AD616 Final Project

COVID-19 PPE Supply Chain

Team ***Healthcare 2***

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Background

Covid-19:

- Over 2 years
- No knowledge and lack of preparation
- Personal Protective Equipments (PPEs) are required
- Demand increased rapidly

Massachusetts General Hospital
Founding Member, Mass General Brigham

Massachusetts General Hospital (Mass General)

- oldest and largest teaching hospital of Harvard Medical School.
- third-oldest general hospital in the United States
- capacity of 999 beds

Our Data

Total adult patients hospitalized (U.S. Department of Health & Human Services)

➔ Avg Daily

# of frontline workers that are required each day (The Association for Health Care Resource & Materials Management)

# of PPEs that are required each day for patients and medical workers (Covid-19 Supply Chain Planning)

Our goal

By adjusting the number of PPEs ordered each time, **reduce the average storage** amount for PPE within the **satisfaction rate**(98%)

Problem Explanation (trivial solution)

Massachusetts General Hospital (Mass General) receives an average of **33 patients** per day, regardless of inventory level, with a total of **6 nurses** and **4 doctors** per day. Medical consumables include masks, gowns and gloves. Patients, doctors and nurses each consume 1 mask, 1 gown and 4 gloves per day. After the order is placed, **the masks would arrive in 1 day, the gowns in 4 days** and **the gloves in 2 days.**

When Mask is in stock for **3 days**, reorder;
When Gown has **9 days** left in stock, reorder;
When Glove has **5 days** left in stock, reorder.

(The time for reorder is 2n+1, n is the time needed for delivery. The hospital will check the inventory that night and start ordering the next day. The extra days are enough for the hospital to deal with the logistic uncertainty and the increased demand.)

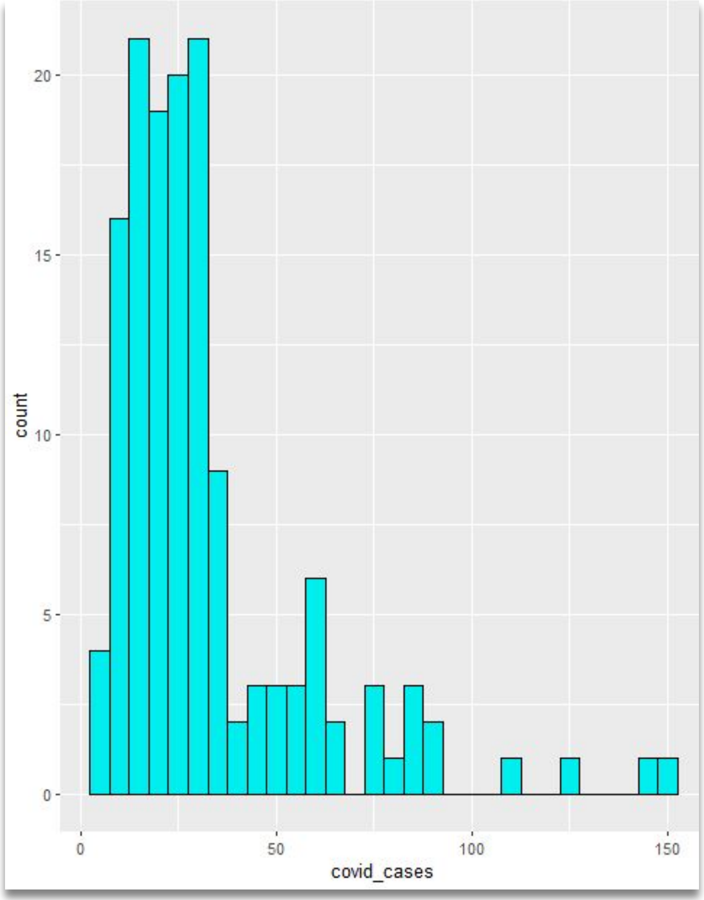
Problem Explanation

Uncertainties

- The number of patients could change. (e.g., in a large infectious disease outbreak or an epidemic in remission)
- The supply chain of PPE Logistics could be affected, (e.g., transportation disruptions, production shutdowns, resulting in changes in the timing of the arrival of supplies).
- Utilization of PPE supplies may change, such as the need for increased usage in specific situations (e.g., operating rooms, isolation wards).
- Supplier pricing and availability may change, resulting in changes in reordering costs.

The Simulation Model

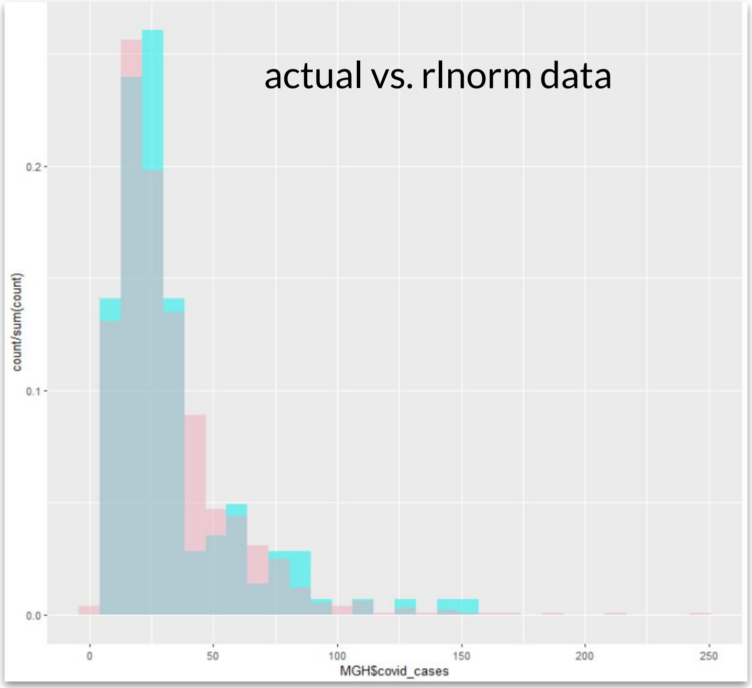
Uncertainty 1:
Histogram of the **number of covid-19 patients** in Massachusett General Hospital for the past 3 years



Simulation Model - Patient Number (Uncertainty 1)

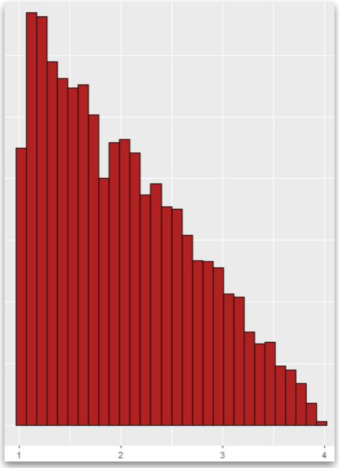
```
## Goodness-of-fit statistics
##                              1-mle-lnorm 2-mle-nbinom 3-mle-gamma
## Kolmogorov-Smirnov statistic  0.09058529    0.1347132   0.1408324
## Cramer-von Mises statistic    0.13055299    0.4247588   0.4585537
## Anderson-Darling statistic    0.71890805    2.5226570   2.4656957
##
## Goodness-of-fit criteria
##                                 1-mle-lnorm 2-mle-nbinom 3-mle-gamma
## Akaike's Information Criterion     1216.224     1236.472    1233.702
## Bayesian Information Criterion     1222.135     1242.383    1239.613
```

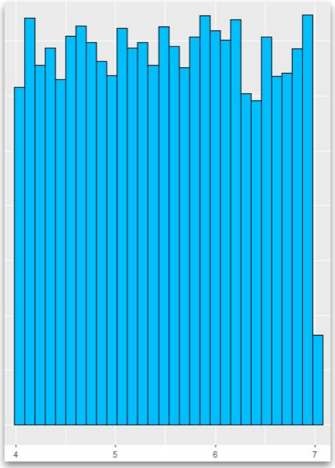
Best-Fit: **Lognormal Distribution**

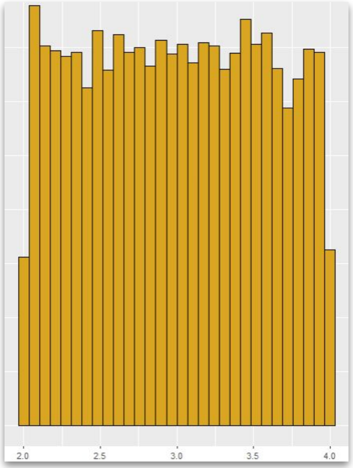


Simulation Model - PPE Lead Time (Uncertainty 2)

Items	Order Lead Time	Patient Use per Day	Total Nurse & Doctor Use per Day
Masks	Triangular(1,4,1)	1	6 + 4
Gowns	Uniform(4,7)	1	6 + 4
Gloves	Uniform(2,4)	4	36 + 8







Simulation Model - Beginning Inventory

	Beginning Inventory (P.S. 33=mean(MGH$covid_cases))	**AKA.**
Masks	(33+6+4)*7	7 days avg consumption
Gowns	(33+6+4)*10	10 days avg consumption
Gloves	(33+*4+36+8)*7	7 days avg consumption

Models have two inputs: **reorder point** and **reorder quantity**

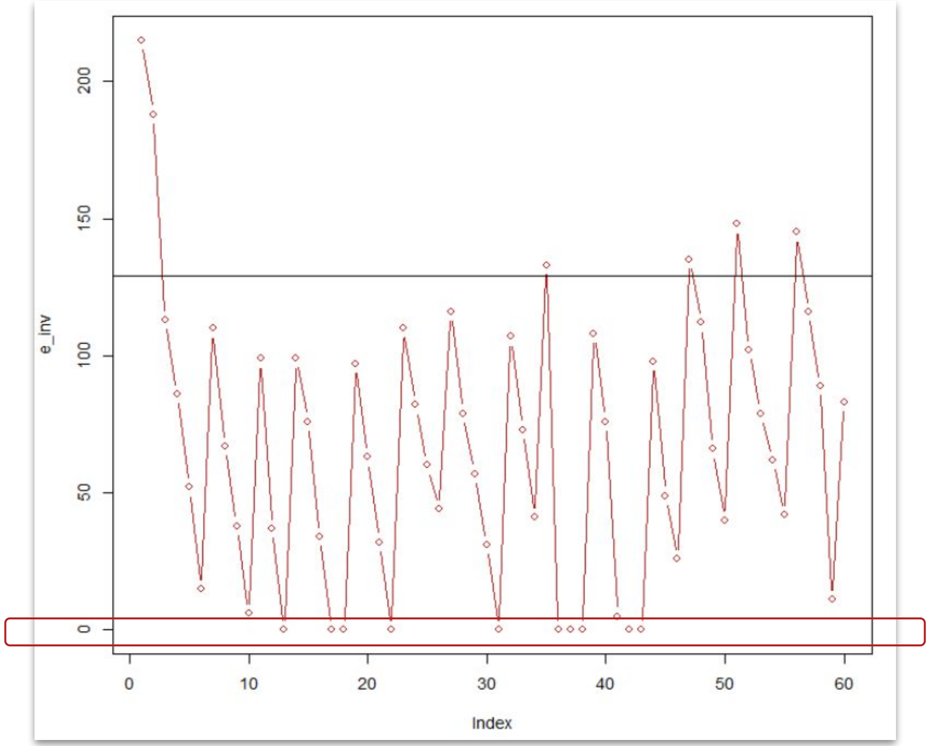
- Runs 50 trials each time
- Simulating a 60-day each trial
- Records the 60-day satisfaction rate and avg. inventory level
- Returns the aggregated avg. satisfaction rate and aggregated avg. inventory level for the 50 trials.

Simulation Model - Demo of Mask Sim

Suppose we use 3-day avg consumption as the inputs (i.e., r_point = 43*3 and r_qty = 43*3).

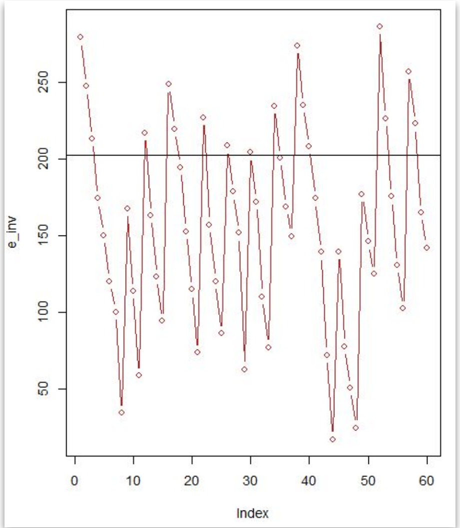
Result:

- Avg. inventory level of 63 pieces of masks
- Satisfaction rate: 84.7%
- Bad, didn't achieve 98%

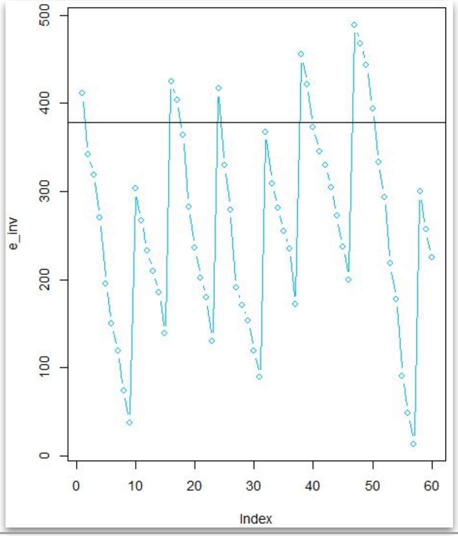


Optimization Result - DEoptim()

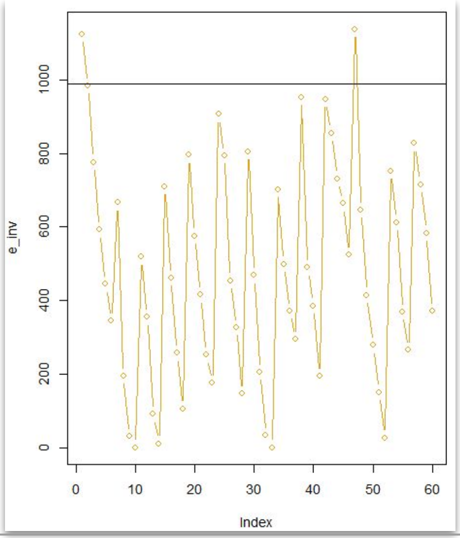
Mask inventory replenishment result:



Gowns inventory replenishment result:



Gloves inventory replenishment result:



Optimal R_Point	203	378	989
Optimal R_Qty	182	316	847
Avg. Inventory Lvl.	141	231	577

Payoffs & Business Implications

Using our model, companies can ...

- Reduce the space and the cost of storage

    Keep control of the max inventory, free up valuable storage space

- Eliminate waste in both the inventory and user sectors

    Risk of contamination and expiration

Payoffs & Business Implications

For future implications in the business sector, both suppliers and demanders can benefit from this optimizing inventory model. Our model can help to save costs associated with yield (aka production), excess inventory, and waste management for suppliers and storage space and possible waste for demanders.

Meanwhile, by computing how many PPEs are needed when, and where, our model can improve the overall efficiency of the supply chain. This can help improve customer satisfaction and loyalty, and help companies maintain a competitive advantage in the market.

Improvements

- Optimize for **different service levels** and risk tolerance
- Incorporate other factors: **shipping cost, stockout cost**
- Consider **joint optimization** to capture **dependencies** between the medical supplies

Questions?

Thank you!

Team *Healthcare 2*

References

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