

# Discrete Event Simulation Of Outpatient Flow In A Phlebotomy Clinic

INFORMS, 11/15/2016

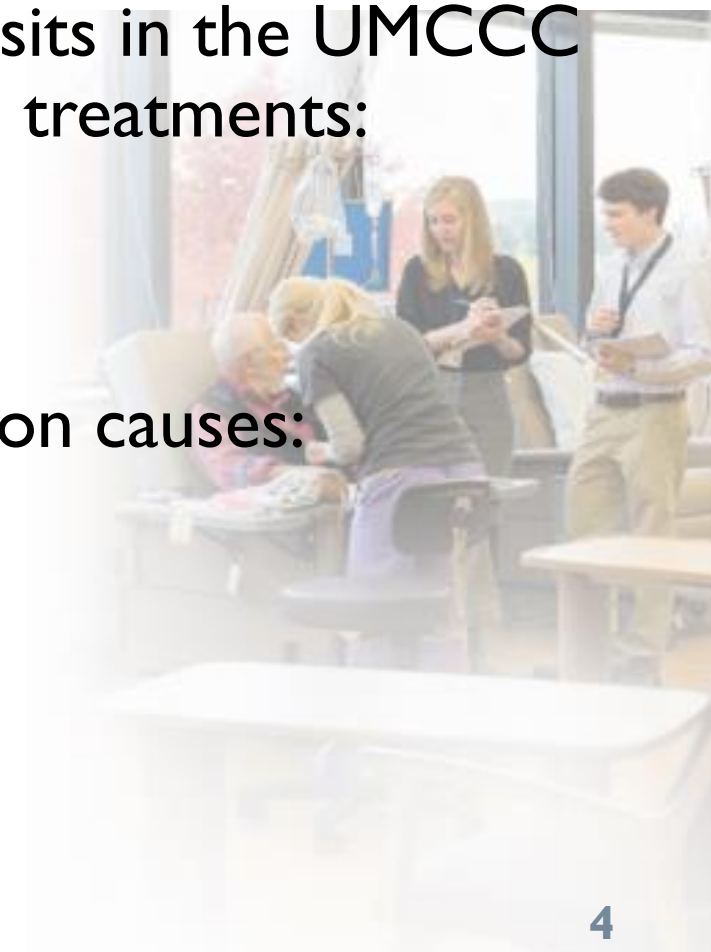
Elizabeth Olin  
Ajaay Chandrasekaran  
Amy Cohn  
Carolina Typaldos

- Background: UMCCC / Phlebotomy Department
- Approach: Discrete Event Simulation
- Analysis: What-if Scenarios
- Future Work

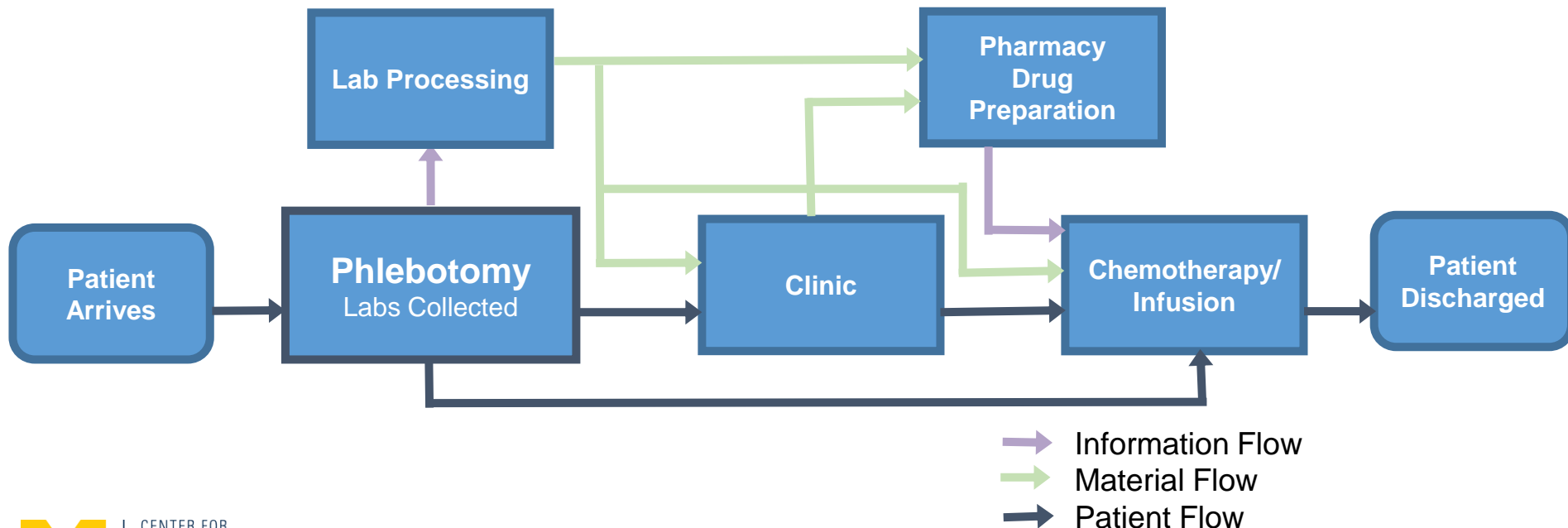


# BACKGROUND

- Home to 17 multidisciplinary and 10 specialty clinics, organized by cancer type
- In 2015, over 50% of outpatient visits in the UMCCC resulted in chemotherapy infusion treatments:
  - 97,147 outpatient visits
  - 58,419 infusion treatments
- High outpatient demand for infusion causes:
  - Process congestion
  - Increased patient waiting times
  - Overworked staff

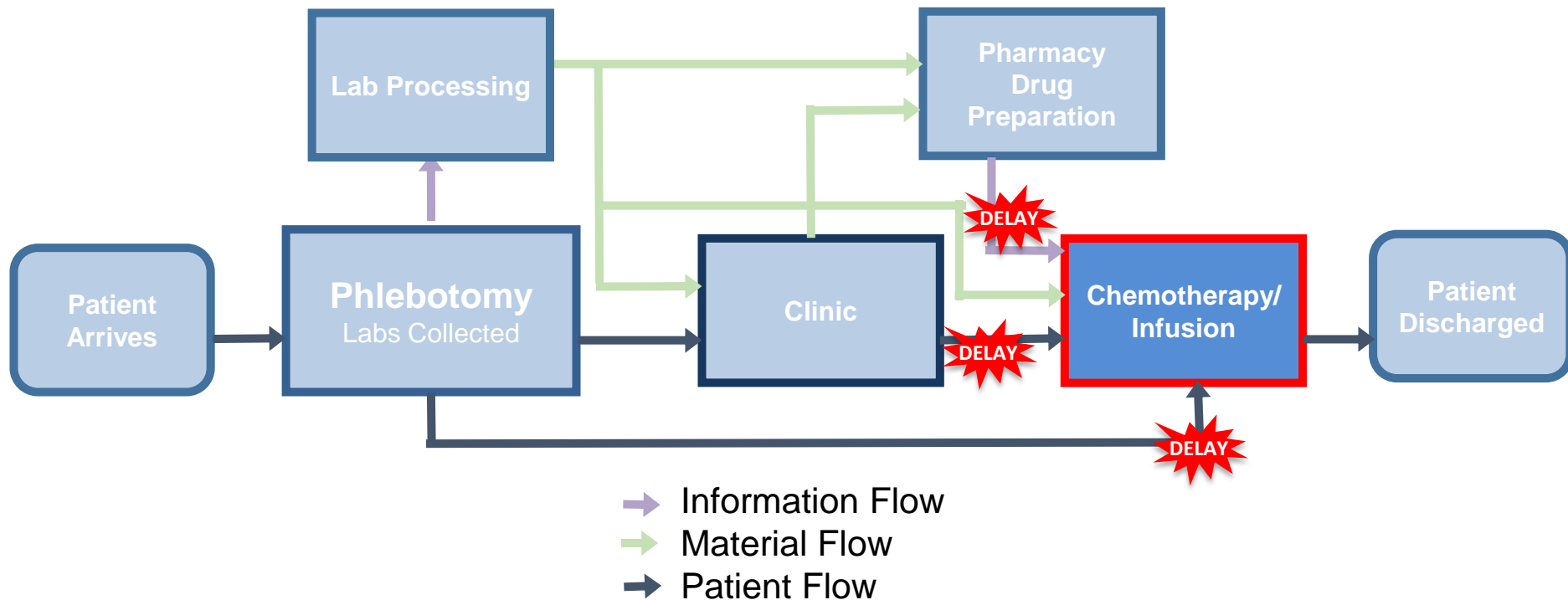


- Patient visit to Cancer Center
  - Often long, multi-step process
  - Can take anywhere from 30 min to 8 hrs
  - Requires multi department coordination



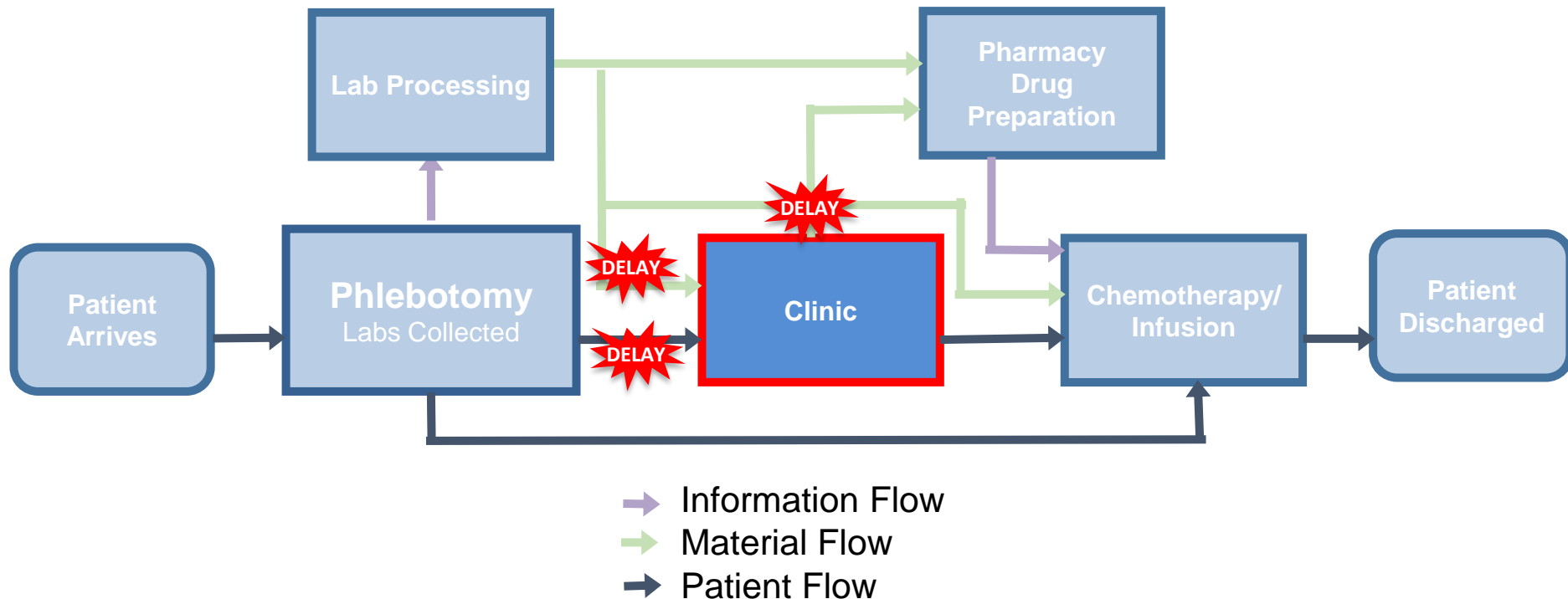
# Potential Delays at Infusion

- Patient is late
- No infusion chairs are available
- Infusion drugs are unavailable



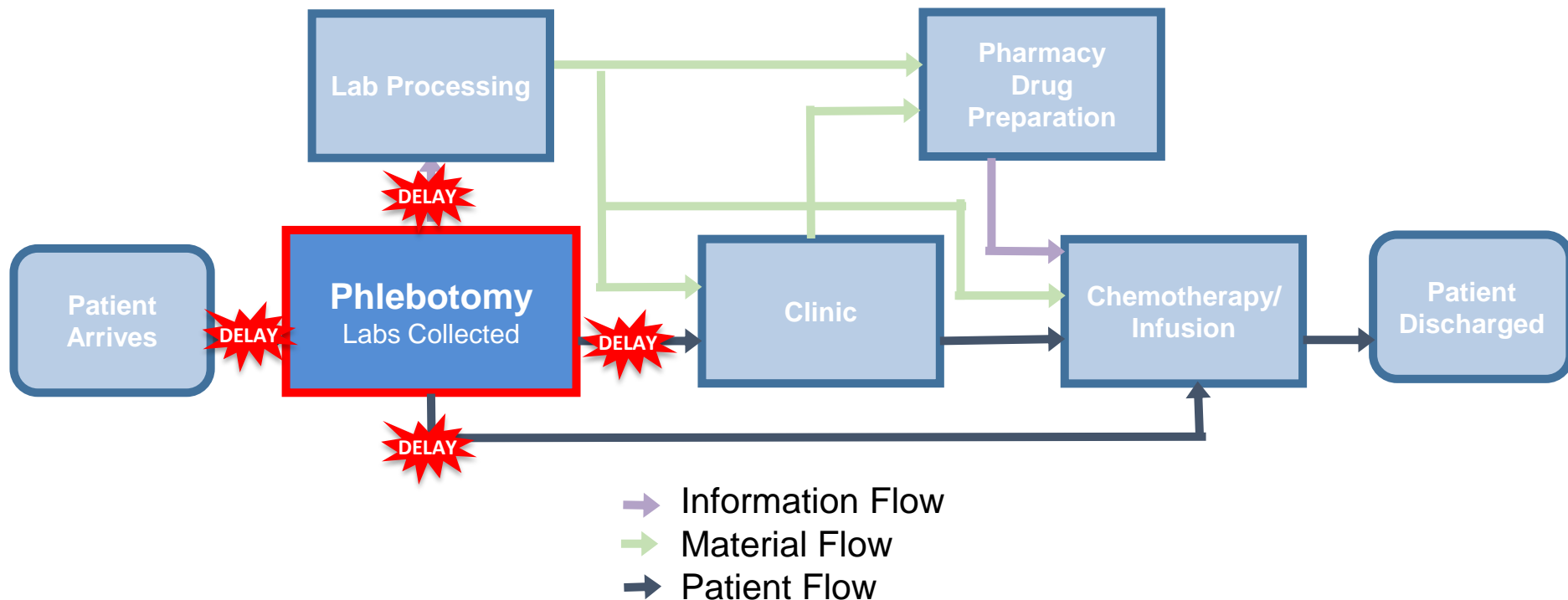
# Potential Delays at Clinic

- Patient is late
- Clinicians are unavailable
- Patient blood draw results are not ready



# Potential Delays at Phlebotomy

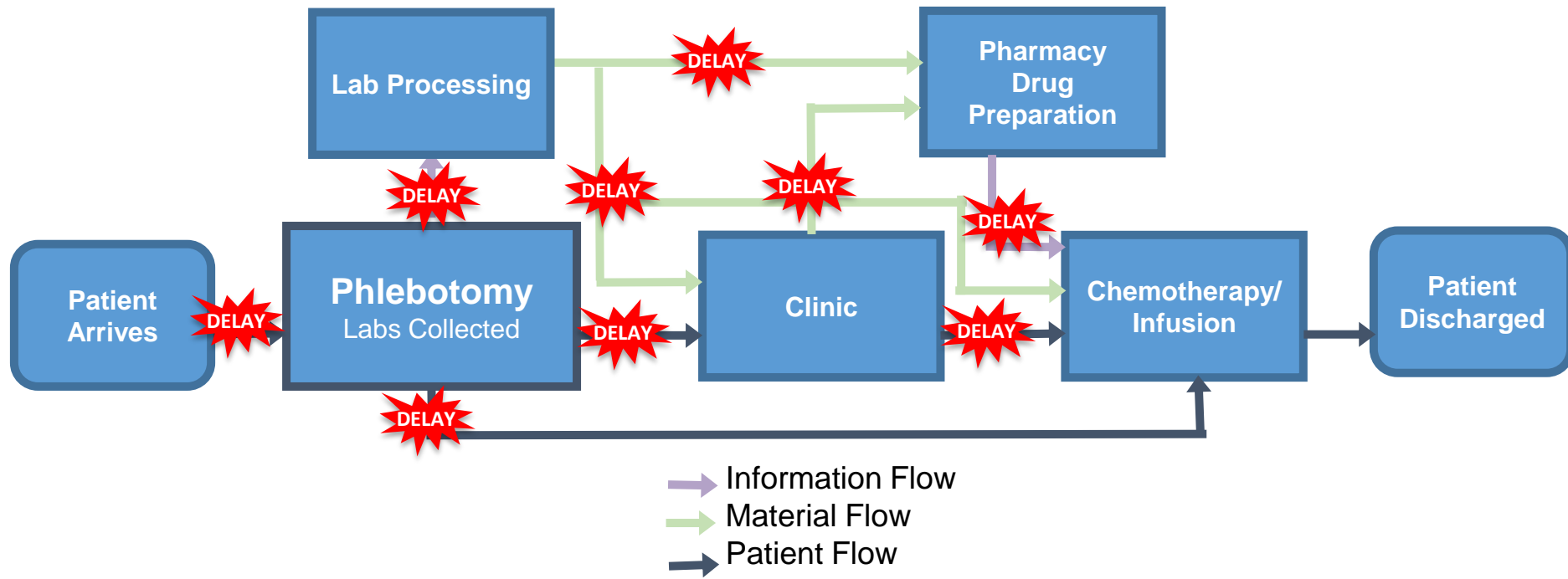
- Phlebotomist not available (check-in and/or draw)
- Chair not available
- Orders not ready

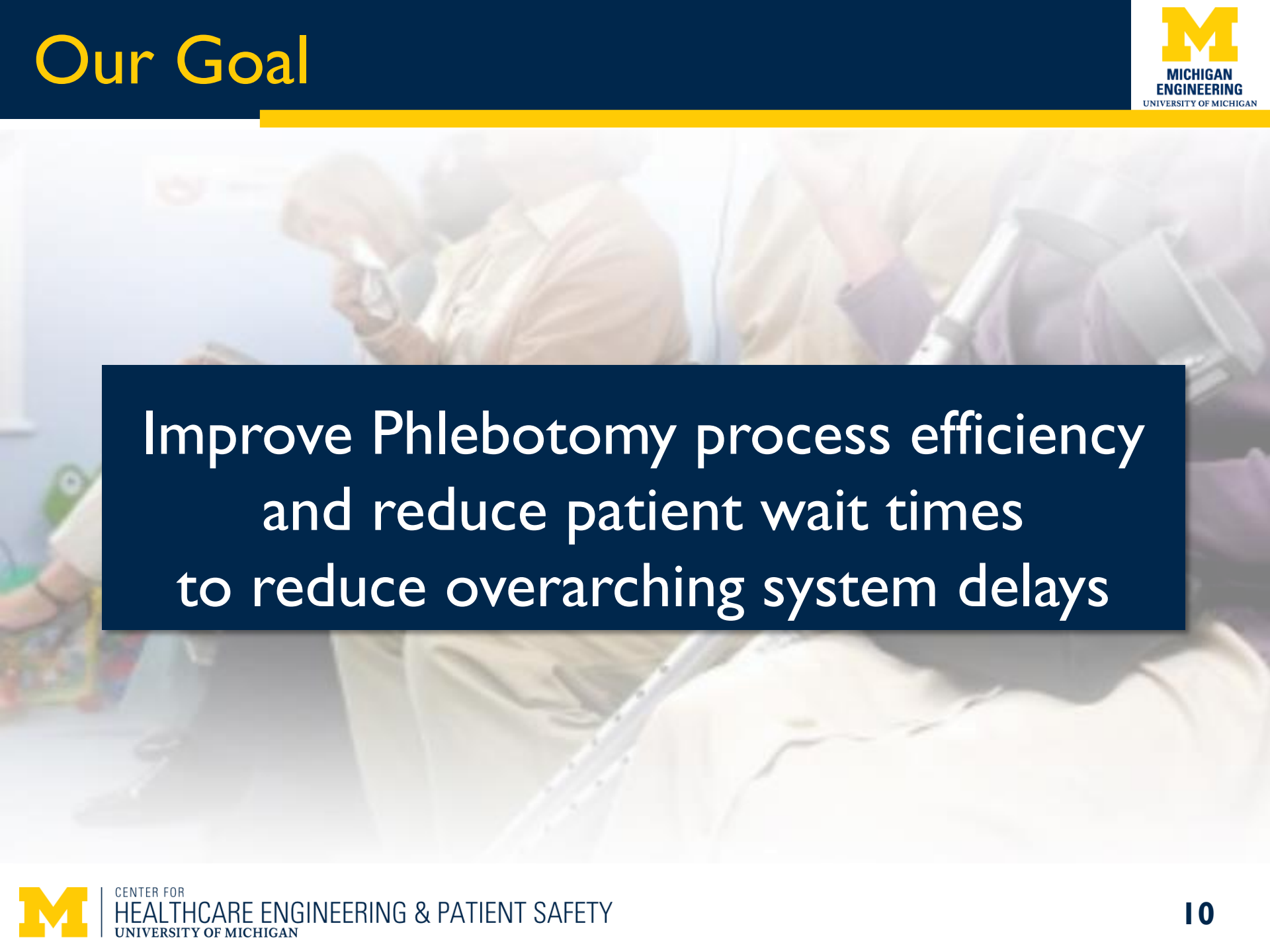




# Problem Statement

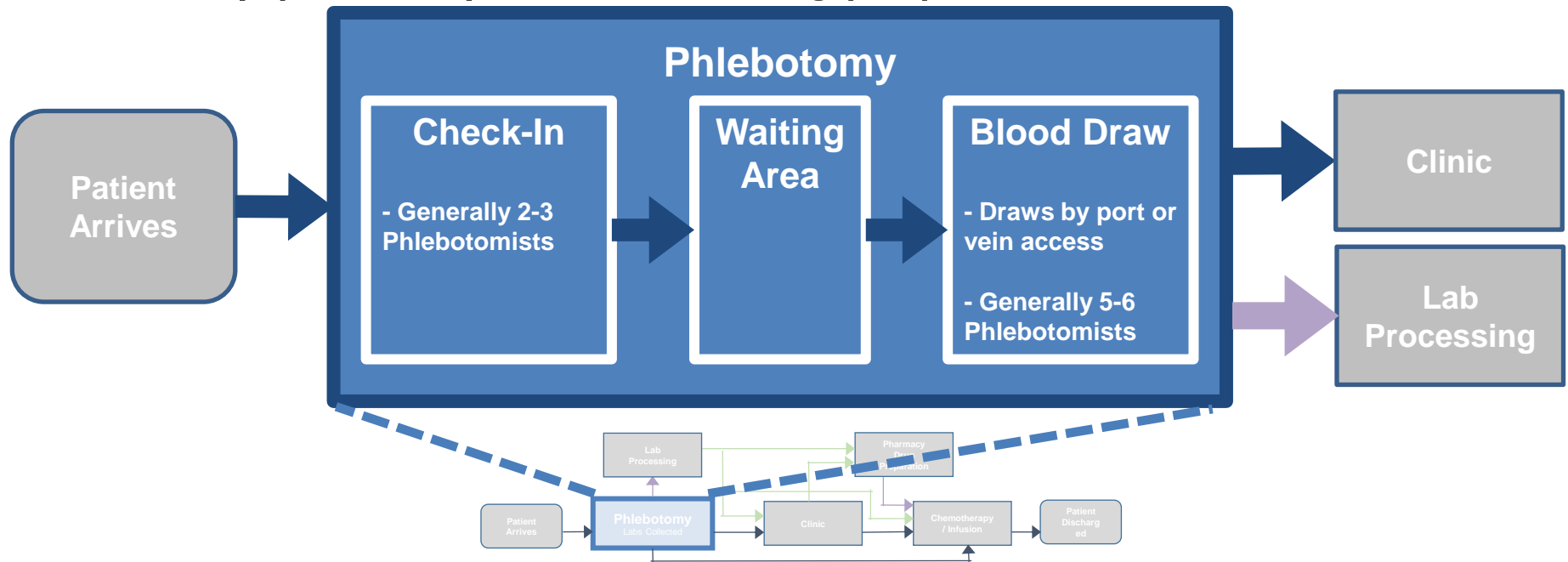
Delays in phlebotomy can ripple through the system

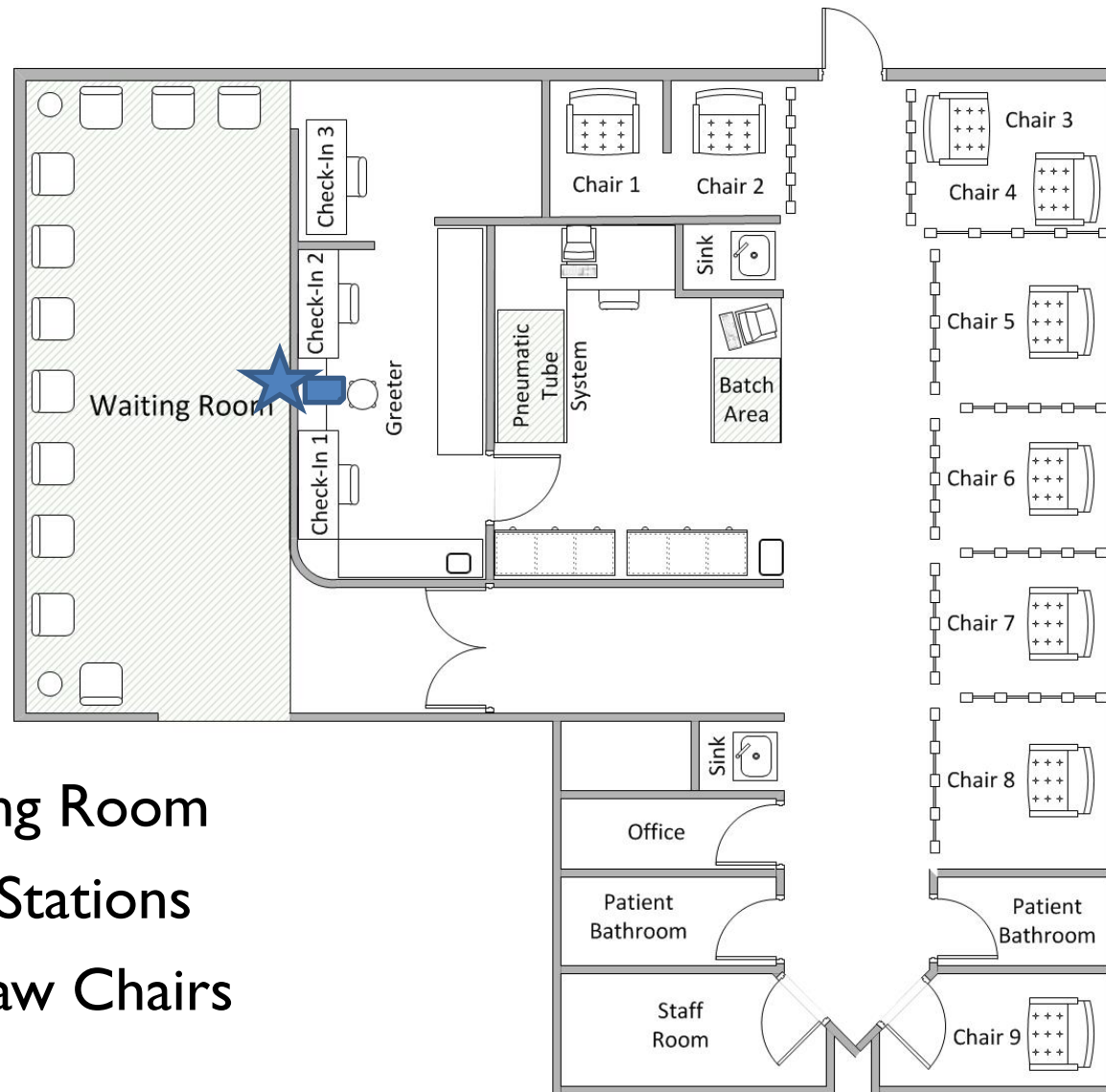




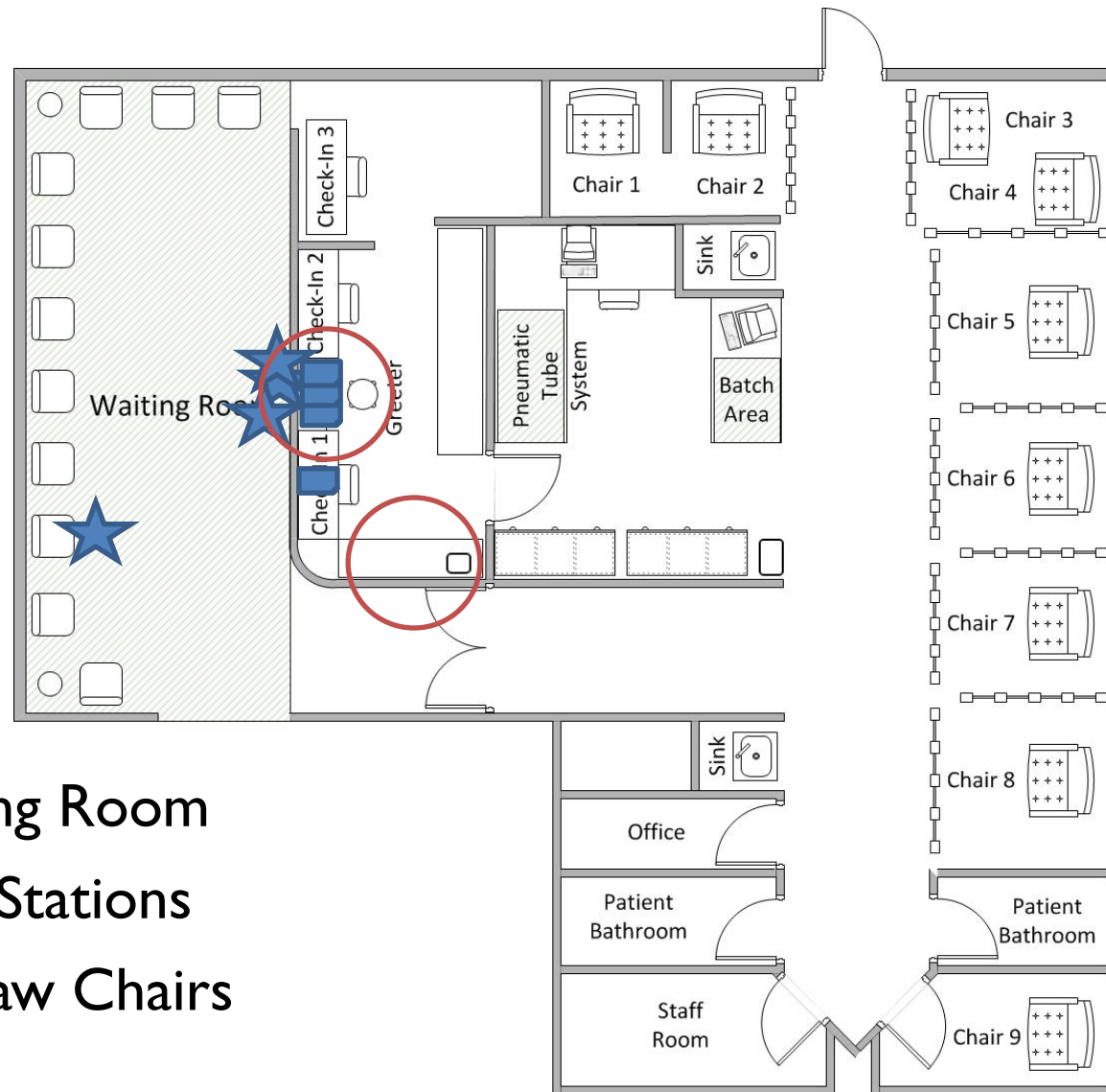
Improve Phlebotomy process efficiency  
and reduce patient wait times  
to reduce overarching system delays

- Nearly all patients enter the system through phlebotomy
- Multi-step/ multi-wait process → increased patient waits
- Blood drawn for labs needed:
  - By provider before clinic appointment to assess patient
  - By pharmacy to initiate drug preparation





- Large Waiting Room
- 3 Check-In Stations
- 9 Blood Draw Chairs



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- 3 Check-In Stations
- 9 Blood Draw Chairs





# APPROACH

- Computer Simulation Tool:
  - Visualize and analyze current operations
  - Test and measure the impact of different “what if” scenarios without having to carry them out
  - Manipulate input parameters to observe effect on various metrics



## Read Parameters

- Based on
  - MiChart data
  - Collected data
  - Expert opinion
  - Hospital regulations

## Run Simulation

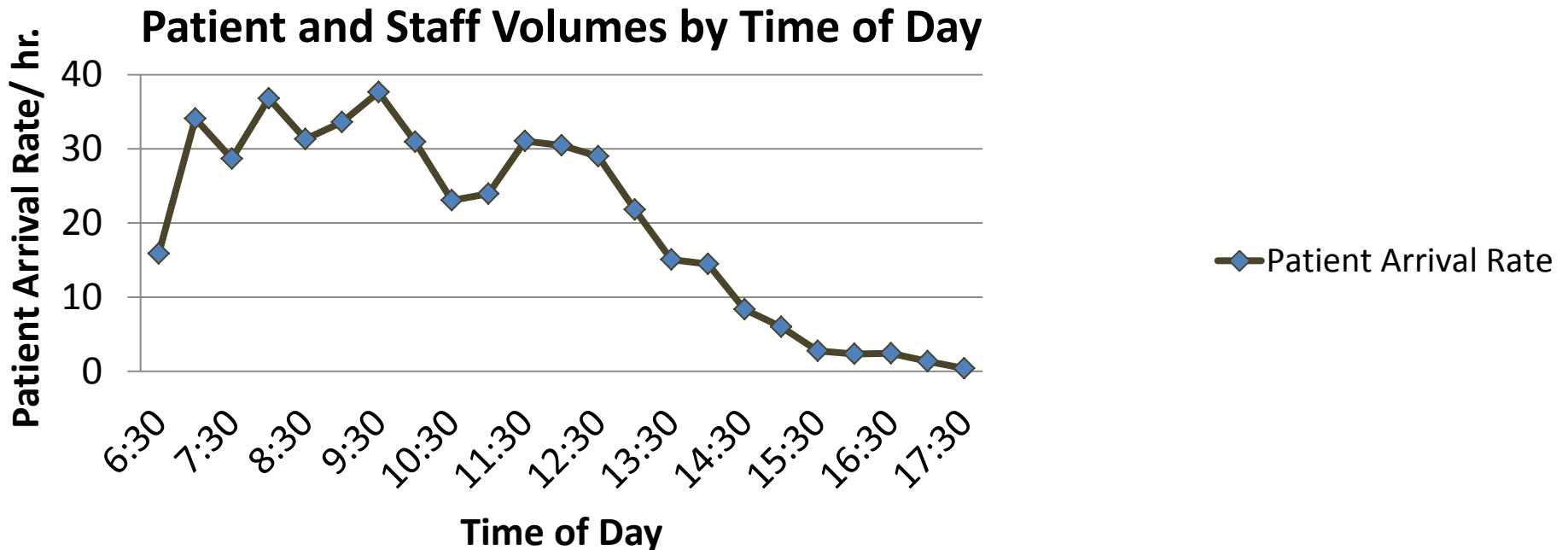
- User-specified number of iterations
  - 1 iteration = 1 simulated “day”

## Generate Results

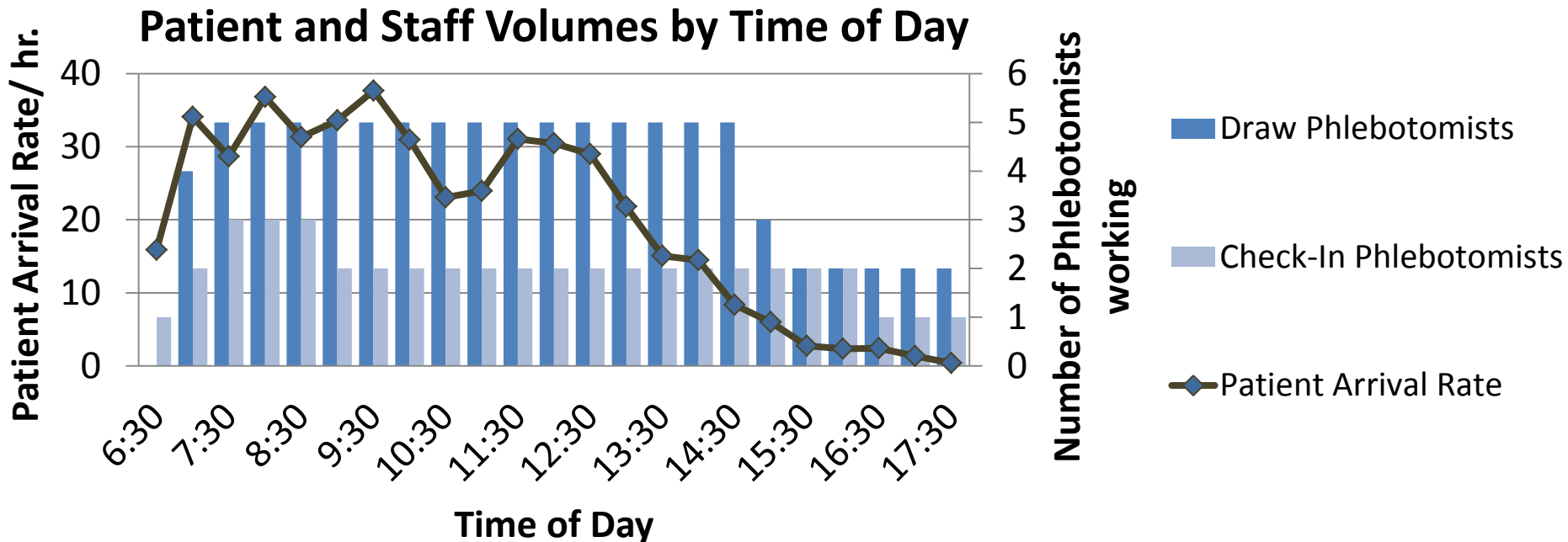
- Summary statistics
- Metrics for patients and phlebotomists
  - Wait times
  - Utilizations

- Developed in C++
- Three (3) main event types, each corresponding to an availability queue:
  - Patient Available for Check-In
  - Patient Available for Blood Draw
  - Phlebotomist Available
- As events occur, they are either completed or added to one of the availability queues
- Event Queue
  - Events are created and added to queue during simulation
  - Events in the queue complete in order (priority queue)
  - While there are still events in the queue, continue completing them

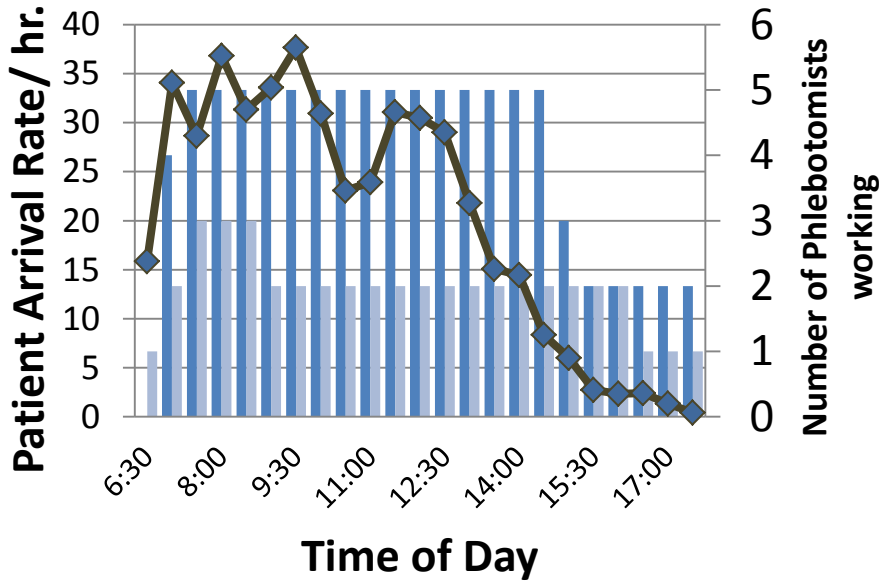
- Patient arrival distributions representing current uneven volumes



- Patient arrival distributions representing current uneven volumes
- Staffing levels based on current schedule (tailored to accommodate varying patient volumes)



# Base Case



Service Times	
Description	Mean (Standard Deviation)
Check-In	3.25 min (1.23 min)
Blood Draw	10 min (4 min)

	Mean Wait Time (m:ss)		
	Check-In	Draw	Total
<b>Base Case</b>	2:52	8:21	11:14



# ANALYSIS

- See system sensitivity to variations in input parameters
- Variable parameters:
  - Patient arrival rates and volumes
  - Staffing Decisions (Number of phlebotomists/ task allocation)
  - Service Times
  - Etc.

# What-if Analysis: Ideal Case

- Leveling system variability

Scenario	Mean Wait Time (m:ss)		
	Check-In	Draw	Total
<b>Base Case</b>	2:52	8:21	11:14
<b>Level Patient Arrivals</b>	2:47	6:18	8:03



# What-if Analysis: Ideal Case

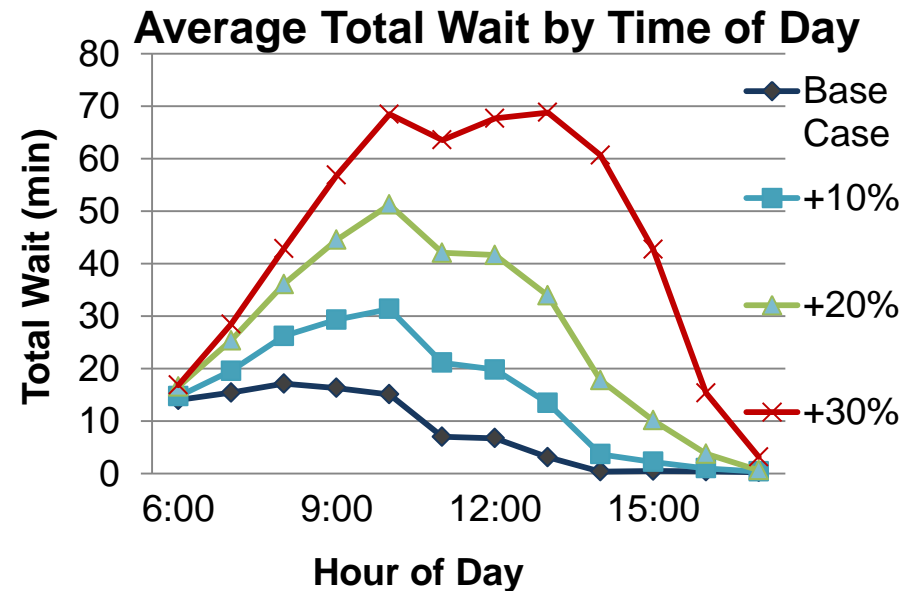
- Leveling system variability

Scenario	Mean Wait Time (m:ss)		
	Check-In	Draw	Total
<b>Base Case</b>	2:52	8:21	11:14
<b>Level Patient Arrivals</b>	2:47	6:18	8:03
<b>Level Arrivals &amp; Adjust Staffing (20 arrivals/hr &amp; 2 Check-in, 5 Draw all day)</b>	1:18	1:28	2:47

# What-if Analysis: Patient Volume Increase

- UMCCC experiences consistent growth
  - **Can current capacity handle increase volume?**

Scenario	Mean Wait Time (mm:ss)		
	Check-In	Draw	Total
Base Case	2:52	8:21	11:14
+10% Patient Volume	4:40	16:45	21:25
+20% Patient Volume	7:24	28:45	36:10
+30% Patient Volume	12:44	40:40	53:29



# What-if Analysis: Patient Volume Increase

- UMCCC experiences consistent growth
  - **Could staffing changes help accommodate?**

Scenario (Assume Increased Volume Base Case: +20% Patient Volume)		Mean Wait Time (h:mm:ss)		
		Check-In	Draw	Total
No additional Phlebotomist	<b>Increased Volume Base Case: +20% Patient Volume</b>	7:24	28:45	36:10

- Cancer Center patient visits can be long, multi-step processes
- Expected growth and bottlenecks in the current system necessitate process improvements
- Simulation techniques allow ‘what-if’ analysis for improvements without impacting current system
- Results can
  - Highlight issues
  - Explore areas of potential improvement
  - Support decisions for change implementation

- Better representing reality (current state) with more accurate:
  - Service time distributions
  - Arrival rate data
  - Non-instantaneous service transitions
  - Phlebotomist roles
- Exploration of additional “what-if” scenarios
- Pilot study for implementation of improvements
- Additional applications (outside of Phlebotomy) of simulation design

- Center for Healthcare Engineering and Patient Safety (CHEPS)
- Seth Bonder Foundation
- UMHS Comprehensive Cancer Center
- Research Collaborators
  - CHEPS students and staff
  - Cancer Center clinical collaborators and representatives (especially those from the Phlebotomy Department)

# Thank you!

# **QUESTIONS?**

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## CONTACT INFORMATION:

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**Amy Cohn** – [amycohn@umich.edu](mailto:amycohn@umich.edu)

Service Times	
<i>Description</i>	<i>Mean (Standard Deviation)</i>
Check-In	3.25 min (1.23 min)
Blood Draw	10 min (4 min)

- 2015 PHLEBOTOMY TIME STUDIES



## Event Queue

<u>Event Type</u>	<u>Participant ID</u>	<u>Time</u>
PatientAvailCI	3948	7:03:42
PatientAvailCI	2084	7:06:12
PhlebAvail	0962	7:15:00
PatientAvailCI	5541	7:16:09
PatientAvailCI	8737	7:20:33

## Clock



## PhlebAvail Queue

Participant ID      Time

## PatientAvailCI Queue

Participant ID      Time

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<u>Participant ID</u>	<u>Time</u>
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PatientAvailCI	5541	7:16:09
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## Clock



07:06:12

*Generate Service Time:  
2 minutes 51 seconds*

## PhlebAvail Queue

<u>Participant ID</u>	<u>Time</u>
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## PatientAvailCI Queue

<u>Participant ID</u>	<u>Time</u>
3948	7:03:42
2084	7:06:12

## Event Queue

<u>Event Type</u>	<u>Participant ID</u>	<u>Time</u>
PatientAvailCI	5541	7:16:09
PatientAvailCI	8737	7:20:33
PatientAvailBD	3948	7:17:51
PhlebAvail	0962	7:17:51

## Clock



## PhlebAvail Queue

<u>Participant ID</u>	<u>Time</u>
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## PatientAvailCI Queue

<u>Participant ID</u>	<u>Time</u>
2084	7:06:12



- Phlebotomy – 253 patients per day
- Clinic (7 Total) – 311 patients per day
- Infusion – 123 patients per day
  - 20% of infusion appointments are coupled

- Staff Schedule

		630	700	730	800	830	900	930	1000	1030	1100
Totals do not include the Associate Supervisor		2	10	12	13	13	13	17	17	17	16
	Front Desk	-2	-3	-3	-3	-3	-2	-2	-2	-2	-2
	Greeter		-1	-1	-1	-1	-1	-1	-1	-1	
	Clinic Sweep				-1				-1		
	Breaks/Lunches					-1	-2	-2	-2	-2	-3
	Part Time/Day Off		-1	-1	-1	-1	-1	-1	-1	-1	-1
	<b>Available to Draw</b>	<b>0</b>	<b>5</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>11</b>	<b>10</b>	<b>11</b>

1130	1200	1230	1300	1330	1400	1430	1500	1530	1600	1630	1700	1730
16	15	15	15	15	15	15	14	7	5	4	4	4
-2	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1	-1	-1
	-1				-1				-1			
-3	-3	-2	-3	-4	-2	-2	-2	-2				
-1	-1	-1	-1	-1	-1	-1						
<b>10</b>	<b>8</b>	<b>10</b>	<b>9</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>10</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>