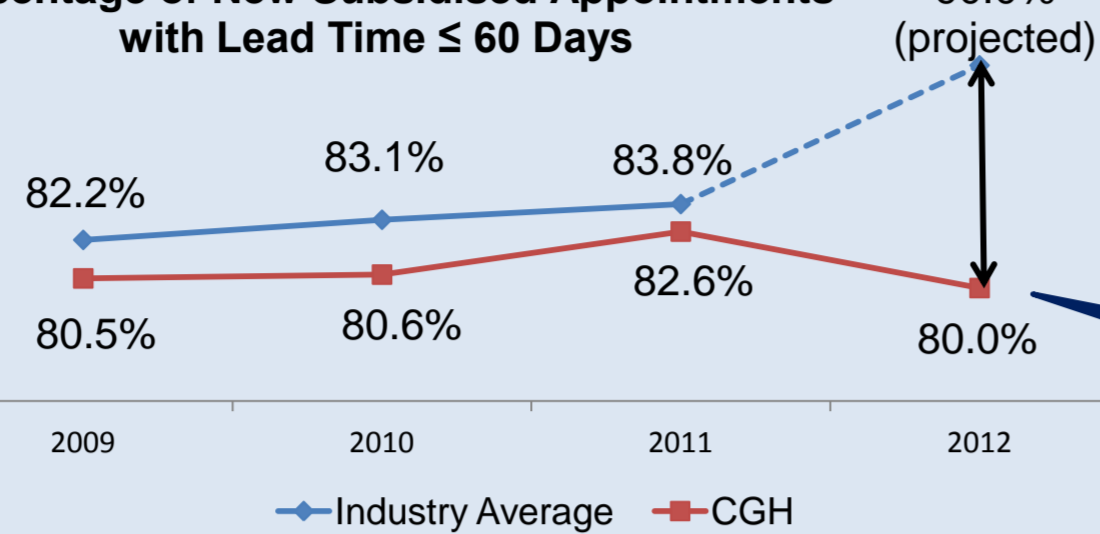
Company Background

Changi General Hospital (CGH)

- Restructured public hospital
- Part of Eastern Health Alliance
- Over 20 Specialties and 17 Specialist Outpatient Clinics (SOC)
- 560,000 Appointments Scheduled in 2011.

Problem Statement

Percentage of New Subsidised Appointments with Lead Time ≤ 60 Days

- Industry Average: 82.2% (2009), 83.1% (2010), 83.8% (2011), 90.0% (projected 2012)
- CGH: 80.5% (2009), 80.6% (2010), 82.6% (2011), 80.0% (2012)

- Appointment **Lead Times**[1] has been **Increasing**.
- CGH's **Key Performance Indicator (KPI)**, defined by MOH, is worse than the National Average

The Gap suggests Room for Improvement.
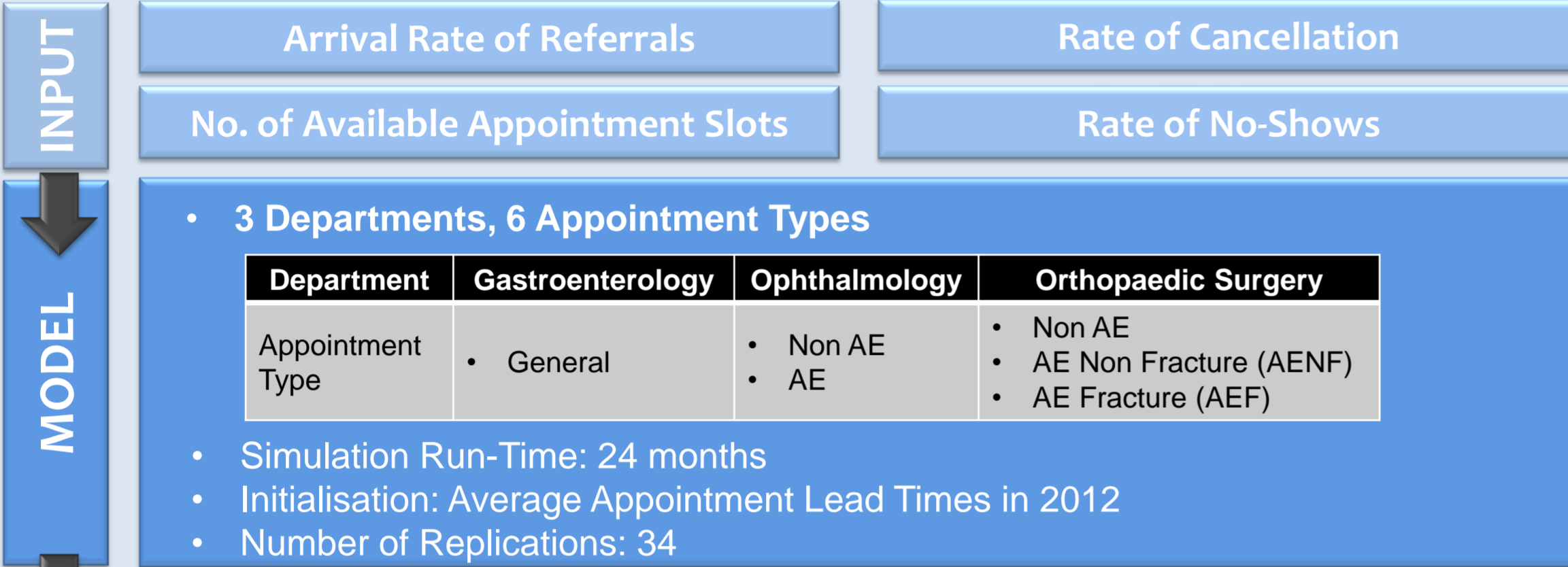
Project Objectives

- Understanding the **causes of High Appointment Lead Times**;
- Studying the **Relationship** between **Lead Time**, Patient **No-Show** and **Cancellation**, and
- Recommending Effective Solutions to **Reduce Resource Wastage** and **Lower Appointment Lead Times**;

Project Scope

- Focusing on three specialties, namely, **Orthopedic Surgery (OTO)**, **Gastroenterology (GAS)** and **Ophthalmology (EYE)**
- **New Patients, Subsidised Appointments** in SOCs

Simulation Model

Goal: To Simulate the Dynamics of Appointment Booking to Understand the Cause of High Lead Times, and Compare Solutions and Recommendation
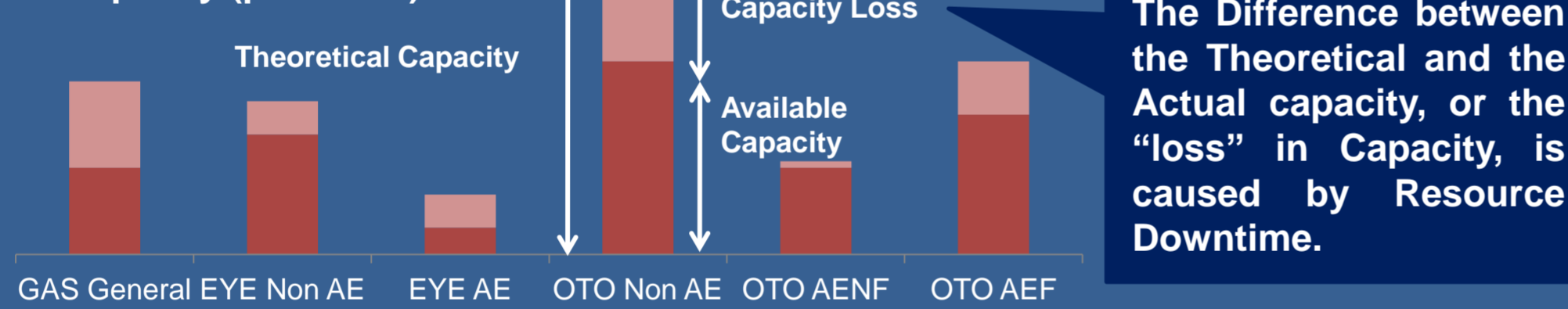
INPUT

| Arrival Rate of Referrals | Rate of Cancellation |
| No. of Available Appointment Slots | Rate of No-Shows |

MODEL

- **3 Departments, 6 Appointment Types**

Department	Gastroenterology	Ophthalmology	Orthopaedic Surgery
Appointment Type	• General	• Non AE • AE	• Non AE • AE Non Fracture (AENF) • AE Fracture (AEF)

- Simulation Run-Time: 24 months
- Initialisation: Average Appointment Lead Times in 2012
- Number of Replications: 34

OUTPUT

Reducing Capacity in the model to understand Actual Available Capacity[2]

	Mean			Medium			95th Percentile		
	Model	Actual	% Dev[3]	Model	Actual	% Dev	Model	Actual	% Dev
GAS	44	49	10.2%	51	49	4.1%	72	70	2.9%
EYE	43	39	10.3%	51	48	6.3%	82	109	24.8%
OTO	58	57	1.8%	53	61	13.1%	166	128	29.7%

Available Capacity

Theoretical[4] and Available Capacity (per Week)

Categories: GAS General, EYE Non AE, EYE AE, OTO Non AE, OTO AENF, OTO AEF

The Difference between the Theoretical and the Actual capacity, or the "loss" in Capacity, is caused by Resource Downtime.
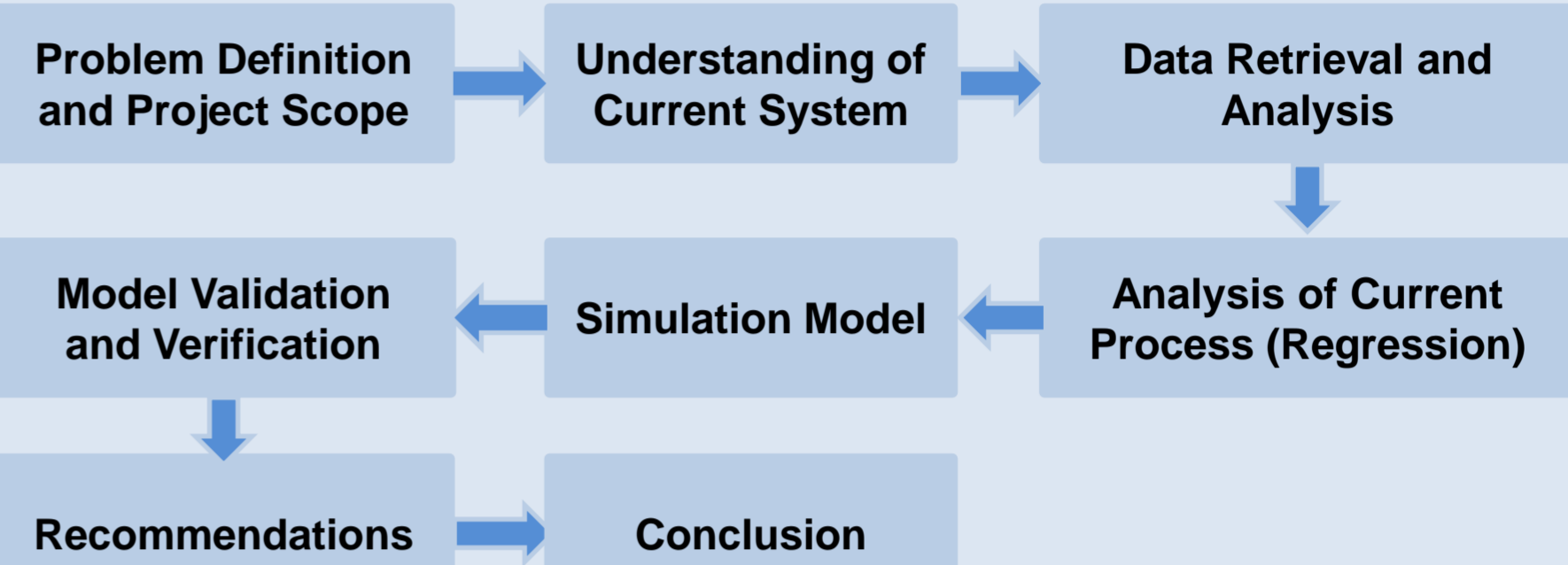
Clumping

- Capacity reductions in common periods
- Example: Doctors taking leave during School Holidays
- Hypothesis Testing shows Evidence of Clumping (10% Significance)
- Increased Lead Time Variability and its Long-Term Average
- 0% Clumping (Spread): Capacity Loss is Evenly Spread out Across the Year
- 100% Clumping (Clump): Losses occur in the Same Period
- Clumping Reduces KPI (% of Lead Times < 60 Days) from **100%** to **69.2%**

Effect of Clumping on Lead Time

Methodology

Problem Definition and Project Scope → Understanding of Current System → Data Retrieval and Analysis → Analysis of Current Process (Regression) → Simulation Model → Model Validation and Verification → Recommendations → Conclusion
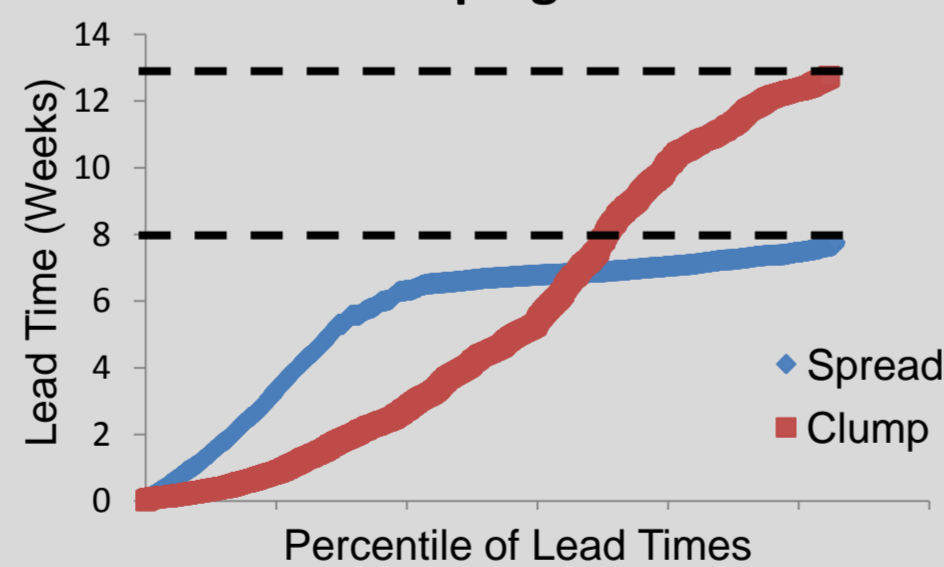
Analysis of Current Process

- **Correlation of Lead Time (Independent Variable) & Other Factors**

No-Shows

		Correlation Coefficient (Adjusted R^2)	Coefficient of Independent Variable	Overall Significance
GAS	General	Low	N.A.	Low
EYE	Non A&E	Low	N.A.	Low
	A&E	Medium	Low	Low
OTO	Non A&E	Low	N.A.	Low
	A&E (NF)	Low	N.A.	Low
	A&E(F)	Medium	Medium	Medium

Cancellation

|		Correlation Coefficient (Adjusted R^2)	Coefficient of Independent Variable	Overall Significance
GAS	General	High	High	High
EYE	Non A&E	High	High	High
	A&E	High	High	High
OTO	Non A&E	High	High	High
	A&E (NF)	Medium	Medium	Medium
	A&E(F)	High	High	High

Recommendations

Objective: To improve KPI to the Benchmark where >90% of Appointment Lead Times are < 60 Days, while Minimising Resource Wastage and Strain

- **Increasing Capacity or Reduce Clumping**

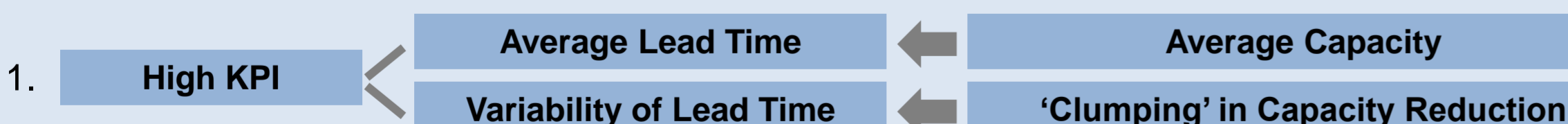|	Average Capacity	Clumping
GAS	**Increase by 3.0%** OR	Reduce from **18.5% (Current)** to **0%**
EYE	**Increase by 6.9%**	
OTO	**Increase by 20.4%**	

- **Setting an Appropriate Overbooking Percentage**

Effect of Overbooking in Ortho on Resource Wastage (Blue) and Strain (Red)
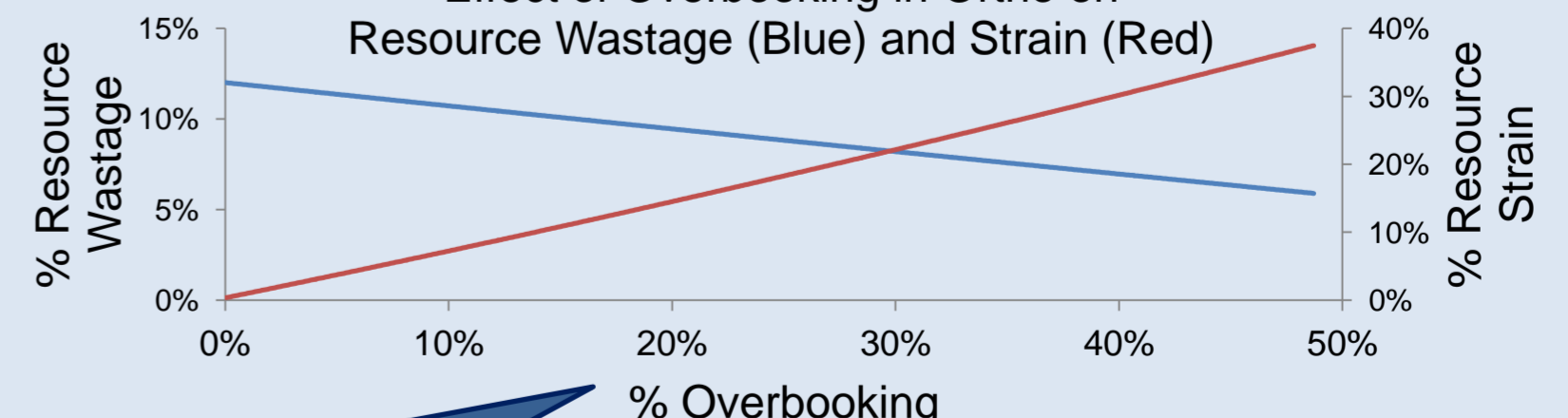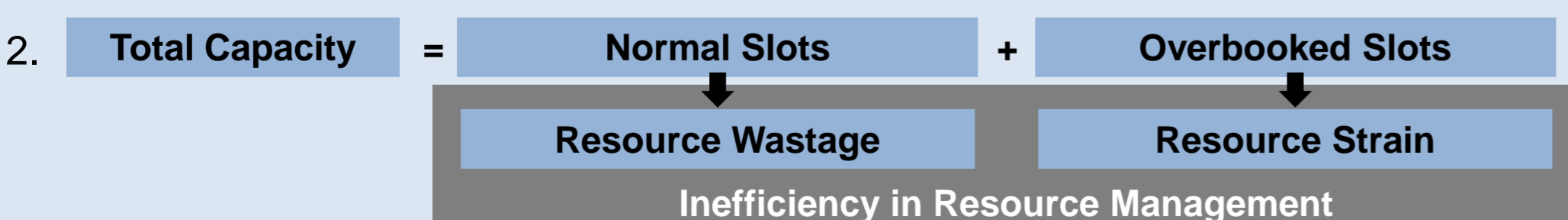

- Set an **Appropriate Overbooking Percentage** to balance between **Resource Wastage** and **Resource Strain**.
- Dependent on **Department's No-Show Rate**, for example, a Higher Overbooking Percentage should be Set for a Higher No-Show Rate

Conclusion

1. **High KPI** ← Average Lead Time ← Average Capacity
   Variability of Lead Time ← 'Clumping' in Capacity Reduction

   Causes of a High KPI are due to the High Mean or Variability of Lead Time. Implementing Solutions targeted at Increasing the Capacity or Reducing Clumping will Improve the KPI.

2. **Total Capacity** = **Normal Slots** + **Overbooked Slots**
   → Resource Wastage   → Resource Strain
   Inefficiency in Resource Management

   To decide amount of Resources required, the Total Capacity and Overbooking Percentage must first be decided. This will affect the KPI, Resource Wastage and Strain.

[1] **Lead Time** is defined as the number of calendar days from the date when the patient first requested for an appointment, to the earliest appointment date allocated for doctor consultation.
[2] **Available Capacity** is defined as the total number of slots that CGH eventually caters to. This includes appointments that result in being attended or No-Show. In addition, this includes overbooking slots.
[3] **Percentage Deviation, % Dev**, is calculated by dividing the absolute difference between the model output and the actual value by the actual value. The actual value is derived from the data collected for Year 2012.
[4] **Theoretical Capacity** is defined as the total number of slots in the calendar set-up. Given no doctors take MC or leave, CGH should have this many slots. This includes overbooking slots.

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