Modelling in Biomathematics: COVID-19 and beyond
(Org: **Monica Cojocaru** (Guelph))

MONICA COJOCARU, University of Guelph

Aggressive testing, social-distancing, lock-down: Assessing options for the control of COVID-19

In this work we present an analysis of the two major strategies currently implemented around the world in the fight against COVID-19: Social distancing & shelter-in-place measures to protect the susceptible, and testing & contact-tracing to identify, isolate and treat the infected. The majority of countries have principally relied on the former; we consider the examples of Italy, Canada, the United States and South Korea. For all four countries, we estimate the level of testing which would be required to allow a complete exit from shutdown and a full lifting of social distancing measures, without a resurgence of COVID-19. We find that a "brute-force" approach of untargeted universal testing requires an average testing rate of once every 36 to 48 hours for every individual, depending on the country. If testing is combined with contact tracing, and/or if tests are able to identify latent infection, then an average rate of once every 4 to 5 days is sufficient. We then show that most countries have employed a blend of social-distancing and testing/tracing to get to their current levels of COVID-19 prevalence, some with more success than others.

ROIE FIELDS, University of Guelph

Adapted SEIR Model for Analyzing the Status of COVID-19 in Ontario, using Age Strati cation, Contact Rates, and Mobility Data

Abstract: As of July 7th, 2020, there have been over 12 million worldwide cases of COVID-19, including over 100 000 in Canada. Many groups have taken various approaches to modeling the spread of this pandemic. We propose our approach to modelling COVID-19 in Ontario, extending the classic SEIR compartmental model by introducing three novel components. First, we incorporate age stratification into our population structure, distinguishing between 0-19 year olds, 20-59 year olds, and individuals aged 60+. Secondly, we apply the age stratified contact rate matrix for Canada found by Prem, Cook, and Jit (2017) to our model. Lastly, we introduce several additional compartments to the SEIR model, distinguishing between pre-symptomatic, asymptomatic and symptomatic infectious individuals, and including an isolation compartment. Using a derivative-free optimization algorithm, we solve for the optimal effective contact rate to fit our model to reported cases of COVID-19 in Ontario by case onset date, as reported by Ontario's integrated Public Health Information System (iPHIS). Lastly, we explore the use of Google Mobility data to infer its effect on contact rates under social-distancing guidelines. As individuals' mobility changes through various phases of containment measures (lockdown, stage 1, stage 2, etc.) we explore the change on pathogen transmission as influenced by other factors such as mask use/wear requirements, bans on social gatherings, reduced social bubbles, working from home policies, etc.

THEODORE KOLOKOLNIKOV, Dalhousie

Saturation in SIR model

Consider the following agent-based model of coronavirus spread: people move randomly and infection occurs with some nonzero probability when an infected individual comes within a certain "infection radius" of a susceptible individual. The question is how the infection radius affects the reproduction number. At low infection rates, this model leads to the classical S-I-R ODE model as its continuum limit. However higher infection rates lead to a saturation effect, which we compute explicitly using basic probability theory. Its continuum limit It leads to an S-I-R type model with a specific saturation term that depends on the population density. We also show that this modified model gives a much better fit to the real-world data than the classical SIR model.

ROSSITZA MARINOVA, Concordia University of Edmonton

COVID-19 Using Inverse Problem for Coefficient Identification in SIR Epidemic Models

The COVID-19 coronavirus appeared in late 2019 and quickly spread across many countries. By the end of April 2020, there were more than 3 million confirmed cases of infected people, with more than 200,000 reported deaths globally. Governments closed the so-called non-essential businesses and services for weeks in order to slow down the growth of infections – especially among vulnerable populations – and thus, save lives.

This work deals with the inverse problem in epidemiology based on a SIR model with time-dependent infectivity and recovery rates, allowing for a better prediction of the long term evolution of a pandemic. The method is used for investigating the COVID-19 spread by first solving an inverse problem for estimating the infectivity and recovery rates from real data. Then, the estimated rates are used to compute the evolution of the disease. The time-depended parameters are estimated for the World and several countries.

Q&A,

HUAIPING ZHU, York University
How Wuhan Curbed the COVID-19? A data-driven modeling study

In this paper, I will present data-driven modeling studies to mimic the transmission of the virus in Wuhan, incorporating the number of hospital beds in both designated and mobile cabin hospitals, in particular the number of mobile cabin hospitals used to isolate large numbers of confirmed cases. Our findings indicate that while designated hospitals saved the lives of the severely infected, it was a large number of Fangcang Shelter Hospitals, and thus, the extra hospital bed capacity, that helped slow down and eventually stop the epidemic of COVID-19 in Wuhan. Given the current global pandemic situation of COVID-19, this study suggests that, whenever possible, increasing the hospital bed capacity together with the healthcare personnel within an affected region is key to curbing the outbreak.