

Open-source individual-based epidemiology simulation

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1. What is JUNE?

JUNE is a primarily data-driven, generalisable, and modular framework for simulating the spread of infectious diseases with a specific focus on understanding the efficacy of policy interventions by utilising a high degree of spatial and demographic granularity. Here, we show the application of JUNE to the specific case of modelling the spread of SARS-CoV-2 in England.

The structure of JUNE

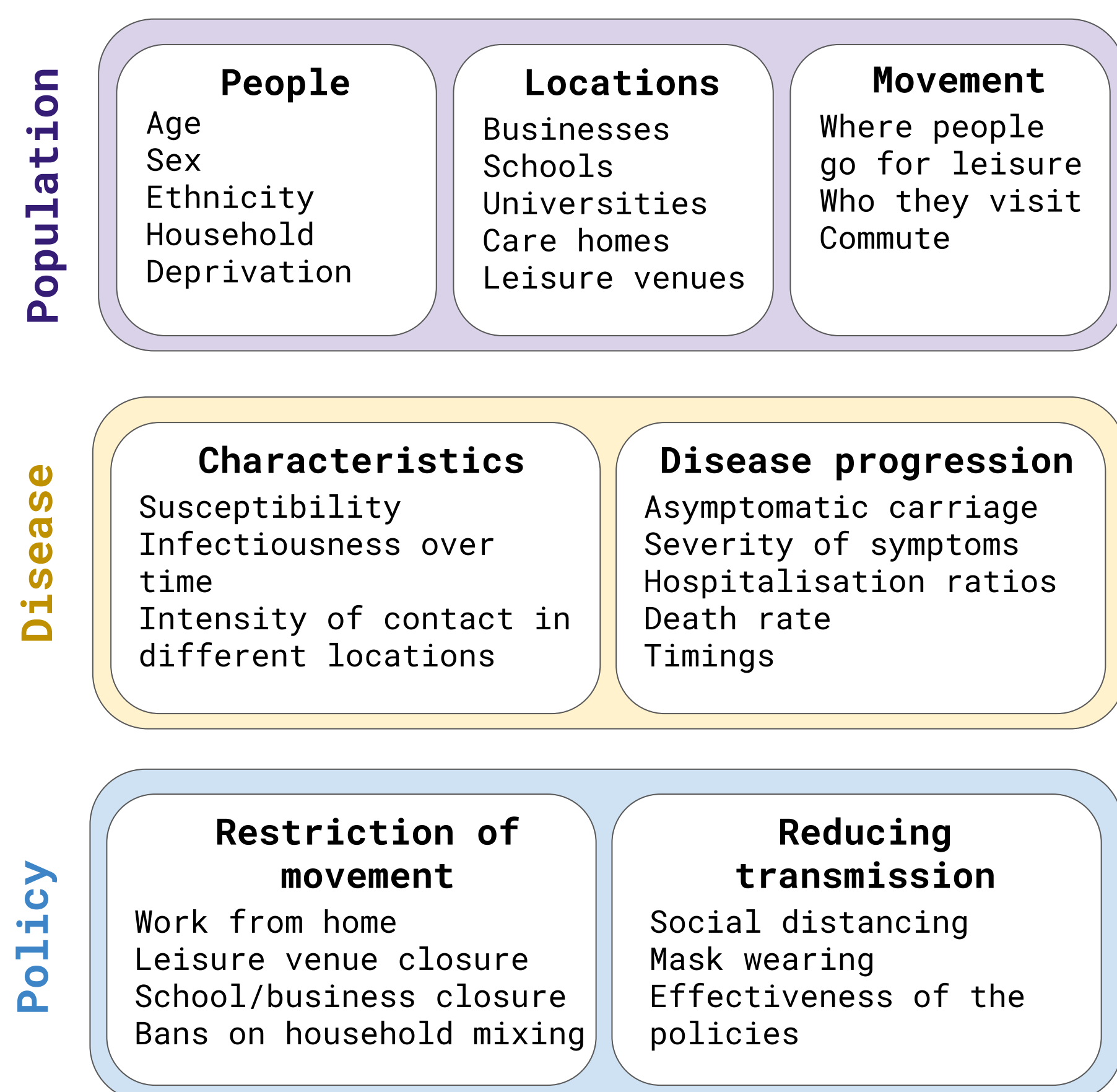


Figure 1. The JUNE framework is composed of three modular layers that combine to achieve the complex model behaviour required to effectively model disease spread in a heterogeneous population.

2. How is a JUNE 'world' constructed?

JUNE leverages the UK census' high resolution geographic and demographic information to build an accurate population through which to spread the infection, along with Open Street Maps and Office of National Statistics (ONS) data to provide locations for mixing in workplaces, schools, and social venues (such as pubs and restaurants, cinemas, and grocery shops).

All of this information is contained within the JUNE 'world'. In Figure 3, we show JUNE's cumulative cases per 100,000 inhabitants at its highest level of geographical resolution.

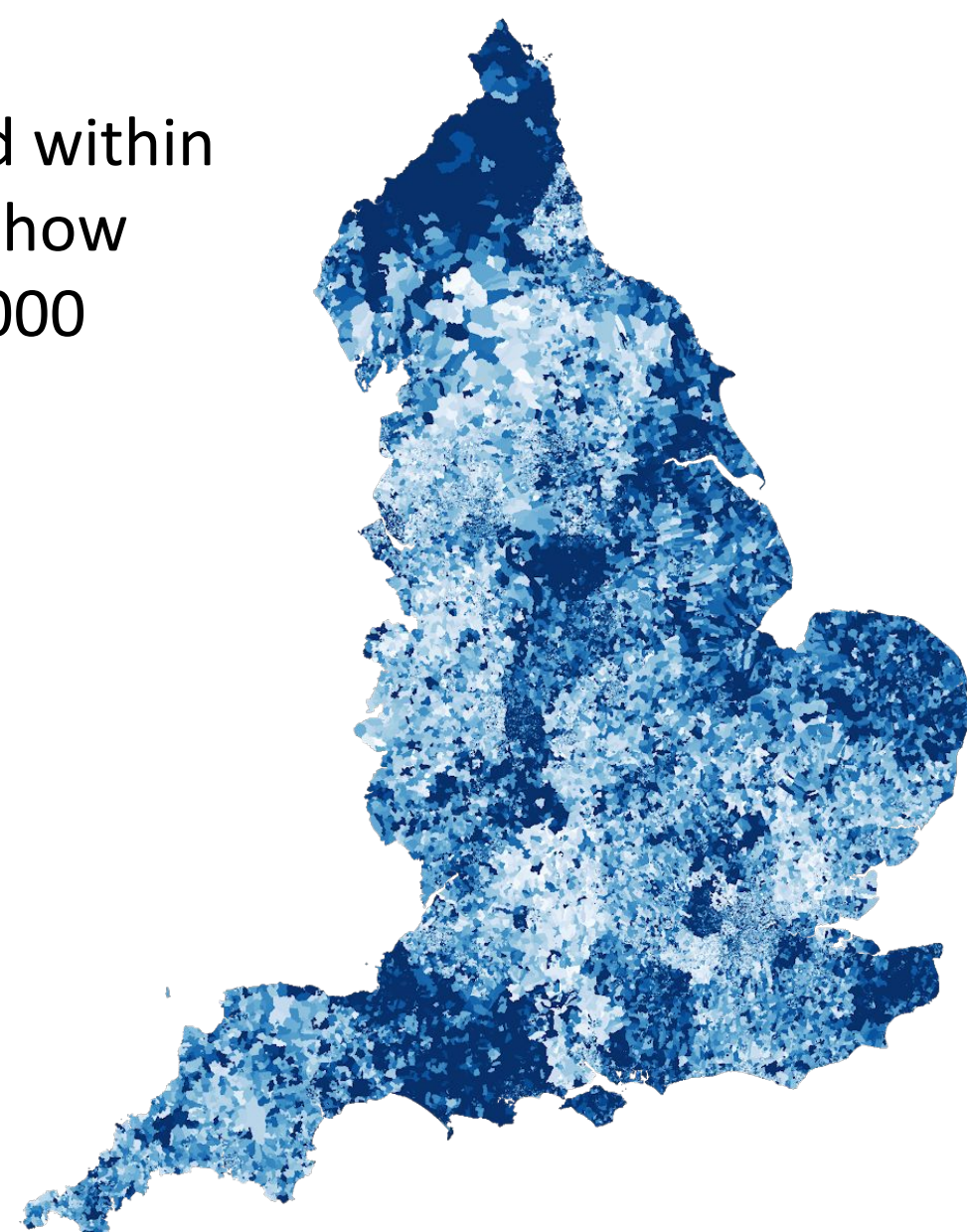


Figure 3. Cases per 100,000 inhabitants on 1st November as predicted by JUNE. Video of a comparison to observed deaths data [2] can be viewed at <https://youtu.be/SzqChh5Oepw>

3. Does JUNE reproduce what happened?

In order to understand what will happen in the future, JUNE needs to learn from our past experience with COVID-19. Although JUNE is a very complex model, the sociology of the population and its dynamics are constrained independently using external datasets and available literature. This leaves us with sixteen free parameters that we fit to observed hospital admissions and mortality statistics at national and regional levels.

In figures 3 and 4, we show an example of a calibrated JUNE run, that has modelled the evolution of the pandemic from the 28th February until mid November. We show that JUNE reproduces trends extracted from [1], for different regions in England and for different age groups.

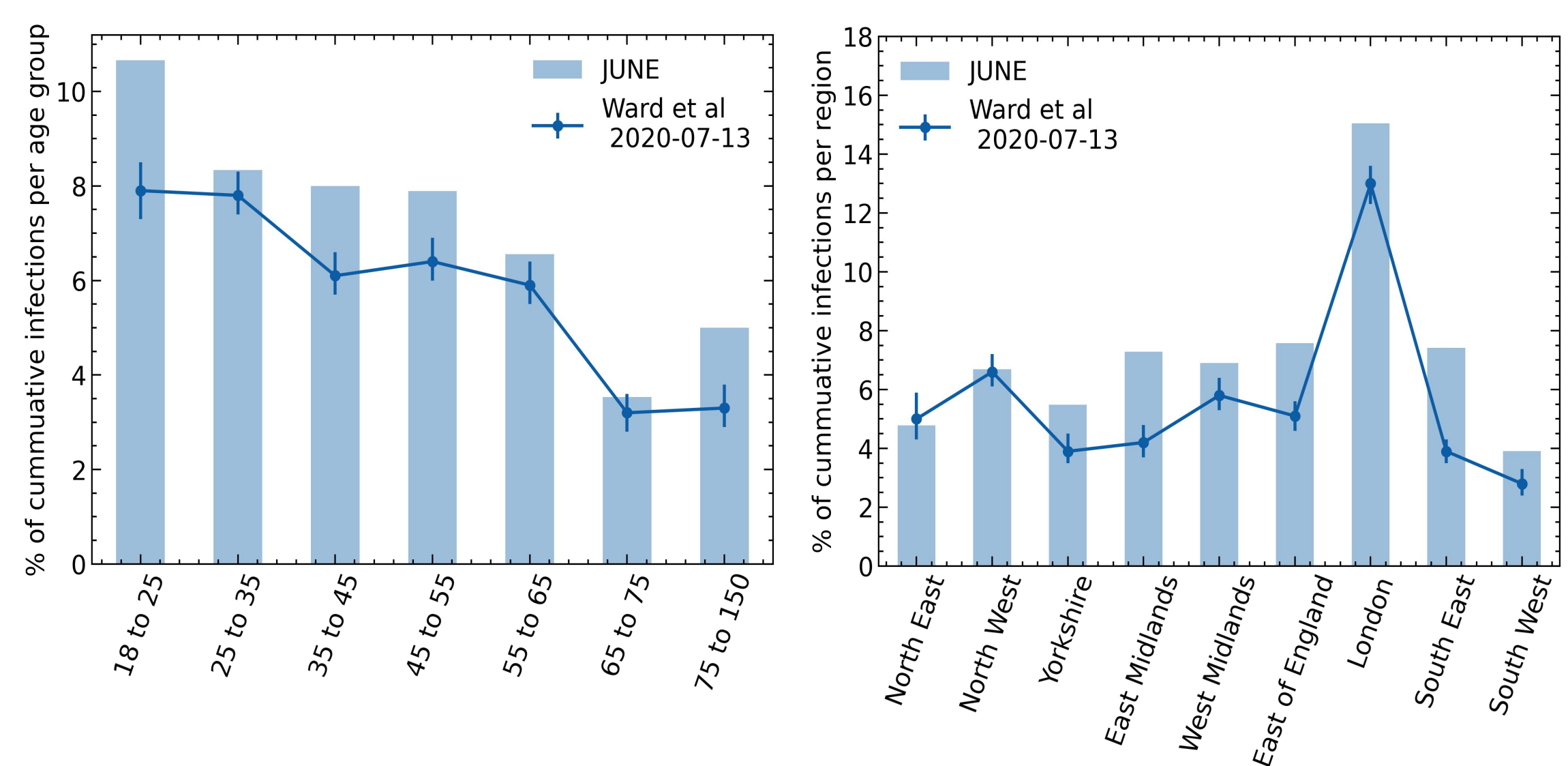


Figure 4. Comparison of JUNE cumulative infections to the React2 study [1].

4. Can JUNE provide insights on how to get out of this situation?

Careful analysis of different scenarios will be instrumental in providing a viable exit strategy from the current situation, which is something that can be scrutinised within JUNE. Its modular structure and the detailed characteristics provided by ONS data allows for model outputs to be aggregated at any readily available spatial level down to areas that contain a few hundred people, and by any demographic.

A number of government policies are already implemented in JUNE as seen in Figure 5, but a variety of other scenarios can be explored in a similar fashion. The effectiveness of these scenarios can be easily examined by virtue of the flexibility and resolution that JUNE provides.

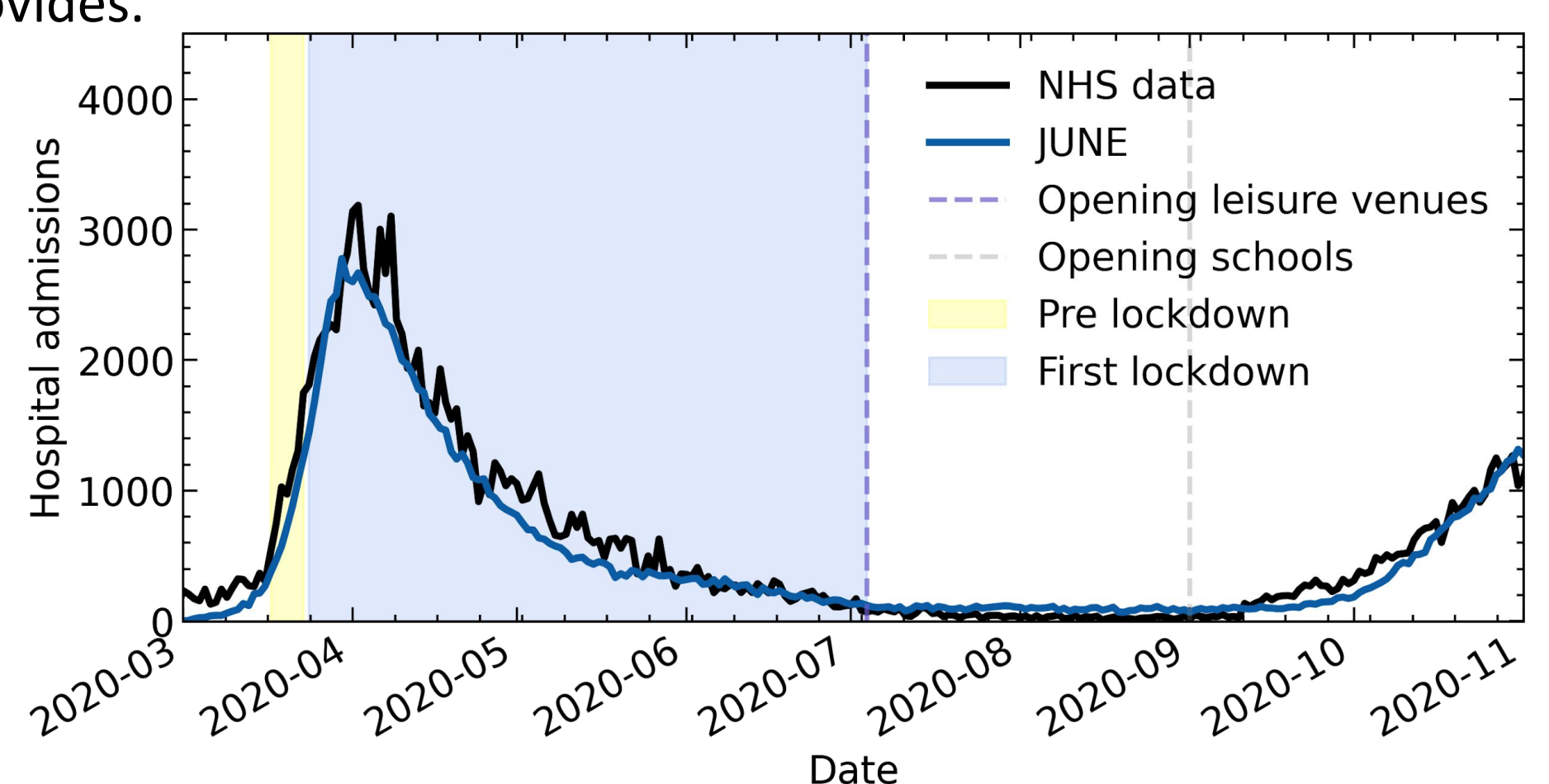


Figure 5. Comparison of COVID-19 hospital admissions [3] in England as predicted by JUNE. Different policies have been implemented to simulate lockdown and its release.

[1] Ward et al. Antibody prevalence for SARS-CoV-2 in England following first peak of the pandemic: REACT2 study in 100,000 adults
 [2] <https://coronavirus.data.gov.uk/details/download>
 [3] <https://www.england.nhs.uk/statistics/statistical-work-areas/covid-19-daily-deaths/>