The Impact of Supply Chain Performance on Seasonal Influenza: An Exploratory Analysis

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Abstract

An ability to optimize policy to mitigate infectious disease helps ensure significant health and economic benefits. This novel approach integrates SEIR with a vaccine supply chain model to explore the impact of vaccination supplies on the progression of seasonal influenza infectious disease.

Flu / Vaccine Supply Line

"Seasonal influenza is an acute viral infection that occurs worldwide causing an estimated 3-5 million severe cases and up to 500000 deaths every year"(WHO, 2014). The vaccine recommended coverage is 75% before the onset of each influenza season.

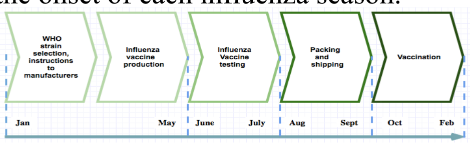

Fig 1.1: Seasonal Influenza Vaccine Supply Timeline

SEIR / Supply Chain Model

The integrated SEIR/Vaccine Supply Chain model evaluates the disease's potential Ro Ratio, HIT, Vaccine Order and Capacity to improve decision-making process. Uncertainty in the determination of vaccine ordering and capacity leads to a significant risk of insufficient vaccine supplies during the epidemic. The model has the following sectors:

1. SEIR Sector
2. Vaccine Supply Chain Sector

SEIR / Supply Chain Model

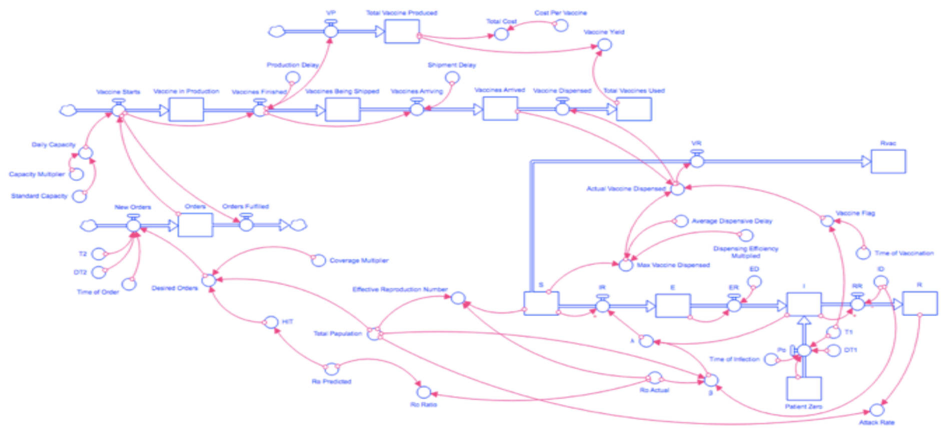

Fig 1.8: SEIR / Vaccine Supply Chain Model

Scenarios / Cases / Sensitivity Analysis Results

A. Vaccine Dispense scenarios

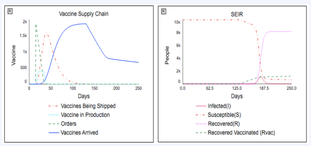

Fig2.2: Avg Dispensive Delay= 4

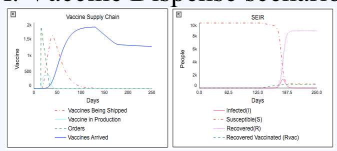

Fig2.3: Avg Dispensive Delay = 8

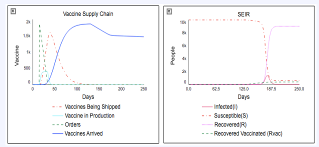

Fig2.4: Avg Dispensive Delay= 12

B. Vaccine Dependent Parameter Cases

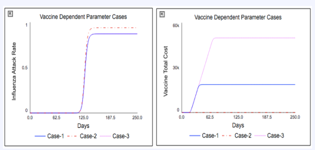

Fig2.5: Vaccine Order Cases (1-3)

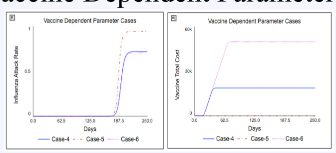

Fig2.6: Vaccine Order Cases (4-6)

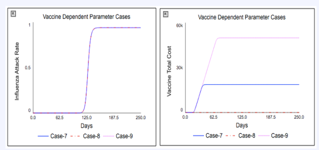

Fig2.7: Vaccine Order Cases (7-9)

C. Sensitivity Analysis

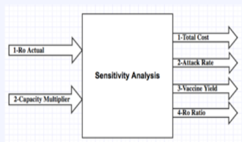

Fig2.8: Sensitivity Analysis

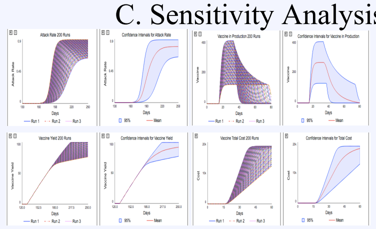

Fig2.9, 2.10, 2.11, 2.12: SA Runs

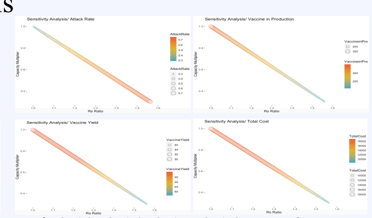

Fig2.13, 2.14, 2.15, 2.16: SA Plots

Key Findings / Conclusion

"Vaccination programs aim to achieve a coverage which is above the Herd Immunity Threshold, outbreaks are unlikely to occur" (Vynnycky and G White, 2019).

A. Vaccine dispense process with minimum delay can protect maximum susceptible population.
B. Vaccine coverage equal to HIT percentage before the onset of each influenza season is a cost-effective solution.
C. Fluctuation in vaccine production capacity and actual disease's potential Ro affect on the system behaviour.

Optimize policy ensures significant health and economic benefits.

Discussion / Future Work

The epidemic response always remains critical due to uncertainty of influenza attack rate, vaccine order and capacity.

- The SEIR model of infectious disease continue research on population group (age cohorts) and add other preventive methods (PPE, antivirals, etc.).
- The Vaccine Supply Chain structure continue research on adjustment stocks to overcome the unfulfilled and unexpected vaccine demand during the epidemic.

Acknowledgments

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