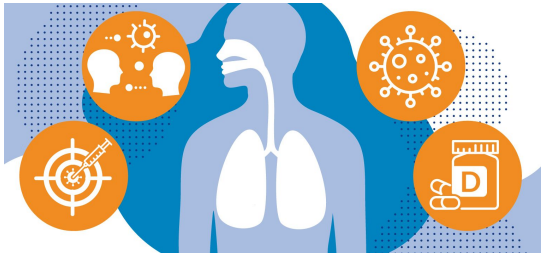
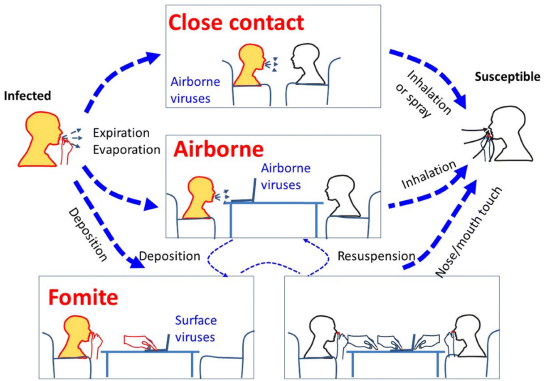
Development of Methods for Minimizing Uncertainty in Modeling the Dynamics of Epidemic Acute Respiratory Infections

Author: Jorge Javier Sosa Briseño.
Program: Big Data & Machine Learning, ITMO University.
Date: 2025.
Location: St. Petersburg, Russia.

Introduction

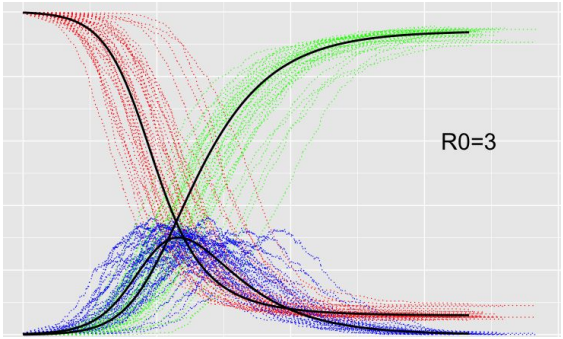
- Acute respiratory infections have a significant impact on global public health
- Characterized by rapid transmission
- Traditional models fail, leading to uncertainty in predictions.

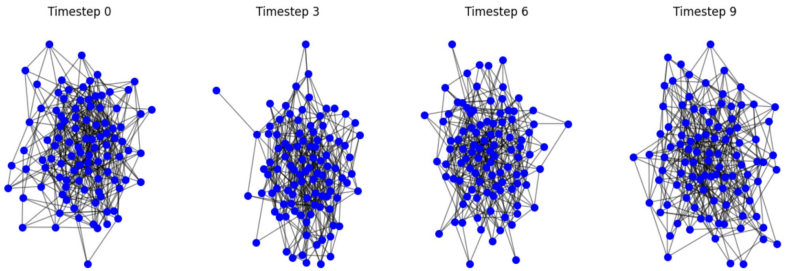


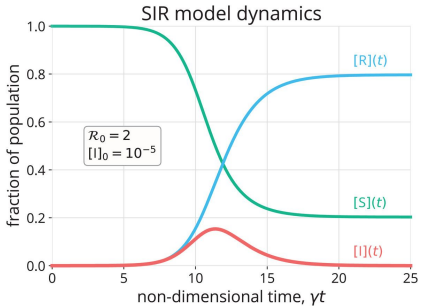


Evolution of Epidemiological Models

- Deterministic models
- Stochastic models
- Network-based models



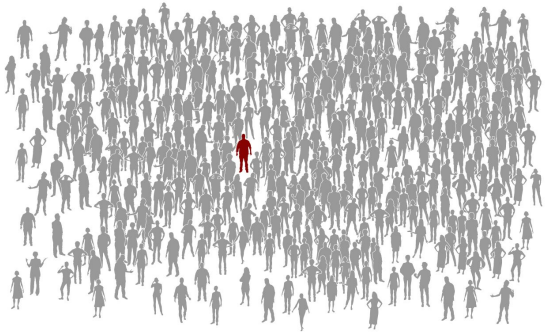


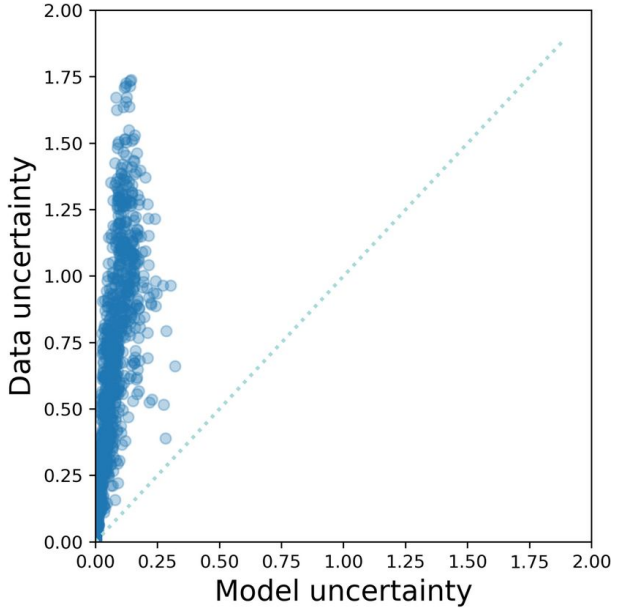


Evolution of Epidemiological Models

ITMO

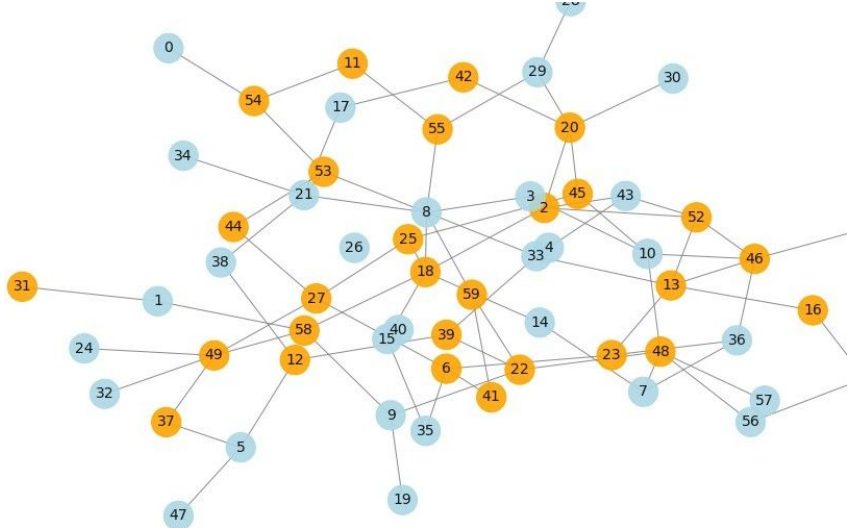
- Data uncertainty
- Simplifications
- Superspreading events





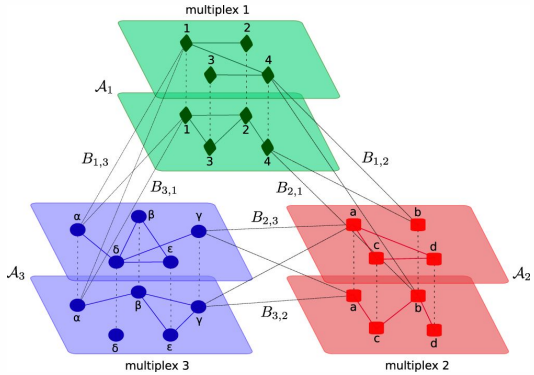
Network-Based Models

- **Dynamic networks** represent changes in social contacts over time
- Clustering and degree distribution are crucial to understanding propagation

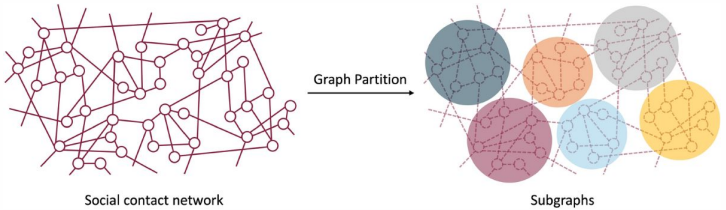


Main ideas

Multi-layer dynamic networks for modeling human interactions



Incorporation of key nodes (superspreaders) and behavioral heterogeneity

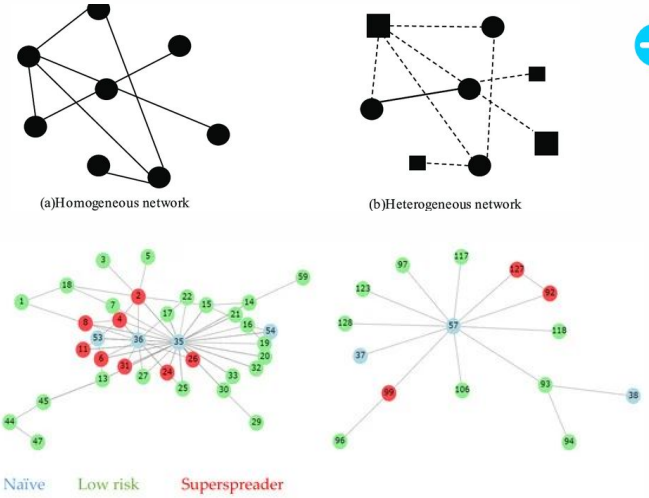


Advantages:

Capture of complex and realistic dynamics

Improved prediction accuracy

Design of specific and more effective interventions

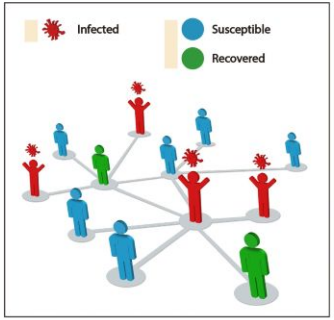


Potential Impact

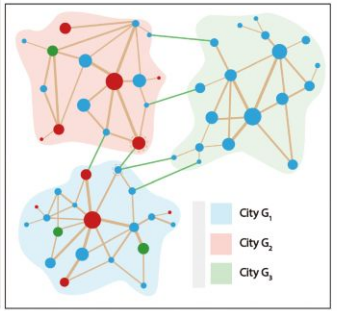
Identifying hubs in networks for targeted interventions.

Adaptive models that reflect changes in human behavior.

Better understanding of epidemic spread.



(a) An illustrated human contact network with susceptible, infected, and recovered individuals.



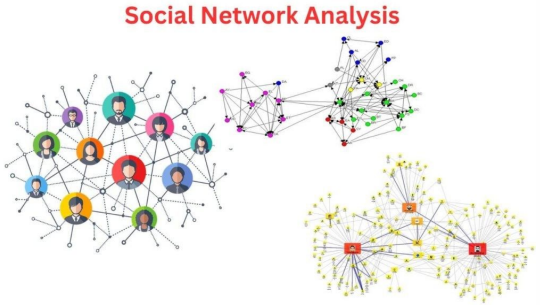
(b) A human contact network with 3 sub-networks and an epidemic spreading from one sub-network to another.

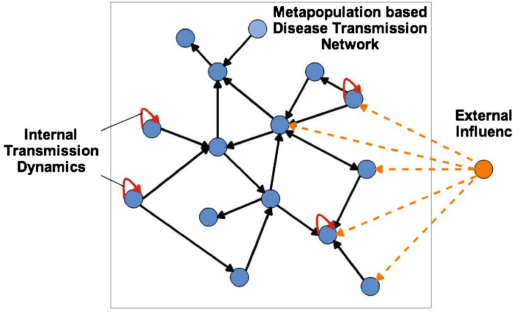
Limitations

Identifying hubs in networks for targeted interventions.

Adaptive models that reflect changes in human behavior.

Better understanding of epidemic spread.





Conclusions

- Proposal of a more robust theoretical framework for modeling epidemics
- Identification of the importance of networks and temporal dynamics in the spread of diseases

Future

- Validate the theoretical framework with empirical data
- Extend the methodology to other diseases and global contexts
- Optimize models to reduce computational intensity

THANK YOU FOR YOUR TIME!

ITMO more than a UNIVERSITY

Your contact info

References

- Pastor-Satorras, R. et al. (2015). *Epidemic processes in complex networks.*
- Kissler, S. M. et al. (2020). *Projecting the transmission dynamics of SARS-CoV-2.*
- Ferguson, N. M. et al. (2006). *Strategies for mitigating an influenza pandemic.*