Imperial College London

Project Proposal

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Life Sciences

Mechanistic Modelling of COVID-19 and Climate

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1 Keywords

Keywords: Temperature, Humidity, COVID-19, Mechanistic, SEIR model, Virology

2 Introduction to Project Idea and Proposed Questions

The current pandemic of COVID-19 is the biggest health crisis humans have faced in the last century. It is caused by a novel coronavirus (SARS-CoV-2), first detected in Wuhan, Hubei, China which spread rapidly (World Health Organization (WHO) 2020). Understanding what affects disease spread allows us to make predictions about where might be badly effected and prepare adequately.

Climatic variables have been shown to affect virus transmission, for example in influenza (Lofgren et al. 2007) and hand-foot-mouth disease (Feng et al. 2014). Influenza is seasonal, peaking in Winter in temperate countries, and does better in cold and wet conditions (Deyle et al. 2016). This could be due to changes in human immunity, human behaviour and virus stability (Lipsitch and Viboud 2009).Experimental evidence has found transmission of influenza between guinea pigs in controlled environments depends on temperature and humidity (Lowen et al. 2007).

Recent studies currently in preprint have explored whether SARS-CoV-2 also varies with climate. Experimentally, SARS-CoV-2 has been found to be more stable at lower temperatures (Chin et al. 2020). Many studies have used phenomenological models (mostly linear models, including LOESS regressions and GLMs) to find links between climate and COVID-19 incidence or mortality (Wang et al. 2020; Luo et al. 2020; Sajadi et al. 2020; Bannister-Tyrrell et al. 2020; Rahman et al. 2020; Oliveiros et al. 2020; Chen et al. 2020; Ma et al. 2020; Poirier et al. 2020). While limited by the quality of their data, most of these studies suggest that lower temperature and humidity increase SARS-CoV-2 transmission. An attempt to mechanistically model COVID-19 including temperature has been made (Shi et al. 2020). In this work, an SEIR model was combined with a linear model representing the time-dependent rate of infectious contact, including temperature and absolute humidity as variables.

The current work aims to mechanistically model the spread of COVID-19 using an SEIR model incorporating climatic variables (temperature and humidity) and use this to make predictions. This project will be more mechanistic than previous work and have access data with more spatial and temporal detail.

The main question being addressed is: To what extent is COVID-19 spread likely to depend on temperature and climate? Between region differences can be described (what locations are more at risk?). In addition, the effect of within region changes in climate would be useful to inform planning for individual countries (is COVID-19 likely get worse over winter in temperate countries?). Factors other than climate are likely to affect COVID-19 so understanding how these interact with climate is important (How does the effect of climate change at different levels of social interaction?).

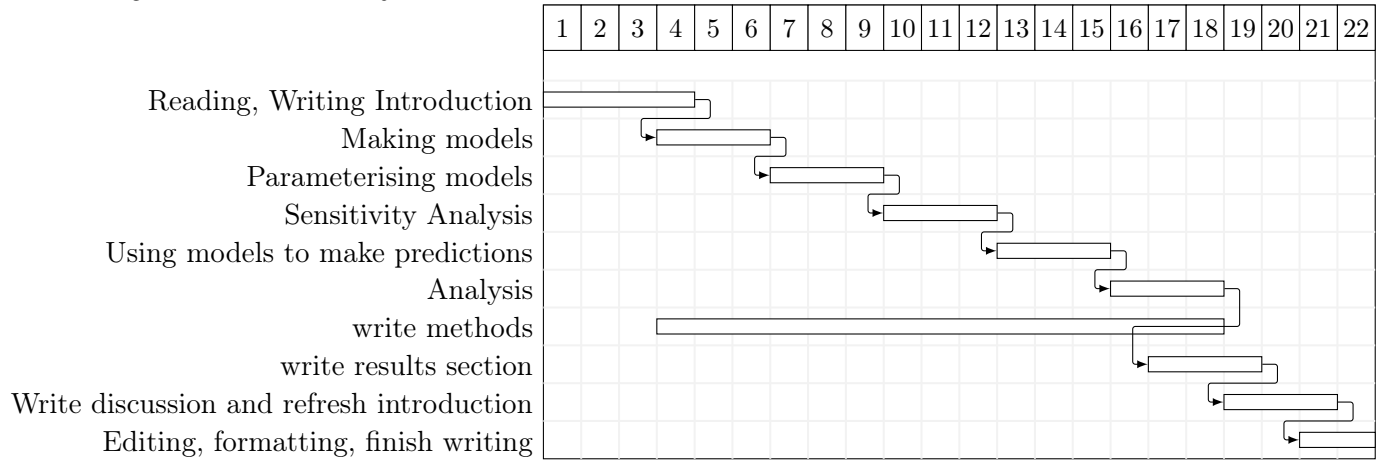
3 Proposed Methods

This project will make an SEIR model for COVID-19. This will include modelling the survival of SARS-CoV-2 in different climatic conditions using experimental data about the survival coronaviruses outside of the host. Data is available for the change in viral titre over time at a range of temperatures and humidities for different coronaviruses (Lai, Cheng, and Lim 2005; Chin et al. 2020; Doremalen, Bushmaker, and Munster 2013; Pyankov et al. 2018; Casanova et al. 2010). These data sources could be combined, to produce a "survivability" function, perhaps outputting a percentage of the maximum possible survival. This will modify the probability of infection given contact between an infected and susceptible person (part of β in the SEIR model). In addition, variation in human movement could be modelled, which would modify the contact rate component of β, improving our understanding of the interaction between climate and movement in the severity of the epidemic. COVID-19 case data will be used to estimate other parameters such as recovery rate. Sensitivity analysis will be carried out to understand how robust the model is to changes in parameters. This model will be used to make predictions about how the disease will spread over time. If time allows, we may attempt to validate the model with data.

4 Anticipated Outputs and Outcomes

The main outcome will be an SEIR model for COVID-19 which will be used to gain an understanding of how climate affects the spread of COVID-19 and how this interacts with human movement. Another outcome will be predictions about winter and potentially the future of COVID-19.

5 Project Feasibility



6 Itemized Budget

Computer improvements -£200- Additional RAM (if needed), possibly a monitor, hard drive

Books- £100- May need to be purchased due to lack of library (if essential and not available online)

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Budget Approval

I have seen and approve the proposal budget

Name: Samraat Pawar

Signature:

Date: