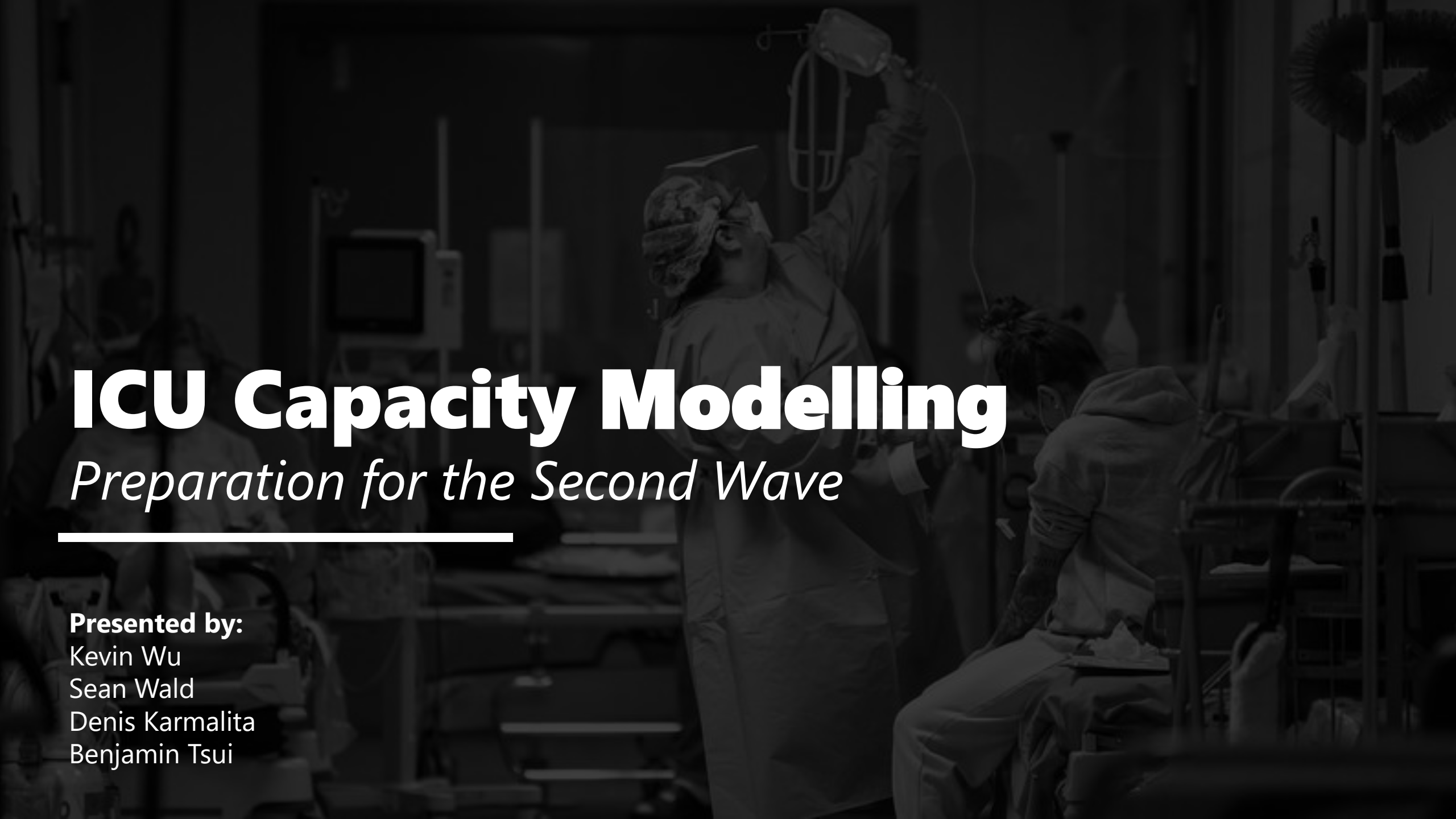

ICU Capacity Modelling

Preparation for the Second Wave

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The Ontario health system is facing a decision on how it can bes prepare itself for the second wave of the COVID-19 Pandemic

The first wave of the pandemic has hit Ontario hard

29,922	Confirmed Cases of COVID-19 in Ontario from January to May
12.7%	Of All Confirmed Cases were Hospitalized
2.9%	Of Patients were Admitted to the ICU
Over 50%	Of Adult Patients in the ICU Died
1,825	**Total Deaths in Ontario from January to May**

Recent Data has shown that **improved management and care** can lead to **I mortality rates to below 50%**, suggesting the **increased importance in improving ICU facilities**

The Ontario Health system has asked Schulich to optimize the number of beds needed to satisfy demand for the upcoming second wave as to not strain the health system

We had two goals in creating the optimization

Primary goal

Every individual that has contracted COVID-19 has access to quality medical care

Reduce unnecessary spending through minimizing the surplus of beds in all regions

As a result, we set out to answer two questions

1 Which LHIN regions will have to buy, receive and/or give beds

2 How many beds will each LHIN region need to buy, receive and/or give

We also set certain managerial constraints

1. Ensure each region can satisfy the demand with 80% of their supply*

*Research shows that anything greater or near capacity stretches resources to thin, resulting in unnecessary fatalities[1]

2. Each LHIN region is not willing to send more than 20% of their supply**

**LHINs may be reticent about supplying a large amount of beds for other regions

[1]https://www.livescience.com/icu-capacity-explained.html

We've created a model with three components that accurately predicts the number of beds each LHIN region needs to buy and move while satisfying the constraints

There are three components to our model

Demand Projections

Our ability to accurately project what Demand will be of hospital beds in the second wave is extremely important as it's the basis of how many beds are needed in each region.

Linear Programming Optimization

The linear Program allows us to create a model that will determine the optimal number of beds each region should move/buy given the peak demand projection

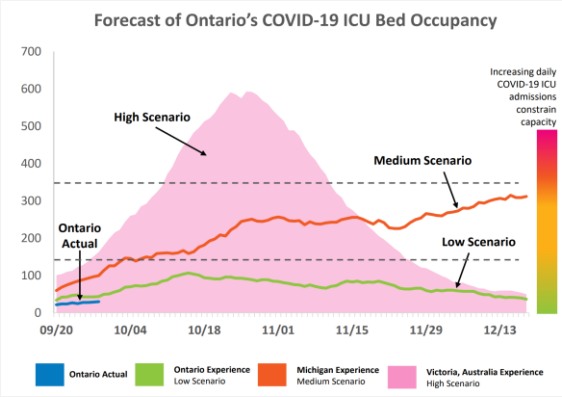
Monte Carlo Simulation

The Monte Carlo Simulation allows us to run our optimization multiple times with different demand inputs to test how the model would work in different situations as well as gain insight on the scenarios that could possibly play out

We projected demand through utilizing expert forecasts of ICU beds, allocating a percentage by region, and finally translating the results to comparable estimates with the supply of beds given

1 Forecasting Peak ICU Demand during the Second Wave

We relied on expert projections for Peak Demand of ICU Beds in the second wave



Source: COVID-19:Modelling Update (September 30th, 2020) by the Ontario government

With bull, base and bear scenarios based off Australia, Michigan and Ontario, we calculated expected demand following a normal distribution

Peak Demand Projected in ICU: **323**

2 Allocating Percent of ICU Beds by Region

With the data provided on historic ICU patients and beds/region, we calculated an average % of total Covid cases per region

	Mean	Median	Standard Deviatio
Central	11%	11%	1%
Central East	10%	10%	1%
Central West	4%	4%	1%
Champlain	9%	9%	0%
Erie St. Clair	4%	4%	1%
Hamilton Niagara Haldimand Brant	11%	11%	1%
Mississauga Halton	8%	8%	1%
North East	3%	3%	0%
North Simcoe Muskoka	2%	2%	0%
North West	1%	1%	0%
South East	5%	5%	0%
South West	8%	8%	1%
Toronto Central	20%	20%	2%
Waterloo Wellington	5%	5%	0%

3 Translating Results to Comparable Estimates with the Supply of Beds Given

We noticed a large discrepancy between reported ICU cases public and the ICU cases reported in the data so we translated our projected cases to match the excel projections

June 26th 2020 public total COVID hospitalizations vs in data provided

Data Total: 2044

Public Total: 61[1]

Data/Public Ratio: 33.5

Peak Demand Projected: **10,659**

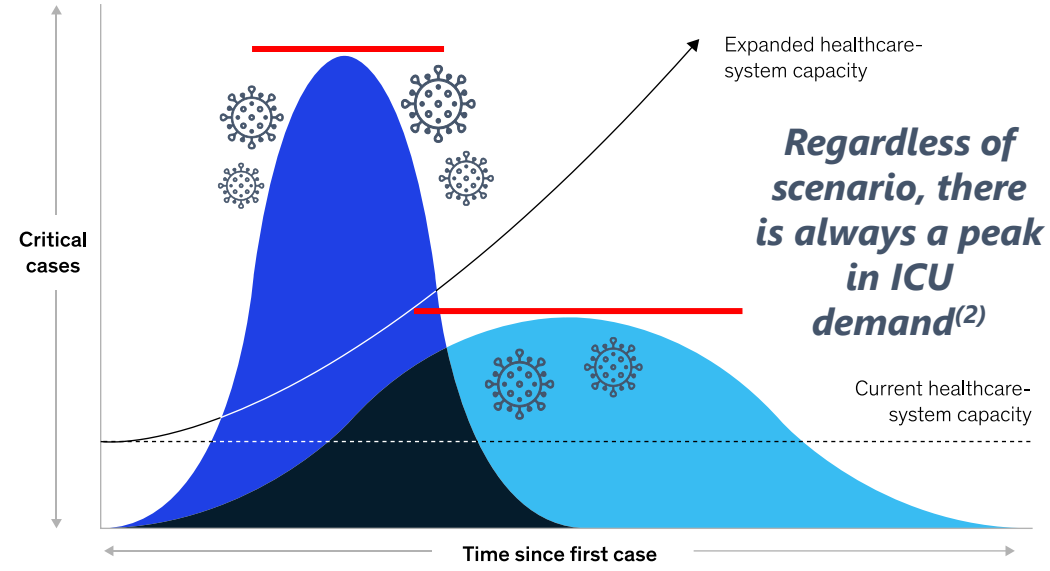
[1]Source: https://globalnews.ca/news/7111050/ontario-coronavirus-cases-june-26-covid-19/

Model Methodology

Objective Function: *Minimize Surplus of ICU beds*

Expanding healthcare capacity is critical to saving lives.

Healthcare-system capacity expansion (illustrative)



Regardless of scenario, there is always a peak in ICU demand(2)

McKinsey & Company

Model Design will be linear & one stage

#1 priority is to ensure all patients in need receive adequate care

#2 priority is to deliver #1 in <u>cost-effective manner</u>

(1) www.livescience.com/icu-capacity-explained.html
(2) https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/critical-care-capacity-the-number-to-watch-during-the-battle-of-covid-19

Decision Variables

How many new ICU beds to supply

How many ICU beds to move & where

Constraints

1. **Demand < Supply**
2. **Each LHIN cannot run over *80% capacity*(1)**
3. **Each LHIN cannot send more than 20% of their supply**

We conducted a Monte Carlo Simulation mitigate the difficulty in predicting demand and derive more applicable managerial insights

Why we chose a Monte Carlo Simulation

Due to the amount of past COVID Projections being inaccurate, a simulation helps create more generalizable managerial insight and give us more confidence in our result

Attributes of the Monte Carlo Simulation

Inputs:

- The Peak COVID Demand
- The % of Demand Allocated for each LHIN region

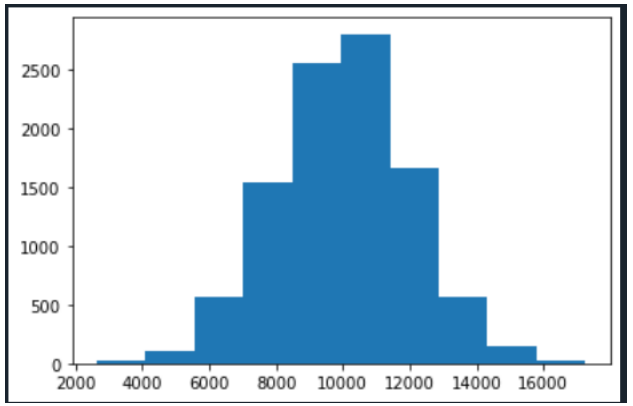
# of Trials:

10,000 Simulations of COVID Demand

Randomness:

Normal Distribution w/ 20% Standard Deviation

Histogram of Demand Distribution



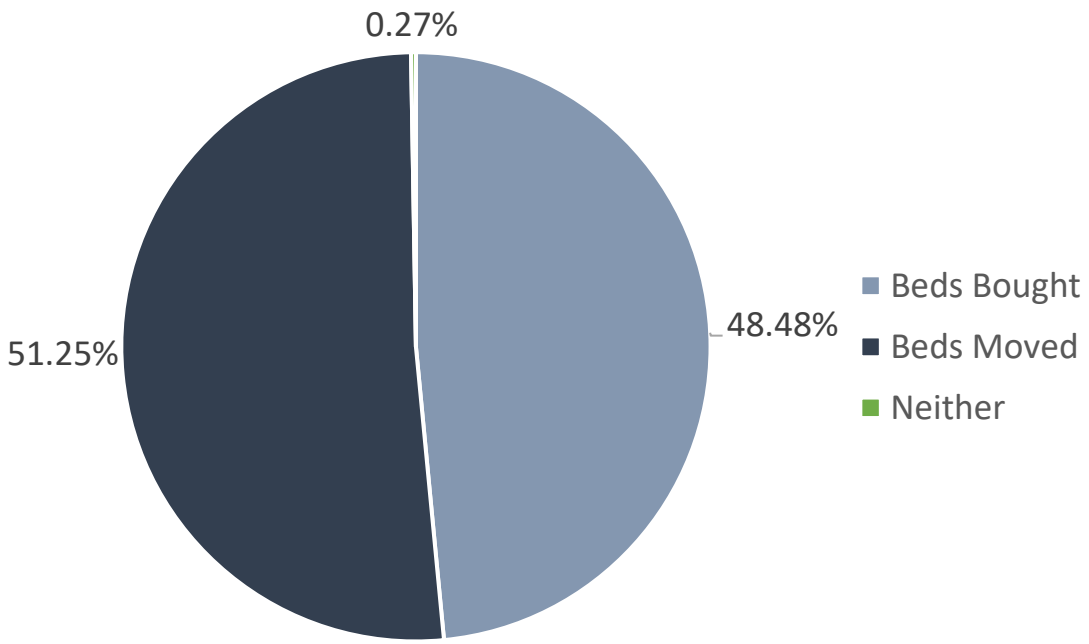
Three Outputs:

1. On average across all regions, what % of times are beds being bought or moved
2. On average, what % of times each regions needs to buy, receive, or give beds
3. On average, what # of beds does each region need buy, give or receive

Recommendation 1: We recommend Ontario begins setting up infrastructure and processes to buy new beds and move existing beds

Relative % of Simulations where Beds are either Bought, Moved or Neither

Out of 10,000 Simulations Ran



Key Takeaways

Ontario is almost guaranteed going to have to buy and move beds as:

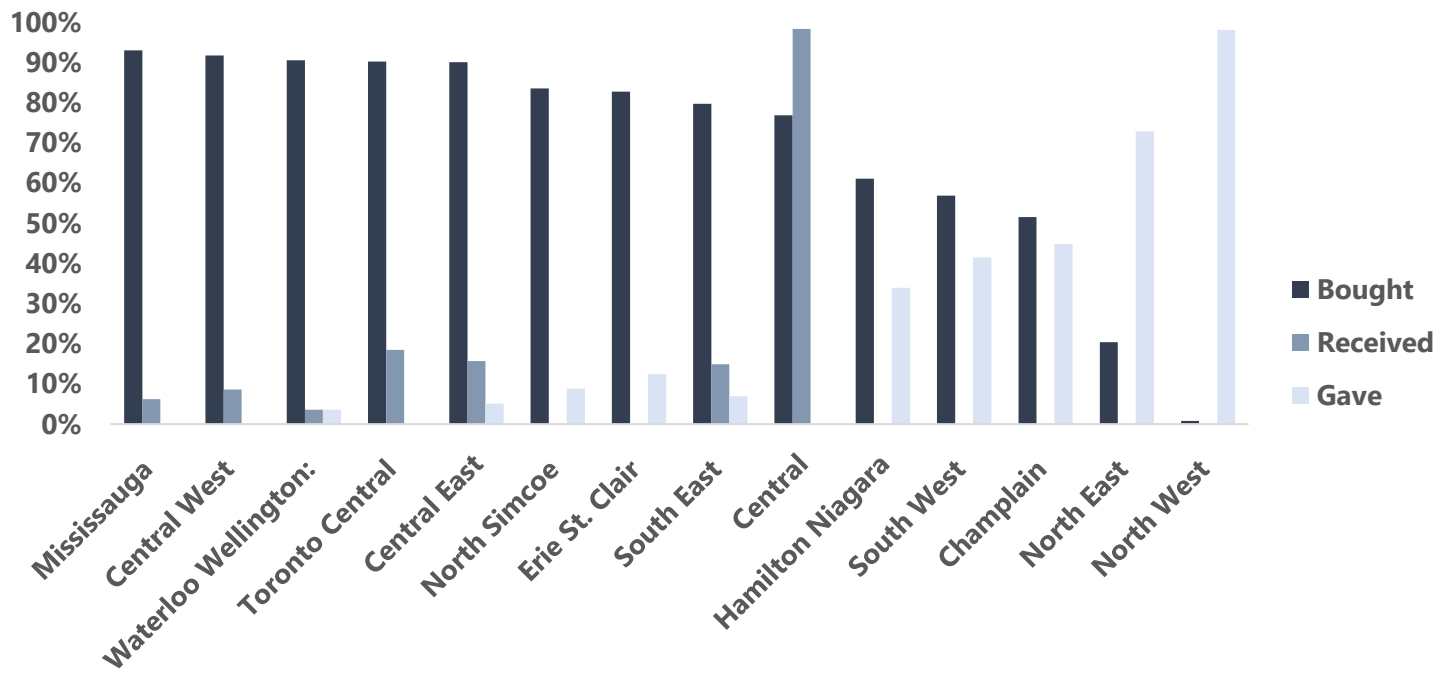
- In **93% of situations, beds need to be bought**
- In **98% of situations beds need to be moved**
- Only in **.5% of situations, does neither happen**

Our recommendation is for Ontario to begin **setting up infrastructure in buying and moving beds**. This includes contacting local and global manufacturers to establish this expectation, as well as contacting logistics company who can support in the moving process

Recommendation 2: Every LHIN region except North East and West should prepare to buy beds; Central, North East and West are expected to move beds

% of Simulations where each Region Bought, Received or Gave Beds

Out of 10,000 Simulations Ran



Key Takeaways

All regions should prepare to buy beds except for North East and West; Central should expect to receive beds, mainly from North East and West

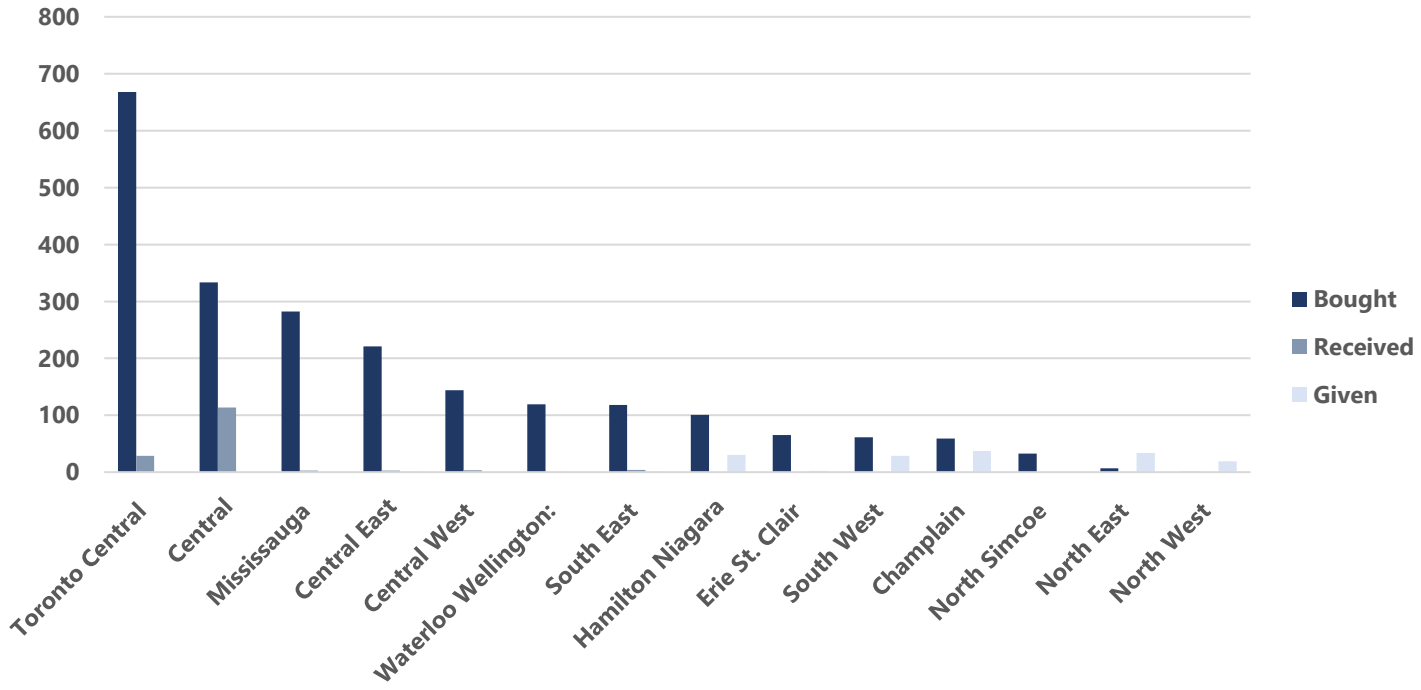
- **North west and North east are giver regions,** giving beds in more than 60% of simulations
- **Central is the main receiver region,** receiving beds in over 95% of simulations
- **10 out of 14 regions are required to buy beds** in over 60% of simulations

Our recommendation is for **all regions except North East and West,** to work with the Province and **allocate purchases of beds to its region.** In addition, **Central** is recommended to **set up relationships with other regions,** specifically North East and West **to receive beds**.

Recommendation 3: Every LHIN region is recommended to set up processes to buy or receive sufficient beds to satisfy the projected demand

Average Beds Bought, Received or Gave per Region

Out of 10,000 Simulations Ran



Key Takeaways

The highly populated regions (Toronto Central, Central, Mississauga, Central East) all are required to buy over 200 beds:

- On average only 6 regions Give/Receive a significant number of beds (>50)
- If a region receives beds, they will also need to buy beds
- North west is the only region does not seem to need to buy beds. ON average they give away 20 beds

Our recommendation is for **all regions to buy at least as many beds** recommended in our model **to satisfy the projected demand** and for **Central and Toronto Central** to **create relationships with "bed givers"** to allow for bed transfers between regions

Although there are inherent risks in our models due to the assumptions and decisions we made, we believe they are adequately mitigated

	Key Risk	Magnitude	Mitigations
1	**Incorrect Forecast of Peak Beds needed during Second Wave**	High Impact	• Allowed demand to vary in simulation by a standard deviation of 20%, allowing our model to handle unforeseen increases in demand and still have enough supply • Higher weighting on worst case in demand projections to be conservative
2	**Lack of specific monthly predictions may lead to inefficiencies in bed delivery**	Medium Impact	• Ensuring peak demand for supply will cover all monthly demands as well • Creating a one-stage delivery and purchase will avoid the risk of unexpected circumstances like delays, inventory lost in transit, logistic errors, and decrease transit costs

Thank You for Listening
We Open the Floor for Questions