SIMULATING THE FLOW OF PATIENTS WITH AORTIC DISSECTION THROUGH A CARDIAC INTENSIVE CARE UNIT

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CHEPS

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A prescription to address system complexity in healthcare

INNOVATING HEALTHCARE DELIVERY

FOSTERING LEARNING

BUILDING COMMUNITY

POSITIVE IMPACT THROUGH...

Research
Education
Implementation
Outreach
Dissemination

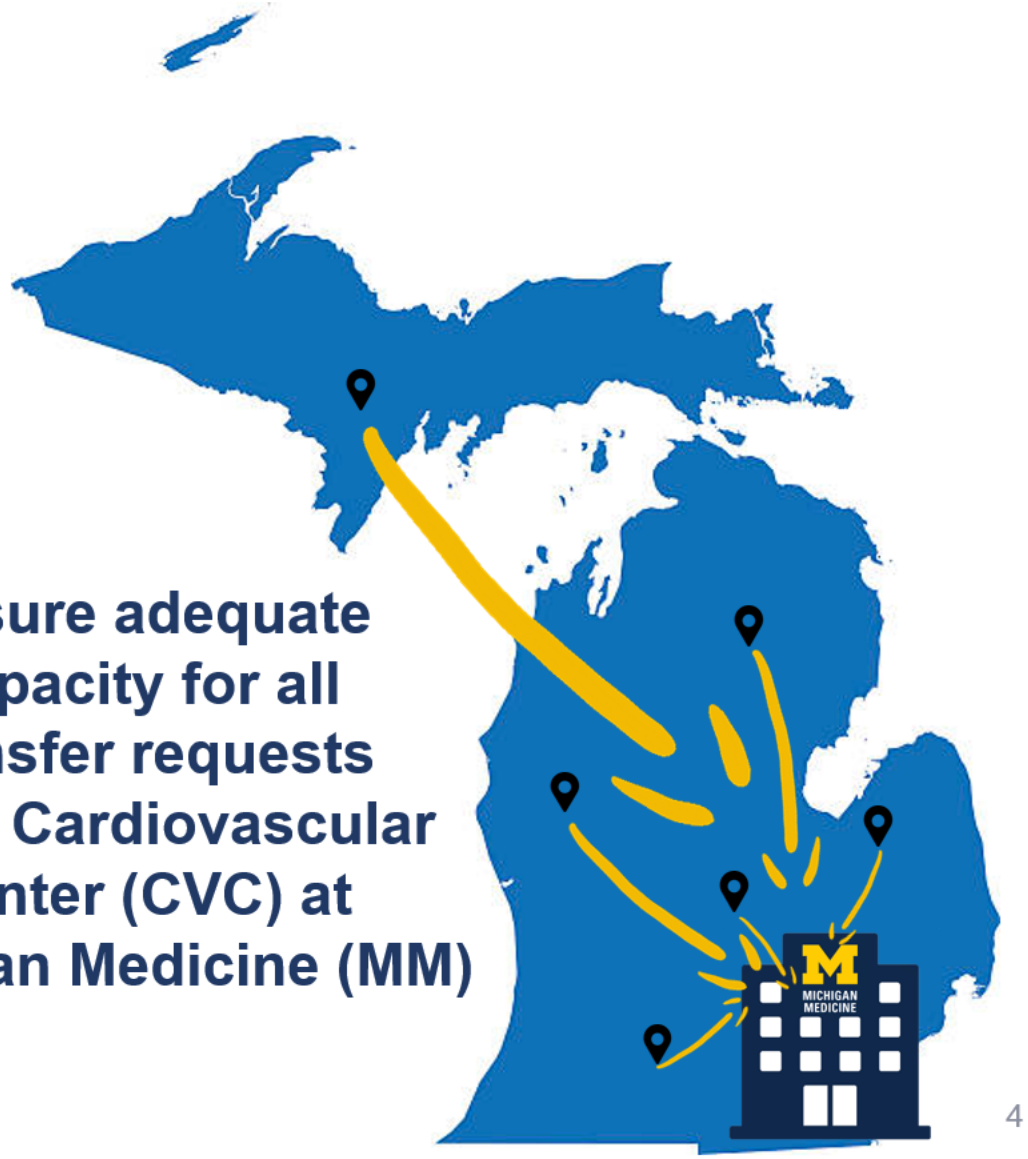
OUTLINE

- Research Motivation
- Introduction
- Problem Statement
- Literature Review
- Simulation Framework
- Analysis
- Future Research

RESEARCH MOTIVATION

What is the aortic dissection (AD) patient experience?

Ensure adequate capacity for all transfer requests to the Cardiovascular Center (CVC) at Michigan Medicine (MM)



WHAT IS AN AORTIC DISSECTION?

Aortic dissection (AD) is an emergency cardiovascular condition affecting the aorta.

It is the result of a tear in the inner wall of the aorta causing severe internal bleeding and potential death.

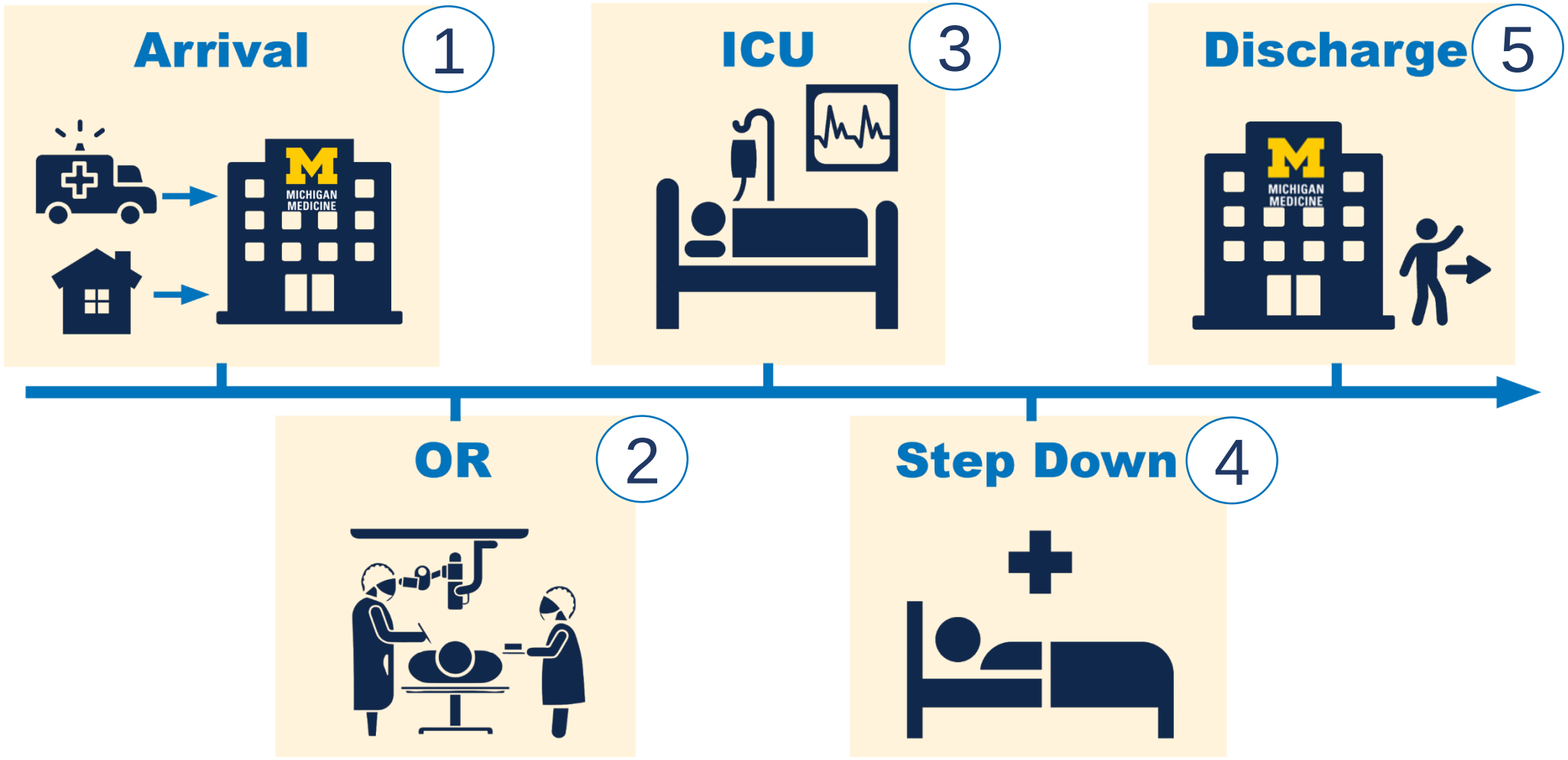
Mortality rate for AD increases 1% per hour [1] and 20% of AD individuals die before reaching the hospital [2].

Aortic dissections are rare, but when they occur, they are medical emergencies.

CARDIOVASCULAR PATIENTS

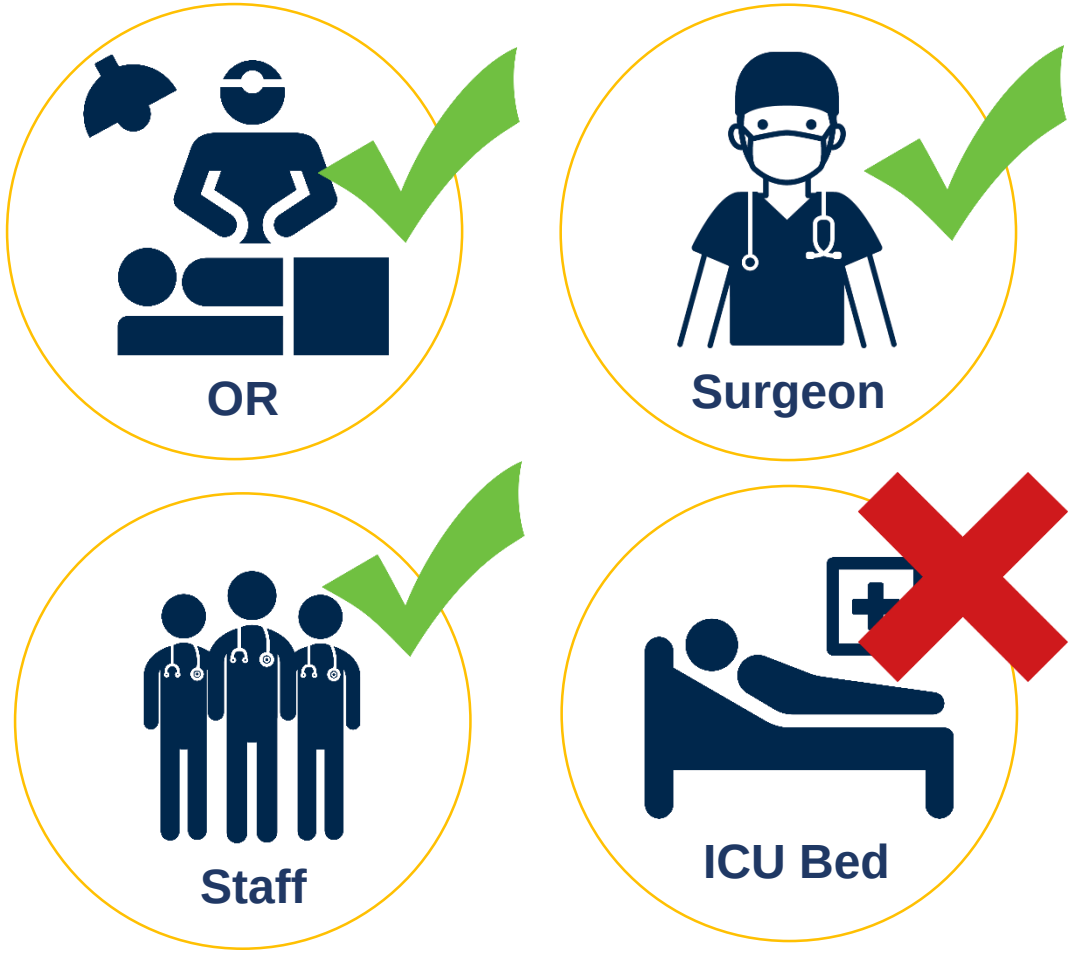
- Cardiovascular disease is the leading cause of death in the US [3].
- By 2030, approximately 40.5% of the US population is projected to have some type of cardiovascular disease [4].
- The most common surgeries in the United States (US) are cardiovascular [3].

PATIENT ARRIVAL STREAM AND FLOW IN CARDIOVASCULAR SURGERY

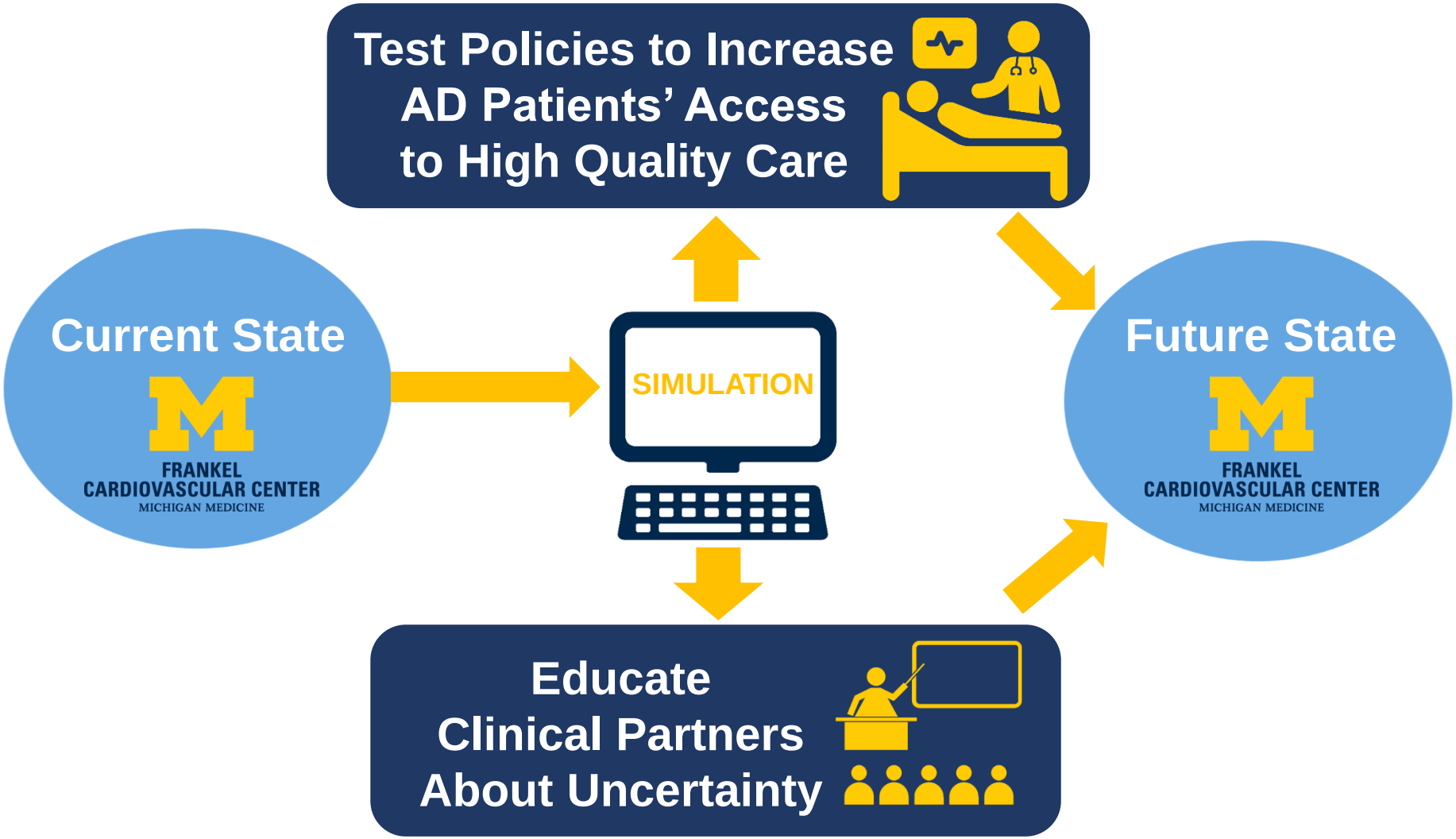


AD TRANSFER DEFERRAL

Preliminary analysis conducted by the CVC staff showed that the most common reason for AD patient deferral when requesting transfer to Michigan Medicine is attributed to unavailable ICU beds.



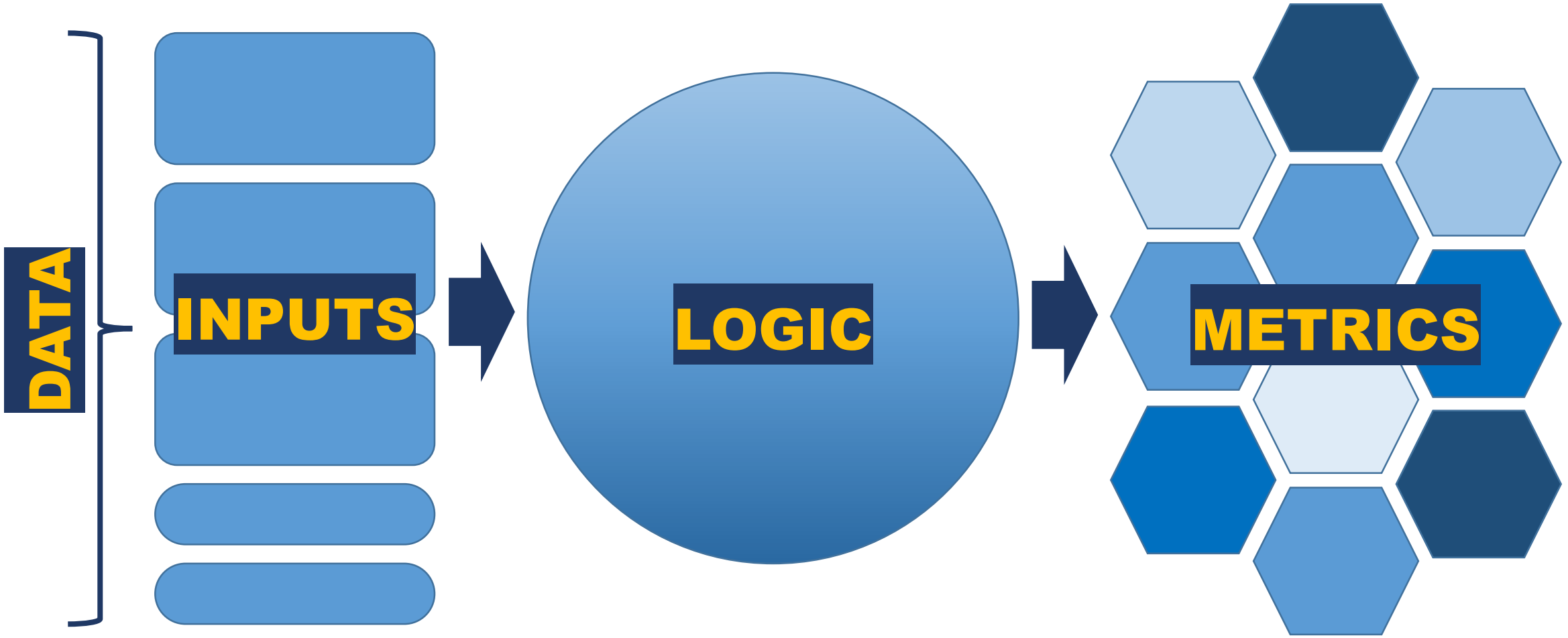
PROBLEM STATEMENT



LITERATURE REVIEW

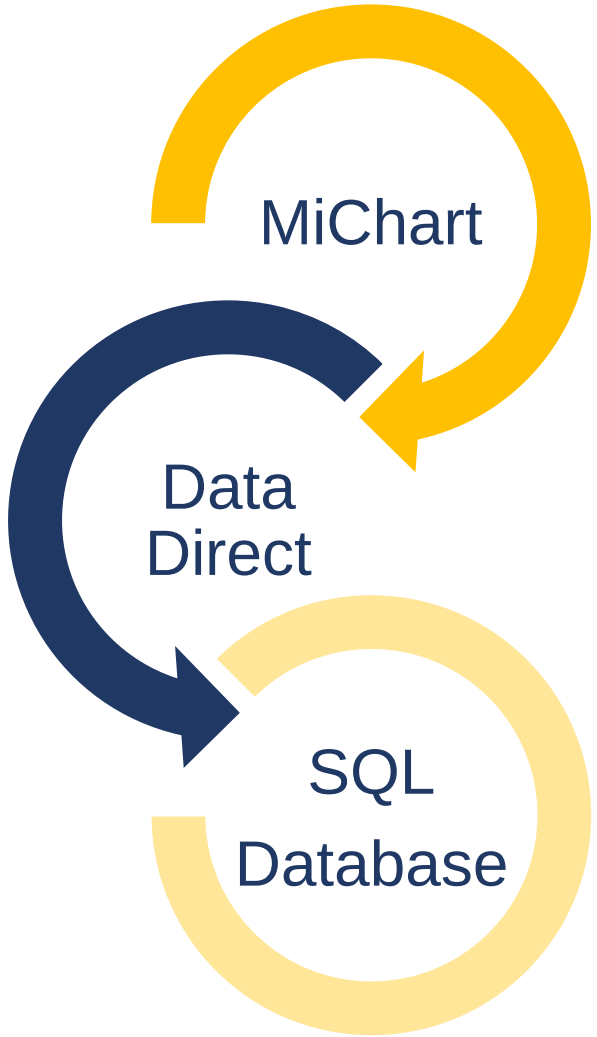
First Author	Reference	Year	Objective/Purpose
Levin, S.	[5]	2011	To test policies to reduce patient's length of stay (LOS) and increase patient throughput.
Marmor, Y.	[6]	2013	To predict minimum bed needs to achieve the high patient service level demanded for the cardiovascular ICU.
Levin, S.	[7]	2015	To estimate patients' wait time while integrating the effect of the transition process (i.e. wait time for a bed to become available) with queuing using embedded regression models.
Kolker, A.	[8]	2009	To establish a quantitative link between the daily load leveling of elective surgeries (i.e. elective schedule smoothing) and ICU diversion of multiple ICU units including cardio ICU.

SIMULATION FRAMEWORK



DATA PRE-PROCESSING

- MiChart, a product of Epic, is Michigan Medicine's patient-centric electronic health record
- Data Direct enables access to clinical data
- SQL Database contains all patients that visited the CVC ICU between Jan 2016 and May 2019



SIMULATION FRAMEWORK

FIXED INPUTS

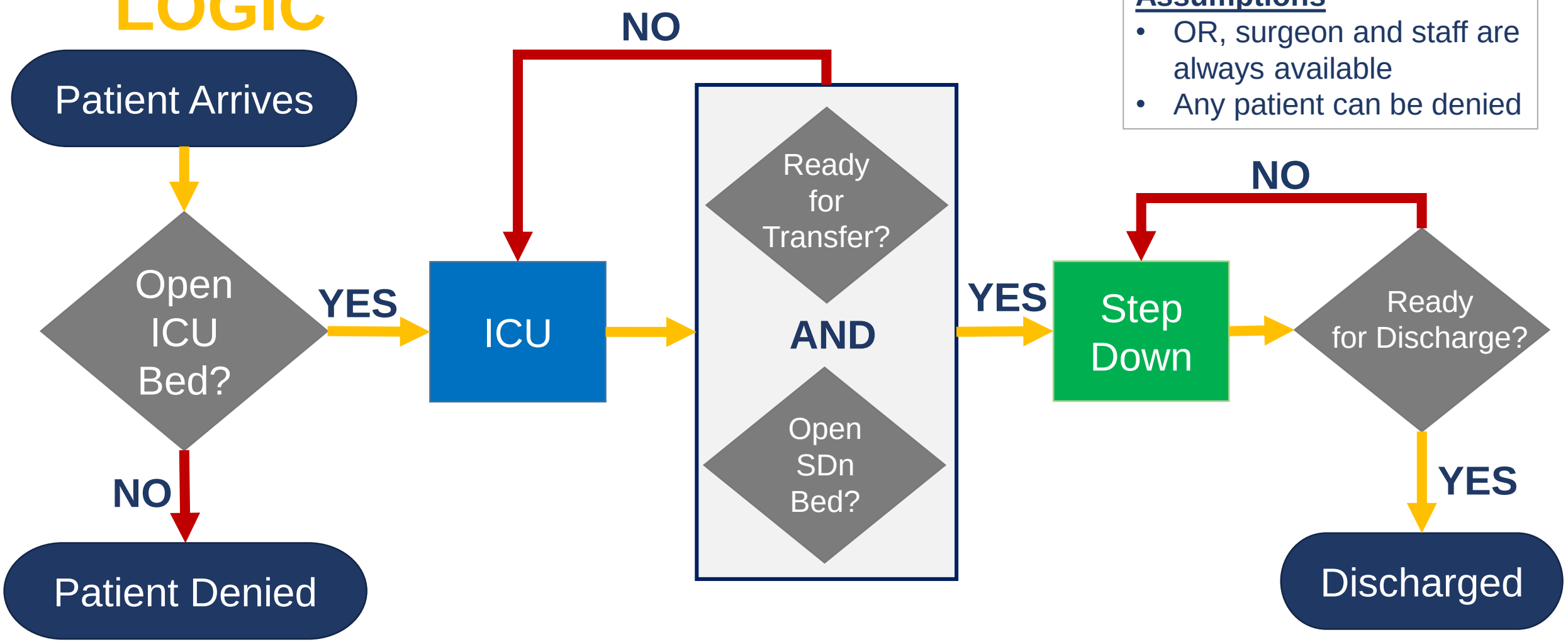
- Bed Count per Unit
- Time Horizon
- Replications

RANDOM INPUTS

- Patient Type
- Arrival Rate
- Service Time per Unit

SIMULATION FRAMEWORK

LOGIC



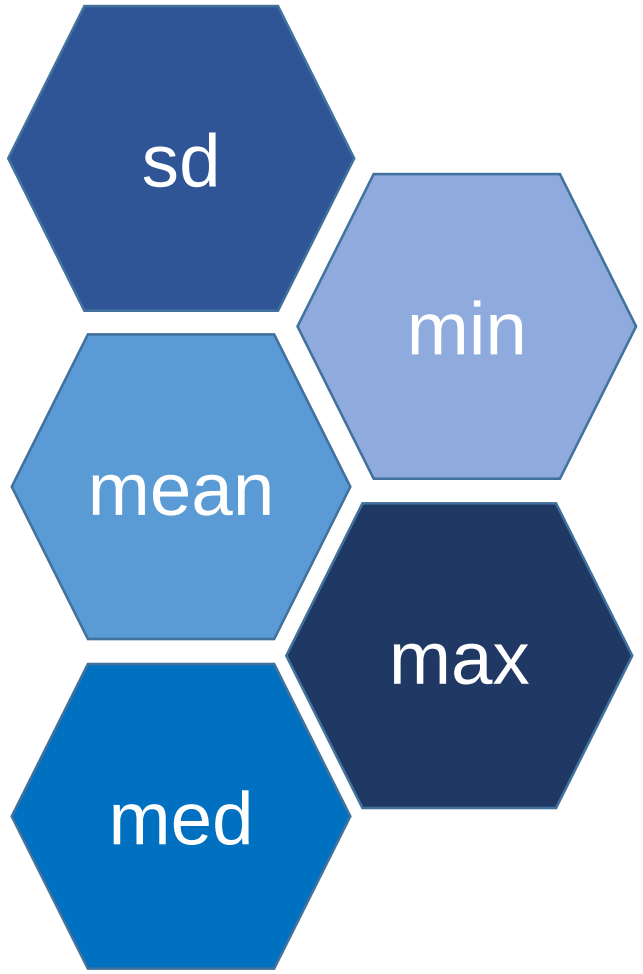
Assumptions

- OR, surgeon and staff are always available
- Any patient can be denied

SIMULATION FRAMEWORK

METRICS

Overall	
Patients Requesting Care (Patient Arrival)	
Accepted Patients	
Declined Patients	
ICU	**Stepdown (SDn)**
• Patient LOS • Unnecessary days in an ICU bed (SDn status) • Bed Utilization	• Patient LOS • Bed Utilization



ANALYSES

1

SDn Variation

- Change number of shared SDn beds

2

Bed Trade Off

- Change the ratio of ICU beds to SDn beds

3

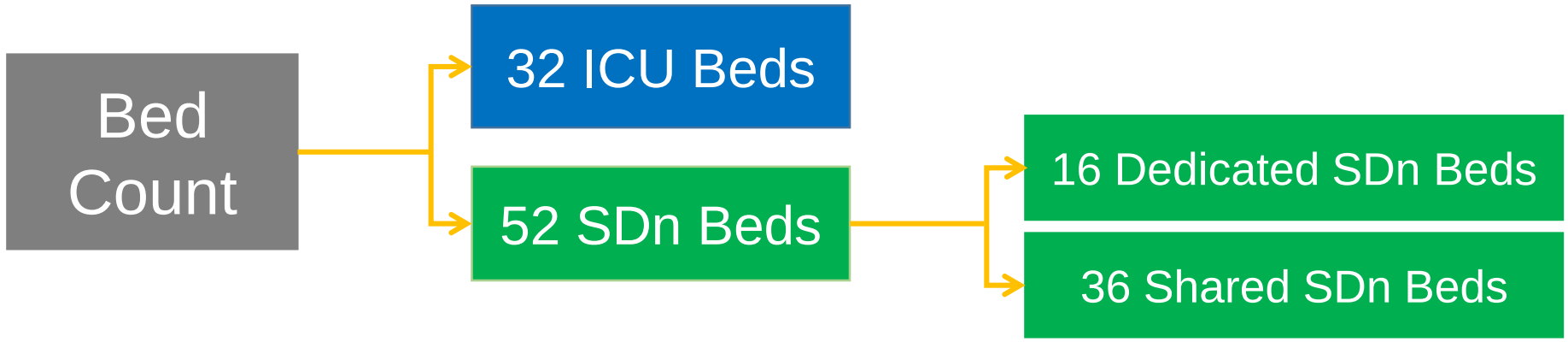
Arrival Rate

- Change the hourly patient admission rate

BASE CASE PARAMETERS

- 1 Patient Type
- Arrival Rate = 0.31 patient/hr
- Time Horizon = 1 Year
- Replications = 1,000

- Bernoulli trial for transfer and discharge from respective units
  - $P_{ICU\ Transfer} = 0.22$
  - $P_{SDn\ Discharge} = 0.24$

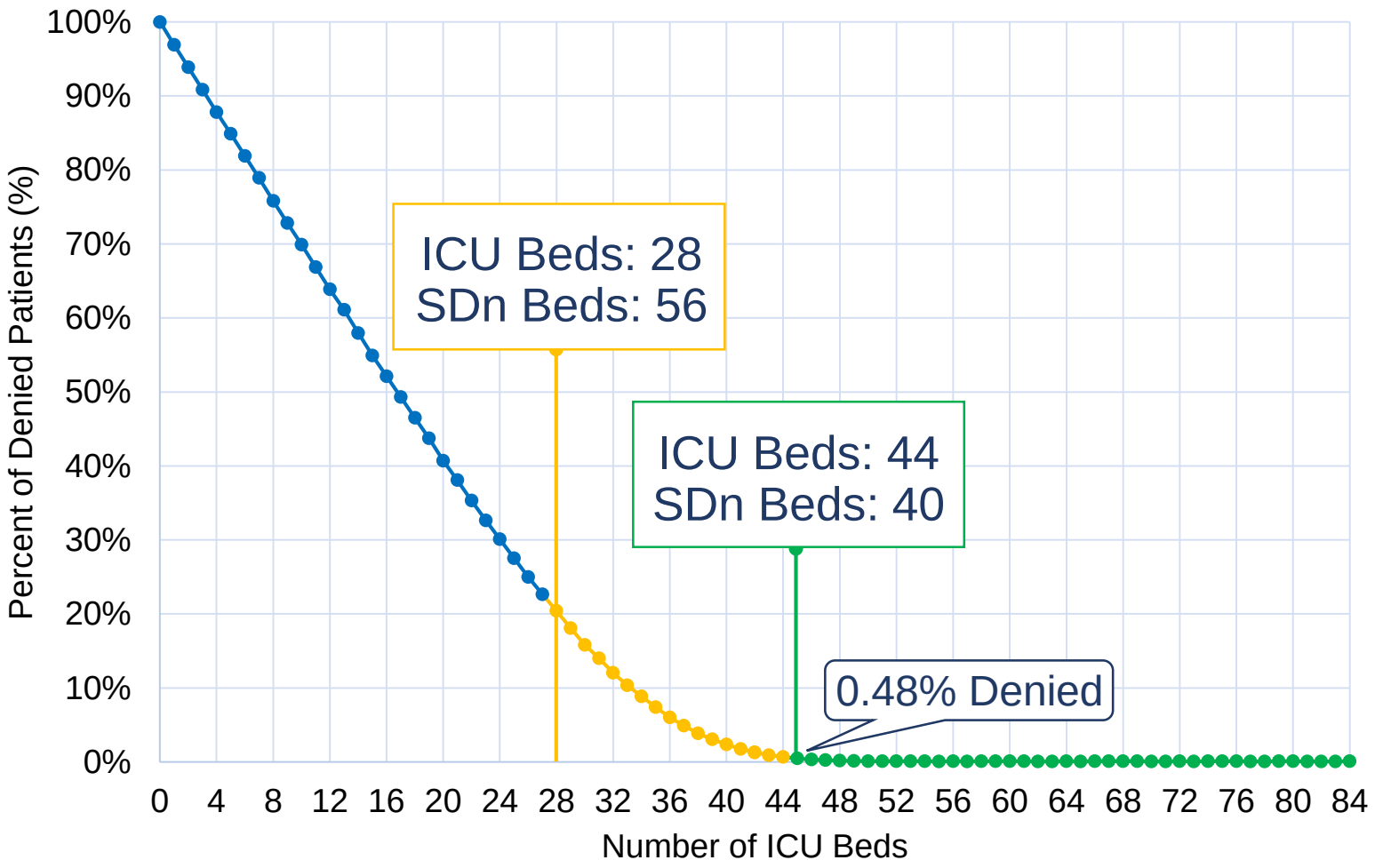


ANALYSIS 1: SDN VARIATION

Allocated Stepdown Beds	25	34	43	52
Patient Arrival	2718	2718	2714	2716
Declined Percentage	**16%**	**12%**	**12%**	**12%**
ICU Average LOS ICU Status	3.94 days	3.93 days	3.93 days	3.93 days
ICU Average LOS SDn status	**0.33 days**	**0.02 days**	**0 days**	**0 days**
SDn Average LOS	3.68 days	3.98 days	4 days	4 days

- Time Horizon = 1 Year
- Replications = 1,000
- 32 ICU Beds
- 16 Dedicated SD Beds

ANALYSIS 2: BED TRADE OFF



- There are always 84 beds in total
- For every ICU bed added, there is one SDn bed removed
- After 44 ICU beds, the percentage of denied patients becomes less than 1% however cost continues to grow

[9]

ICU Daily Cost $4,300/bed

SDn Daily Cost $1,909/bed

ANALYSIS 3: ARRIVAL RATE

Arrival Rate Increased by 30%

Arrival Rate	0.31	0.40	0.52	0.68	0.88
Patient Arrival	2718	3503	4556	5955	7710
Declined Percentage	**16.26%**	**32.51%**	**47.54%**	**59.80%**	**68.88%**
ICU Average LOS ICU Status	3.94 days	3.99 days	4.07 days	4.14 days	4.19 days
ICU Average LOS SDn status	**0.33 days**	**0.39 days**	**0.42 days**	**0.42 days**	**0.42 days**
SDn Average LOS	3.68 days	3.61 days	3.59 days	3.58 days	3.58 days

- Time Horizon = 1 Year
- Replications = 1,000
- 32 ICU Beds
- 25 SDn Beds

FUTURE RESEARCH

- Expanding the tool
  - Relaxing assumptions
  - Patient type
  - Admission logic

- Conducting Analysis
  - More Data!!!
  - Collaborator goals: Explore smoothing elective surgery

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Questions?

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