Leveraging your Electronic Data Warehouse to Drive Operational Change

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MASSACHUSETTS GENERAL HOSPITAL

Agenda

HSE Background

Cancer Center Scheduling

Just-In-Time Bed Assignment

Bed Reallocation

Discussion

MGH-MIT Collaboration

MGH

Health Systems Engineering, collaborating with:

- Admitting
- Primary Care and Specialty Clinics
- Cancer Center
- Department of Medicine
- Hospital Inpatient Units
- Perioperative Services

MIT

Sloan School of Management & Operations Research Center

- Broad set of disciplines:

Operations Research
Operations Management
Economics
Organizational Behavior
Finance

The Team

Peter Dunn, Bethany Daily
Cecilia Zenteno, Mark Seelen,
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Clinicians, administrators,
data analysts, project specialists

Retsef Levi

Postdoctoral Fellows
Masters and PhD students
Undergraduate students

Collaboration

Data Analytics
(decision support tools)

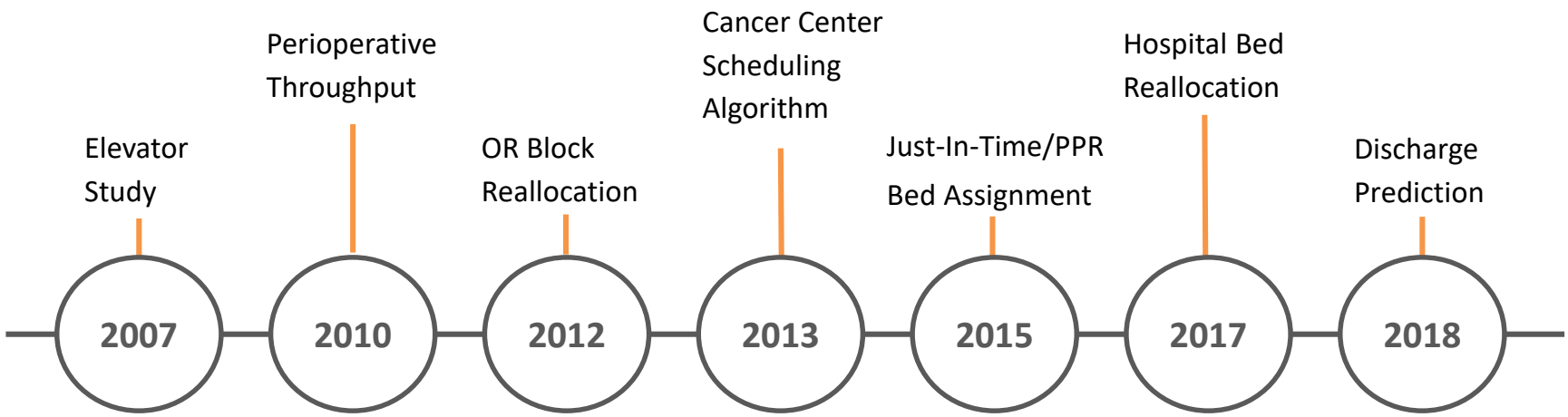
Simulation-Optimization Models
(predictions)

System/Process Innovation
(new practices)

Healthcare Systems Engineering (HSE)

Mission Statement

Healthcare Systems Engineering (HSE) tackles the **complex operational challenges** that arise in the highly variable environment of Academic Medical Centers by **developing and applying data-driven** Operations Research methodologies. We aim to redesign and optimize system-wide practices with the goal of **improving the quality and efficiency of patient care** processes.



Major Implemented Projects

HSE has spearheaded numerous projects in the hospital that have been fully implemented

1. **OR Block Reallocation** – Increased surgical units' effective capacity, enabling a **9% volume increase** and a **25% reduction in pre-op wait-time** for all waitlist patients; Referenced by McKinsey as a best practice to spread to other Partners hospitals

2. **Surgical Supply Optimization** – **Generated $1.5M in savings annually** by optimizing surgical custom packs

3. **Cancer Center Infusion Unit** – Improved Infusion Unit efficiency by increasing throughput of **12 additional patients/day** which will contribute **~$600K+ to the Cancer Center's** annual net margin

4. **Just-In-Time Bed Assignment (JIT)** – developed new hospital-wide bed assignment methodology for surgical patients, **decreasing median Patient Wait Time from the ED to Surgical Units by 33%.**

5. **Primary Care Centralization of Rx Management Process** – reduced required resources to process Rx's from **4.1 to 3 FTEs**; Inspired model adopted by **Physicians Organization for all Primary Care Practices**

Current Initiatives

HSE has several ongoing initiatives that are poised to make a significant impact on the institution

1. **Discharge Prediction Tool –** identified **128 bed-days that could be saved during a 90-day pilot** period on two surgical floors. Annualized and scaled to all surgical floors, this would equate to approximately 3,000 bed-days saved

2. **Bed Allocation** – Using optimization and simulation to determine bed reallocation moves across services that would **minimize ED congestion and off-service placements**

3. **Code Help** – Aiming to **classify Code Help incidences**, assess events' predictability, and **determine levers to minimize disruptions** in collaboration with multidisciplinary team from the ED, Admitting, and Clinical Staff

4. **Avoidable Admissions –** Aiming to reduce avoidable Heart Failure admissions via outpatient interventions, for which we built a **predictive model for CHF admissions for high risk patients (AUC of 0.78)**. We are working with Primary Care and Cardiology to implement within outpatient setting

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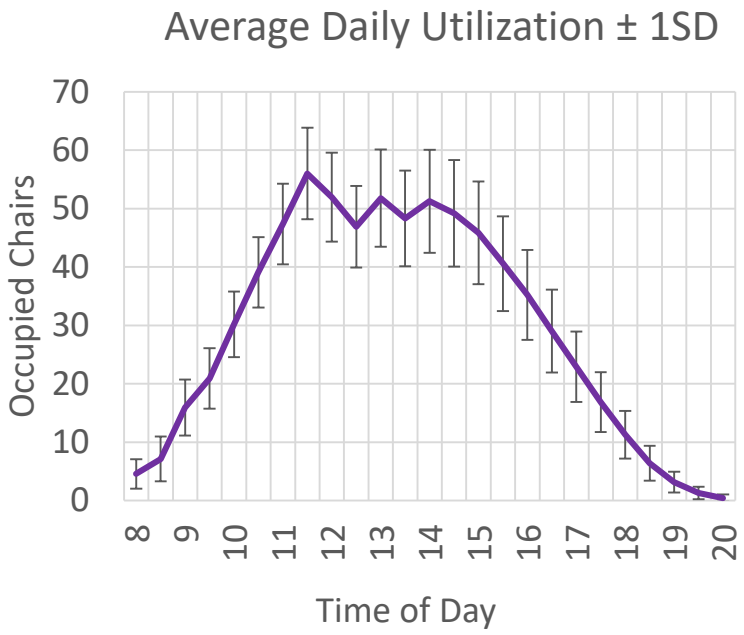
Infusion Scheduling: Problem Definition

The MGH Cancer Center Infusion Unit experienced extremely high volume during peak hours (10am - 2pm) and was otherwise underutilized.

Consequences:

- Long patient wait times
- Higher potential for patient-safety problems
- Staff and patient dissatisfaction
- Low utilization of expensive resources
- Wrong perception of insufficient capacity
- Prevents volume growth

Root cause: sub-optimal scheduling practices



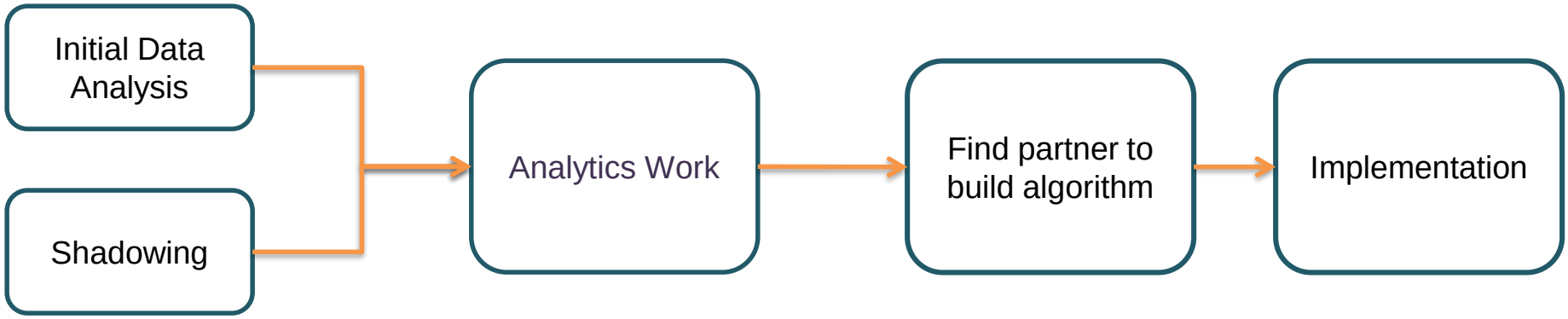
Average chair utilization throughout the day is ~55%

MASSACHUSETTS GENERAL HOSPITAL

Data source: MGH Cancer Center Patient Tracking
Timeframe: Jan-Dec 2013

Infusion Scheduling: Solution Approach

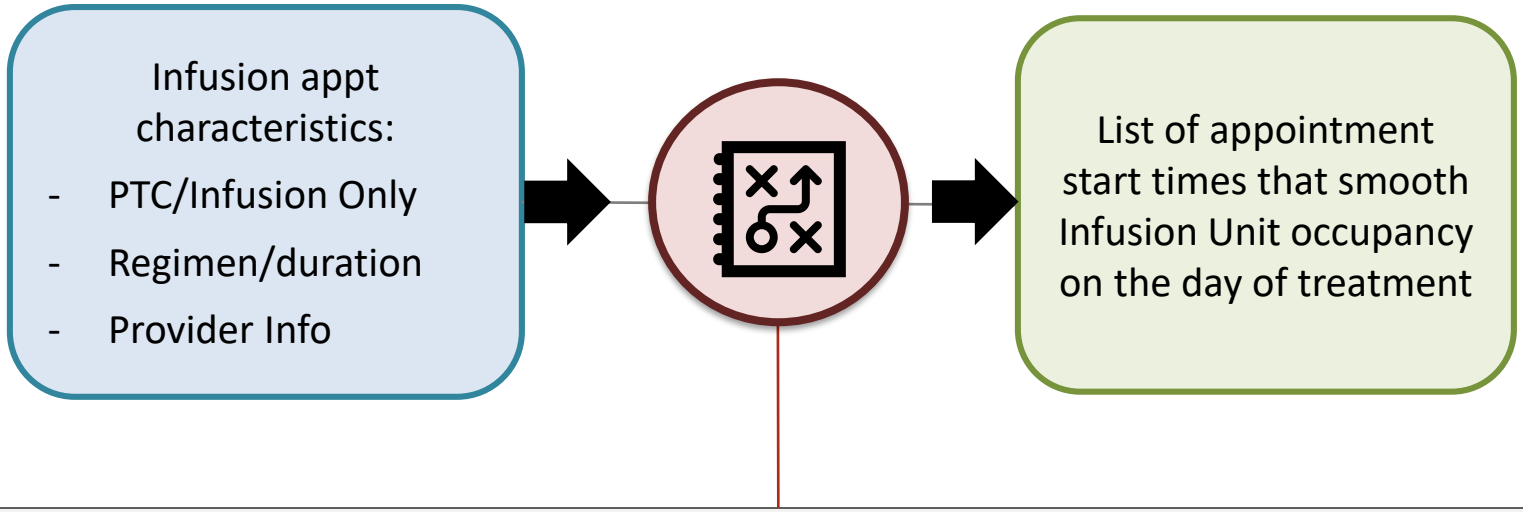
We sought to balance intraday bed/chair utilization while increasing daily throughput of patients.



Understand major system constraints → Used optimization and simulation to derive online-scheduling guidelines → Design tool with schedulers' workflow in mind → Staff training Communication strategy Monitoring

Infusion Scheduling: Technology Overview

The algorithm uses infusion appointment characteristics to generate a list of appointment start times that level infusion unit occupancy.



Infusion

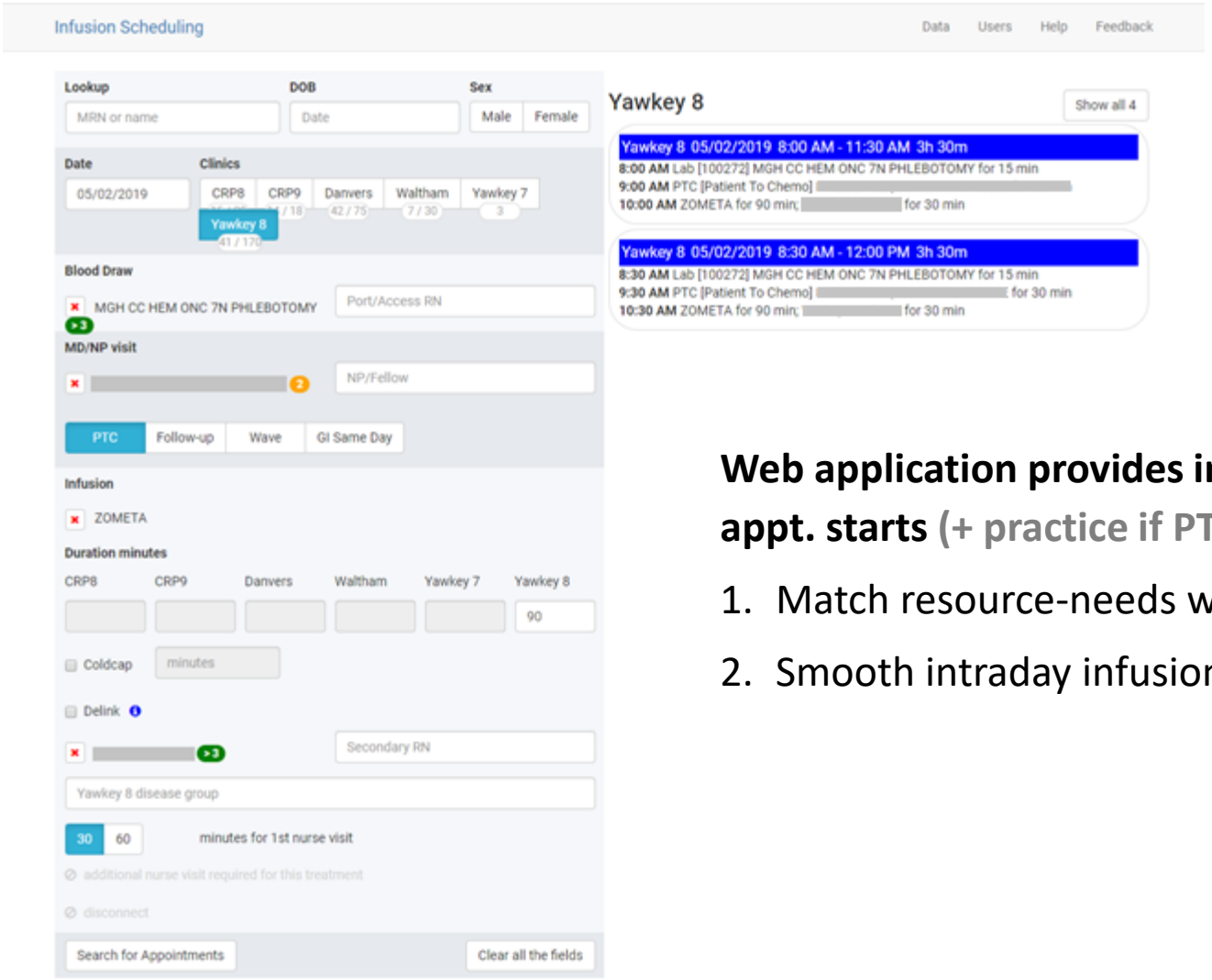
- Capacity – number of chairs
- Infusions start between 8am and 6pm
- Infusions should end before 7:30pm
- Treatments identified by nursing as sensitive to move to the tails of the day are scheduled between 9am and 4pm

Practice (PTC visits)

- MD-appt should happen between 1 hour and 2 hours before infusion start time
- Practice appointments are scheduled according to existing clinician schedules

Infusion Scheduling: Implementation

We partnered with MGH Lab of Computer Science to create external scheduling application that interacts with Epic.

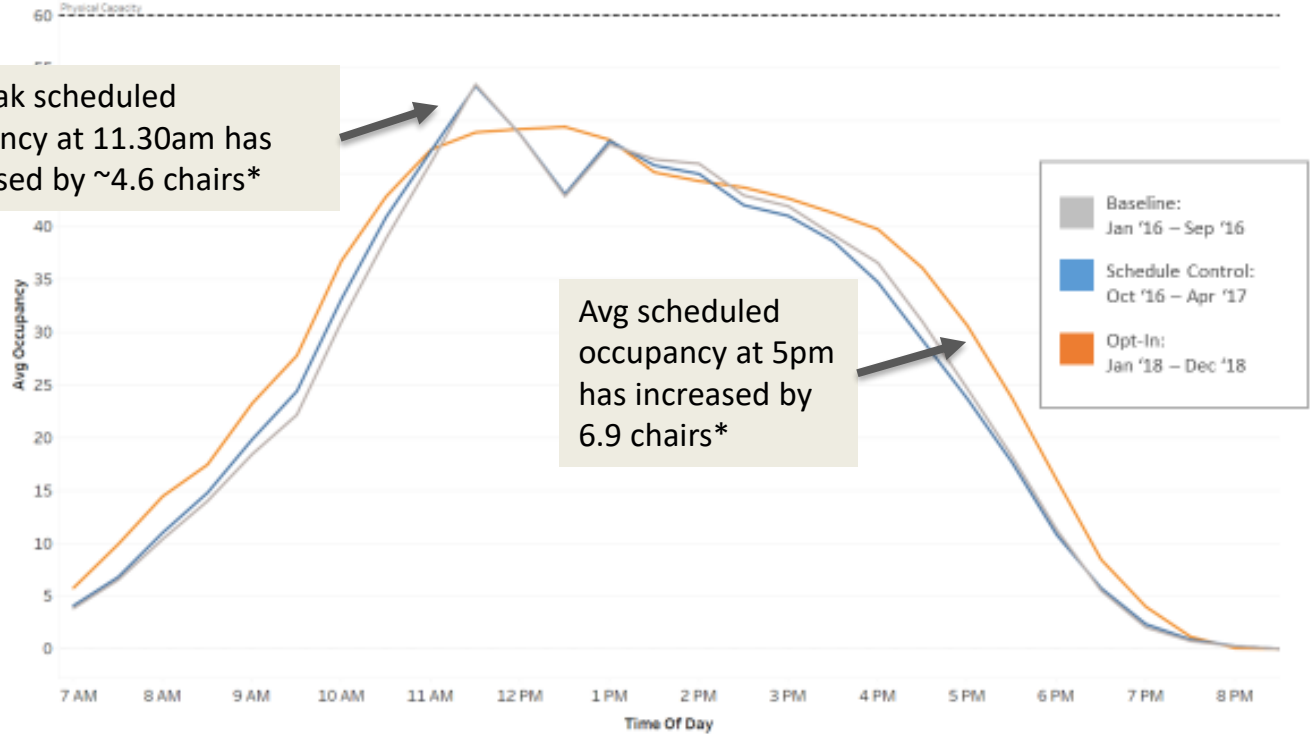


Web application provides infusion unit appt. starts (+ practice if PTC) that:

1. Match resource-needs with schedules
2. Smooth intraday infusion occupancy

Infusion Scheduling: Results

The tool also smoothed actual utilization across the main campus and enabled infusion for approximately 12 additional patients per day



Time Period	Average Patients/Day	Median Patients/Day	Avg Chair Hours / Day	Median Chair Hours / Day	Average Peak	Median Peak	Number Days in Period
Baseline	130.5	132	362.1	370.5	53.8	55	192
Sched Control	129.7	134	363.5	375.5	53.7	54	147
Opt-In	142**	146**	392.8**	402**	51.4**	53**	255

Source: EPIC Cadence. Includes completed appts, Mon-Fri; holidays not included (Infusion center is closed).
** Statistically significant ($p < 0.05$) per 1-sided K-S Test w.r.t. Schedule Control period.*
*** Statistically significant per 1-sided K-S Test w.r.t. Baseline period.*

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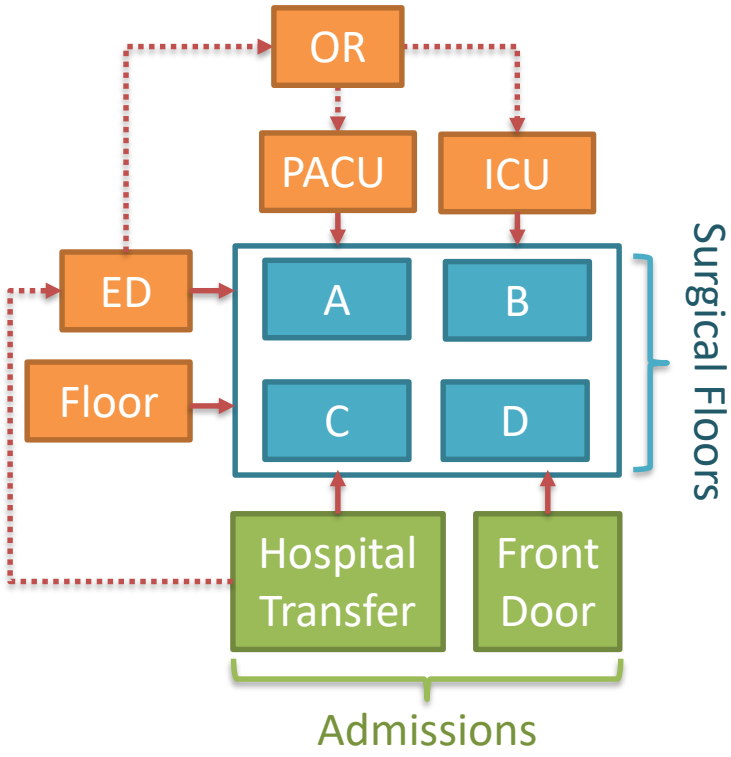
Discharge Prediction Tool

Closing Remarks

JIT Bed Assignment: Motivation

Main challenges in hospital bed assignment:

1. Uncertain arrivals from multiple sources
2. Patients must be matched to a bed that fits their needs
   a) Private vs. non-private rooms
   b) Cohorting: sex and infection precautions
   c) Prioritization by patient source
   d) Care team assignment
3. Uncertain discharges throughout the day



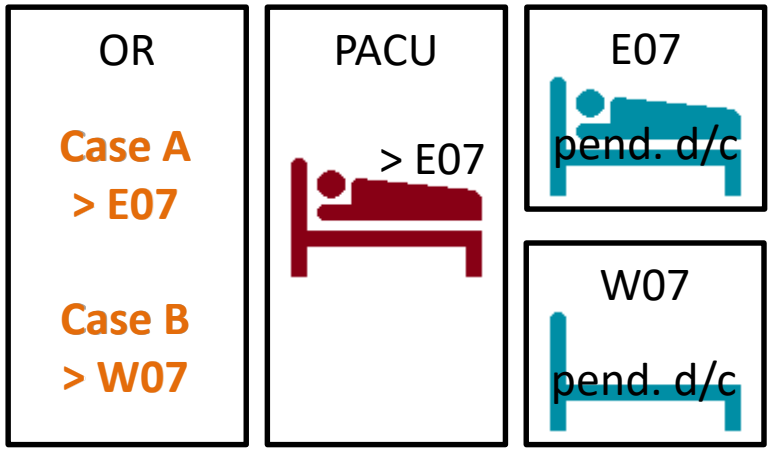
Suboptimal bed assignment:

- Upstream congestion (e.g., ED, PACU)
- Excessive patient wait times
- Prolongation of length-of-stay

Figure shows a stylized depiction of demand for surgical beds.

JIT Bed Assignment: Motivation

- Previous policy assigned beds early in the day, before surgery is finished



- ICU bed assignments were heavily deprioritized w.r.t. ED and PACU

Goal: Design a new bed assignment policy that would

- Decrease patient wait time for inpatient surgical beds
- Reduce congestion in PACU, ED, and ICU

JIT Bed Assignment: Solution Approach

Used discrete-event simulation to model and evaluate a **new bed assignment policy** in 4 surgical units.

I. JIT bed assignment:

Ready patients* are assigned to ready beds**

** Patients medically ready to transfer*

*** Empty beds (not necessarily clean)*

II. Equal Prioritization:

All floor-bed-requests are treated in a First-Come-First-Served basis, irrespective of the source*

** There may be exceptions if the ED is at full capacity*

Performance Metric – Patient wait for bed (hrs):

Patient medically ready until latest of {bed assigned, bed clean, patient medically ready} *(This excludes hand-off and transportation times)*

Implemented across all the surgical and neuroscience units.

JIT Implementation:

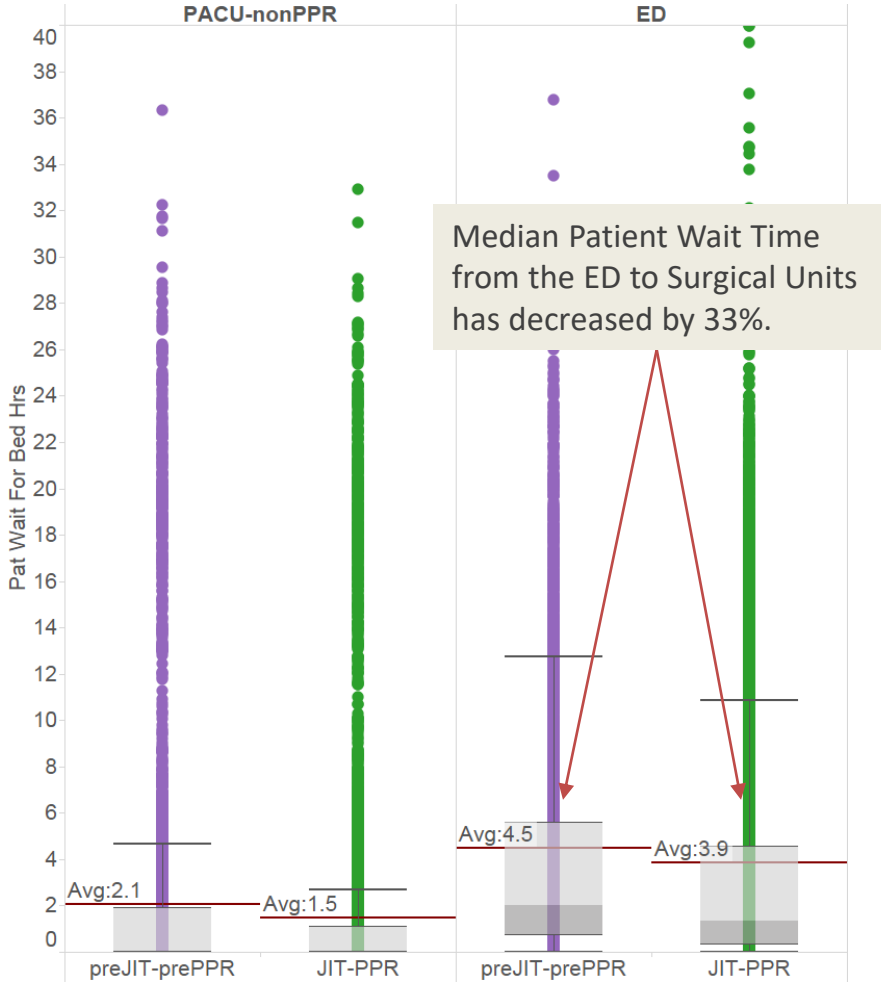
3 waves throughout 1st half 2017

Equal Prioritization Implementation

2 waves: Nov 2017 & Jan 2018

JIT Bed Assignment: Results

These methodologies led to significant reductions in patient wait time for beds



Median Patient Wait Time from the ED to Surgical Units has decreased by 33%.

	preJIT-prePPR	JIT-PPR
PACU-nonPPR		
5th-p	0.0	0.0
25th-p	0.0	0.0
med	0.0	0.0
avg	2.1	1.5
75th-p	1.9	1.1
95th-p	14.8	6.8
N	4847	9363
ED		
5th-p	0.2	0.0
25th-p	0.7	0.3
med	2.0	1.3
avg	4.5	3.9
75th-p	5.6	4.5
95th-p	17.3	16.8
N	3458	6501

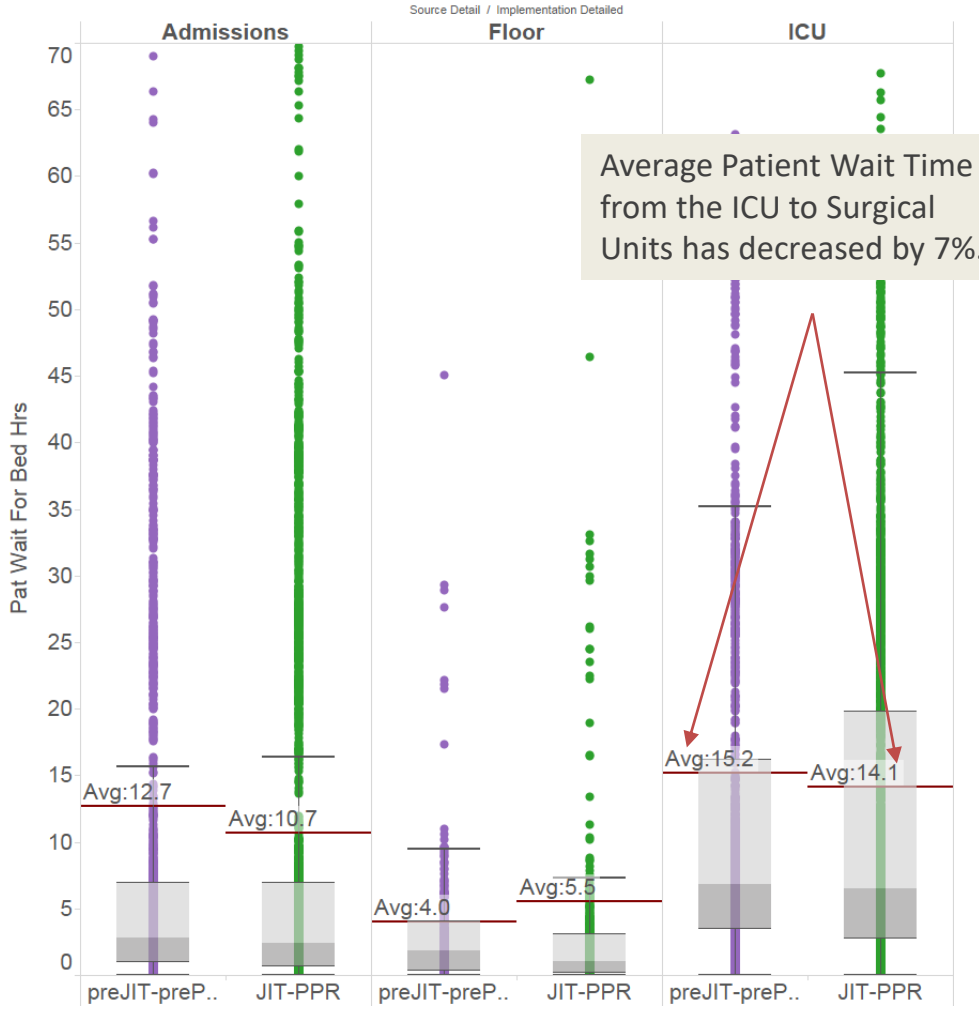
preJIT-prePPR *07/01/2016 - 01/29/2017 (146 days)*
JIT-PPR *wave start - 05/25/2018 ({316, 261, 247} days)*

Sources: EPIC:= {Encounter_ADT_MGH, BedPlanHist, OR Case data}.
Time frame: 7/1/16 – 5/25/2018, weekends and holidays excluded.

1st Wave (2/27/2017): := Ortho + Urology (66), General Surgery (63)
2nd Wave (5/15/2017): Neurosciences (32 & 32), Gynecology (20), Surg/Med/Ortho (19)
3rd Wave (6/5/2017): Cardiac Surgery (36), Thoracic surgery/Medicine (30), Vascular (27), Transplant (21), Plastics/OMF/Burn (21) – [Services affected (#beds)]

JIT Bed Assignment: Results

These methodologies led to significant reductions in patient wait time for beds



Average Patient Wait Time from the ICU to Surgical Units has decreased by 7%.

preJIT-prePPR *07/01/2016 - 01/29/2017 (146 days)*

JIT-PPR *wave start - 05/25/2018 ({316, 261, 247} days)*

	preJIT-prePPR	JIT-PPR
Admissions		
5th-p	0.2	0.0
25th-p	1.0	0.6
med	2.9	2.4
avg	12.7	10.7
75th-p	6.9	7.0
95th-p	40.1	41.0
N	1745	3085
Floor		
5th-p	0.1	0.0
25th-p	0.4	0.2
med	1.8	1.0
avg	4.0	5.5
75th-p	4.0	3.1
95th-p	9.6	20.9
N	291	469
ICU		
5th-p	0.9	0.2
25th-p	3.4	2.7
med	6.8	6.5
avg	15.2	14.1
75th-p	16.2	19.8
95th-p	56.6	52.0
N	1477	3021

1st Wave (2/27/2017): := Ortho + Urology (66), General Surgery (63)
2nd Wave (5/15/2017): Neurosciences (32 & 32), Gynecology (20), Surg/Med/Ortho (19)
3rd Wave (6/5/2017): Cardiac Surgery (36), Thoracic surgery/Medicine (30), Vascular (27), Transplant (21), Plastics/OMF/Burn (21) – [Services affected (labels)]

Sources: EPIC:= {Encounter_ADT_MGH, BedPlanHist, OR Case data}.
Time frame: 7/1/16 – 5/25/2018, weekends and holidays excluded.

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Closing Remarks

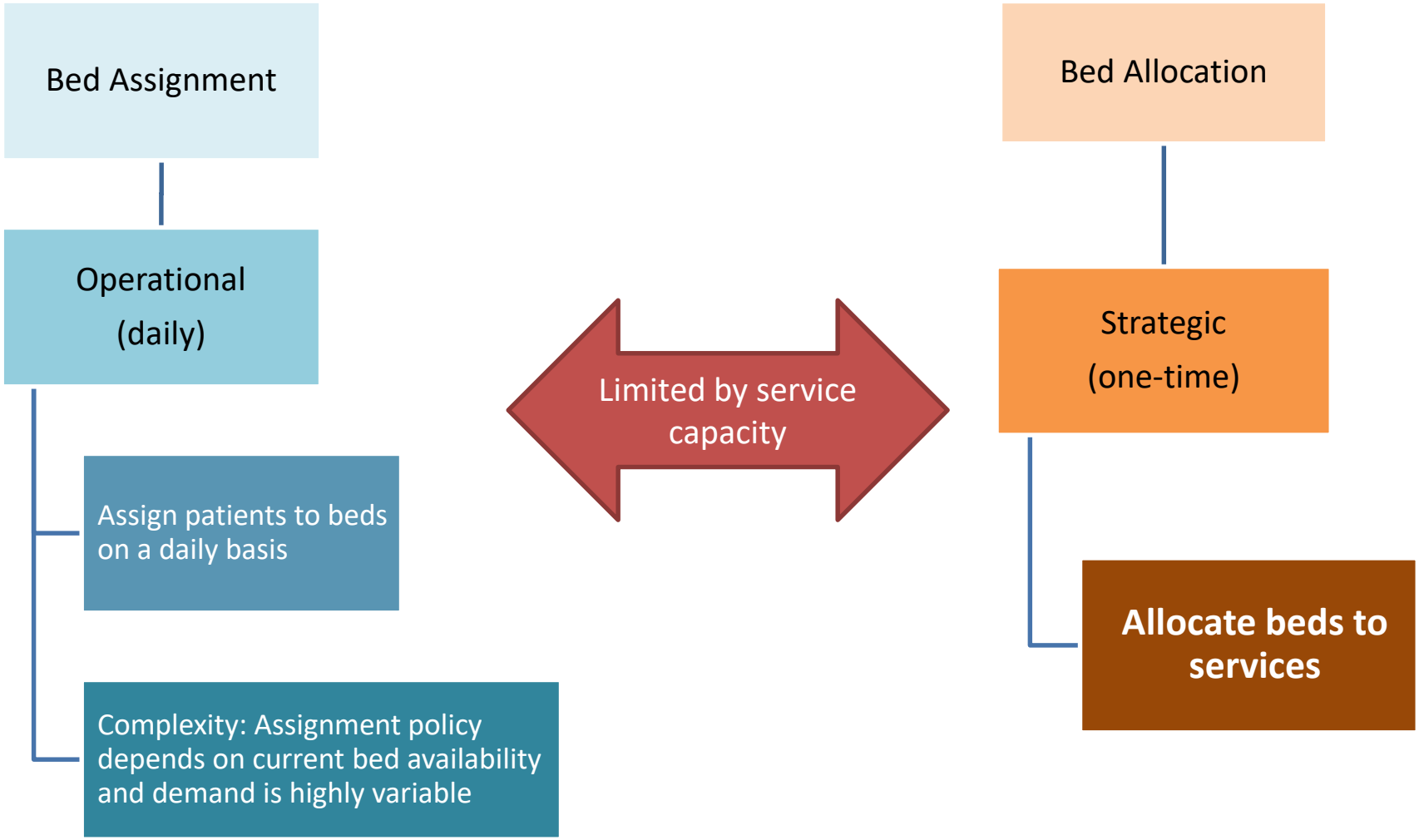
Bed Reallocation: Motivation

- **Off-service placements** occur when a patient cannot be placed on the unit that she is intended to go to for optimal care.
- MGH has experienced a significant number of off-service placements in recent years, typically due to high variability in the demand for services.

Category	CY17 Average daily # off-service patients at 7am
Patients held in ED	11.4
Off-service Medicine	43.3
Off-service Surgery	16.2
Patients held in Hospital Transfer or Front Door	5.2
Patients held in ICUs	5.1
Patients held in PACU	0.9

Note: current state off-service placements measured at 7am for CY2017; only patients requiring a general care level shown. "Medicine" excludes patients historically on E8, E10, and E11; patients with service listed as "Oncology" are included in the "Medicine" patient category here.

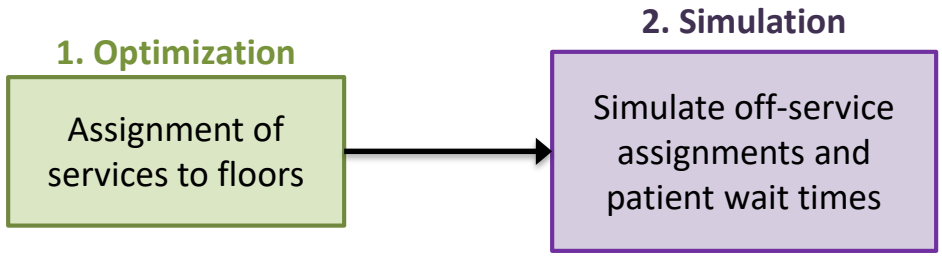
Bed Reallocation: Motivation



Bed Reallocation: Solution Approach

Built an optimization model to find bed allocation that would:

1. Reduce number of ED patients waiting for an inpatient floor bed
2. Reduce number of off-service medicine patients and patients held in ICUs (waiting to transfer to general care floors)
3. Reduce number of off-service surgical patients



Created a detailed simulation model of the surgical and medicine floors to assess impact of different allocations.

Main data sources used: bed assignment, cohorting (infection status, precautions, etc.), and care teams.

Bed Reallocation: Model Results

Service	Previously Allocated Beds	Average 7am weekday census	*New State Allocated Beds*	
General Medicine	232	253	270	↑
Oncology	80	84	90	↑
General Surgery	71	57	61	↓
Neurosciences	64	61	68	↑
Orthopedics	59	44	53	↓
Vascular Surgery	27	12	15	↓
Transplant	21	15	21	→
Thoracic Surgery	20	11	15	↓
Gynecology	20	11	11	↓
Plastics/Burn/OMFS	14	13	14	→
Flexible Surgery	0	-	8 + {10}	↑
(unassigned/unavailable until mid 2019)	18 + {10}		0	

Note: current beds as of September 2018; beds denoted in {brackets} are unlicensed. Only licensed general care floor beds and White 13 included; not listed are 158 ICU and RACU beds, nor the nursery beds on E13 and B13. "Unassigned beds" represent 18 licensed beds on Bigelow 7 that are currently used as ED observation beds and will become available for general care use in mid-2019. "Flexible Surgery" is bed capacity available for use by any surgical service. *: 6 beds on Ellison 8 are designated as cardiac medicine beds, although these are regularly used for cardiac surgery and general medicine patients due to insufficient staffing. "Census" denotes the average number of patients in a general care bed at 7am in CY17, regardless of service assigned to the location.

Bed Reallocation: Model Results

Category	CY17 avg. daily # patients at 7am	New state avg. daily # patients at 7am
Off-service Medicine	43.3	5.6
Off-service Surgery	16.2	14.9
Patients held in ED	11.4	10.2
Patients held in Hospital Transfer and Front Door	5.2	5.7
Patients held in ICUs	5.1	5.2
Patients held in PACU	0.9	1.5
Total off-service patients	**82.1**	**42.1**

Off-service surgical patients represent common, existing assignments between surgical units. "Patients held" are estimated at 7am as patients who have requested a bed and are medically ready, but not yet been assigned a bed.

Note: current state based on CY2017 (patients held estimated based on simulation time period then annualized). "Simulated" based on simulation over time frame June 5, 2017 to December 31, 2017, with results then annualized for direct comparison. Simulation reflects information on isolation statuses, cohorting, bed assignment practices, and so on. Number of off-service medicine patients limited to six patients at any given time. "Off-service" patients are those in a general care floor bed not allocated to their respective service. (Therefore, no patient bed-day is counted twice.)

Bed Reallocation: New Allocation & Implementation

Floor	Current	New state
Ellison 16	Gen Med (20) / Oncology (16)	Gen Med (10) / Oncology (26)
Ellison 19	Thoracic (20) / Gen Med (10)	Thoracic (15) / Vascular (15)
Bigelow 14	Vascular (27)	Gen Med (27)
Phillips 21	Gyn (20)	Gen Med (20)
Phillips 22	Gen Surg (10) / Gen Med (7) / Ortho (2)	Gyn (11) / Flex Surgery (8)
White 6	Ortho (30)	Ortho (26) / Neuro Spine (4)
White 13	ED Obs (10)	Short Stay (10)
Bigelow 7	ED Obs (18)	Gen Med (18)

First stage

January and February 2019

Second stage

Spring 2019

Third stage

September and October 2019

Note: Phillips 22 has six "premium" beds (out of 19 total beds) which, when specifically requested, carry a surcharge. However, historical requests for premium beds are limited, and so functionally these six beds are treated like other beds on the floor. Operationally, these beds can be made available to medicine patients as needed (per patient requests for premium bed).

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Closing Remarks

HSE Project Lifecycle

Key Tenets and Considerations:

- Large effort to **understand system and acquire data** as projects are based on **sophisticated and comprehensive analysis**
- **Success** of implementation depends on **change management** through deep understanding of the workflows and **careful communication and education** with all stakeholders
- The last phase requires **significant effort for ongoing monitoring, process-tweaking, and improvement**
- Successful projects have been based on **multi-disciplinary teams** to complement the data modeling.

Closing Remarks

Work only on **top priority burning** problems (have a map!)

Understand the **real system level problem** (diagnosis) and the real **constraints** (use hypothesis testing via data analytics)

Reach out for **leadership engagement** to support planning & implementation (help breaking cultural/organizational barriers)

Translate the (real) problem to a model that can provide effective **decision support tools** (what if scenarios & optimization)

Monitoring results and impact is a must (could be a challenge)

Thank you

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