The Alan Turing Institute

Dynamic Microsimulation fo Epidemics - Urban Analytic

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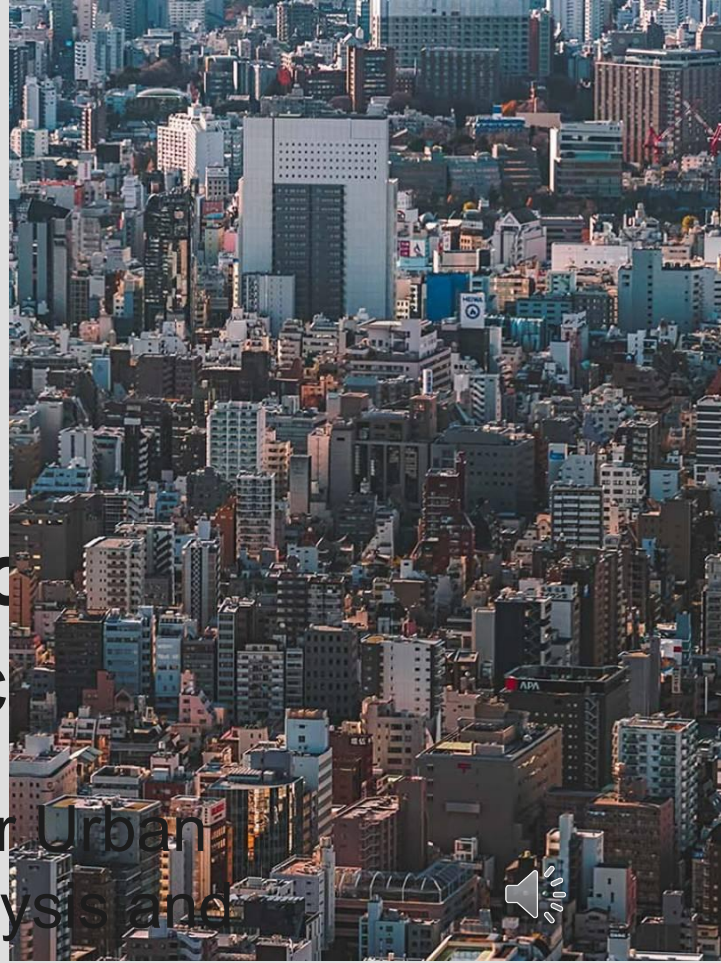


The Royal Society RAMP Initiative

- **R**apid **A**ssistance in **M**odelling the **P**andemic
- A call to the community from the Royal Society in March 2020 for broader scientific support to government and policy making
- More than 1800 responses from individuals and scientific groups, including approx. 30% from government and commercial organisations
- Led to the formation of 8-10 working groups focused on various aspects of pandemic modelling

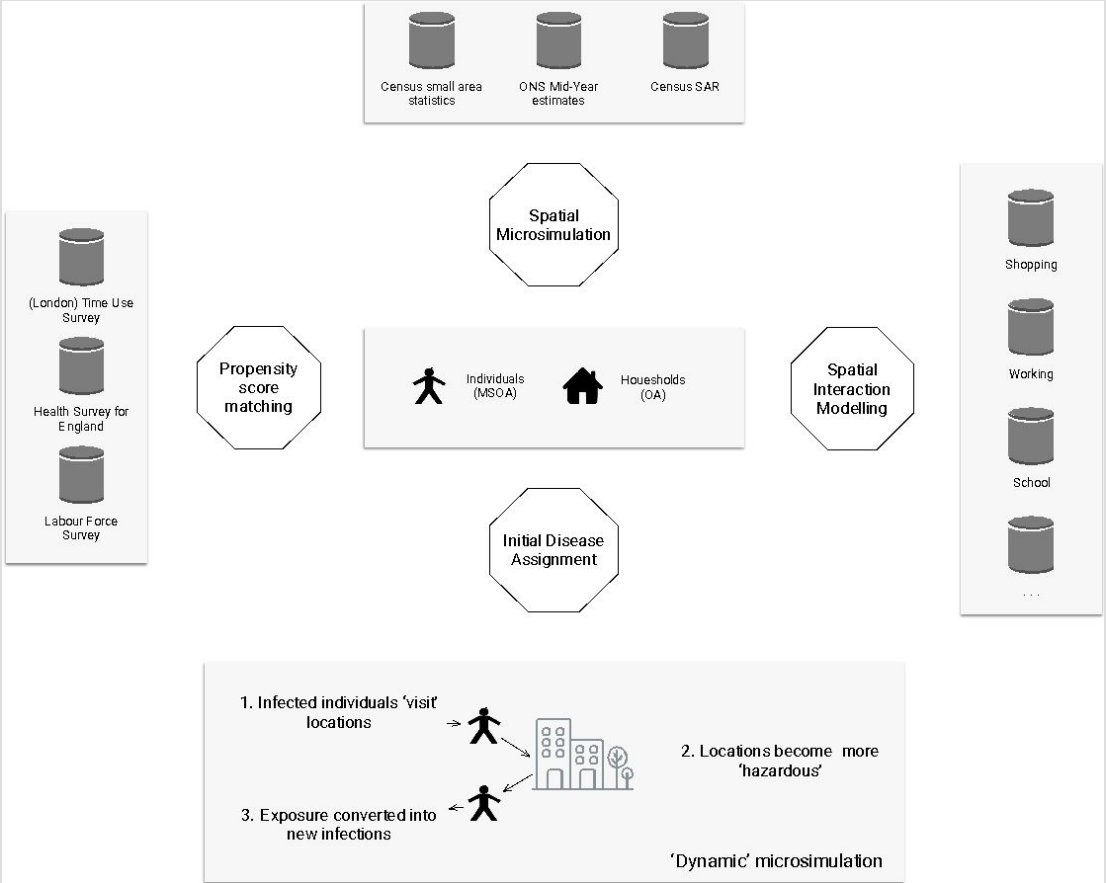
The Royal Society RAMP Initiative

“Is there a pre-existing model of human social behaviour and contacts into which new SEIR type labels for disease state can be introduced, with appropriate statistics for changing these labels?”

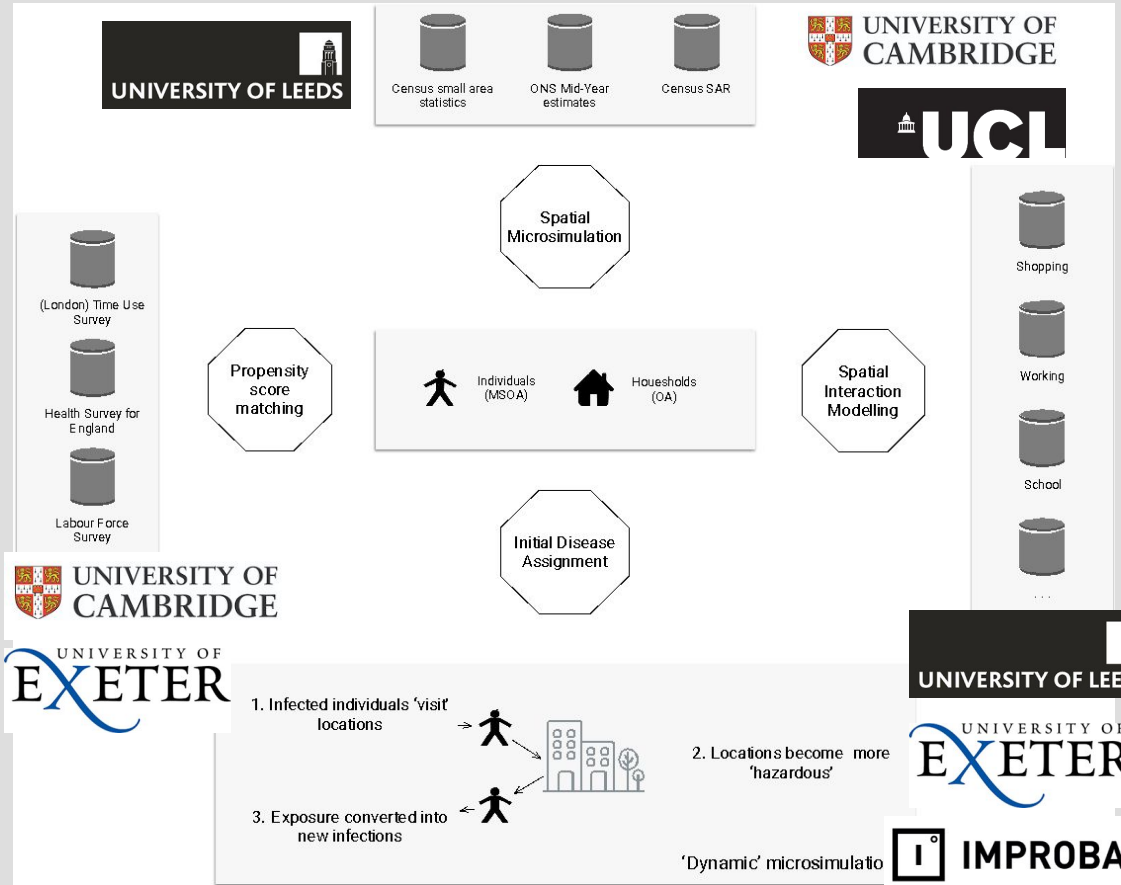
Established models and approaches limited in a number of fundamental regards:

- Coarse spatial resolution, e.g. region or city level
- Abstract spatial behaviour patterns, circular catchment areas, or distance to nearest
- Commuting focus unable to capture interactions beyond work and/ or school
- Restricted demographic profiling disaggregation by age and sex at best

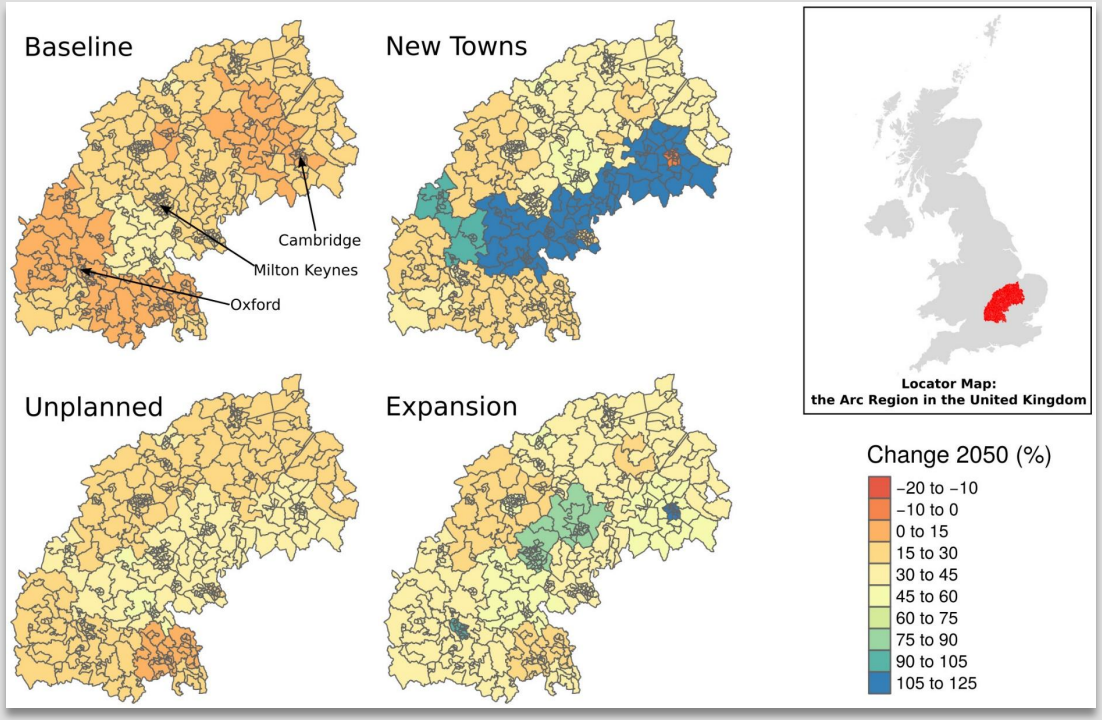
The RAMP Urban Analytics Approach



The RAMP Urban Analytics Approach



RAMP UA – Microsimulation

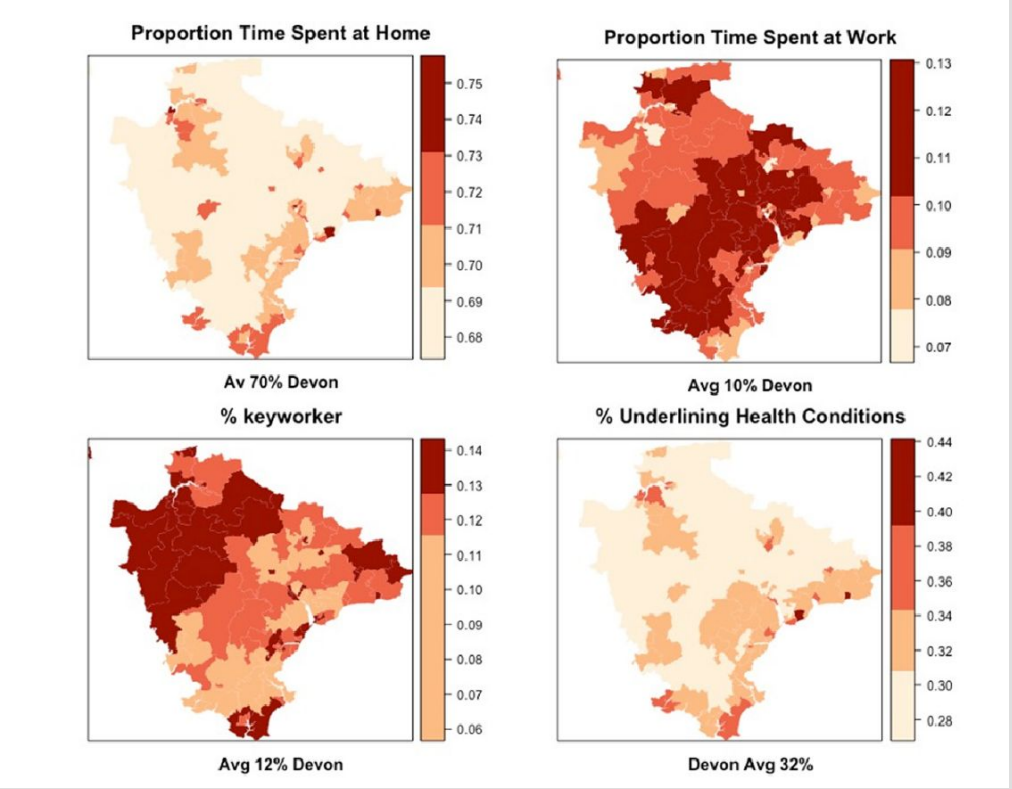


Lomax, N., Smith, A.P., Archer, L., Ford, A. and Virgo, J., 2022. An Open-Source Model for Projecting Small Area Demographic and Land-Use Change. *Geographical Analysis*. https://doi.org/10.1111/gean.12320.

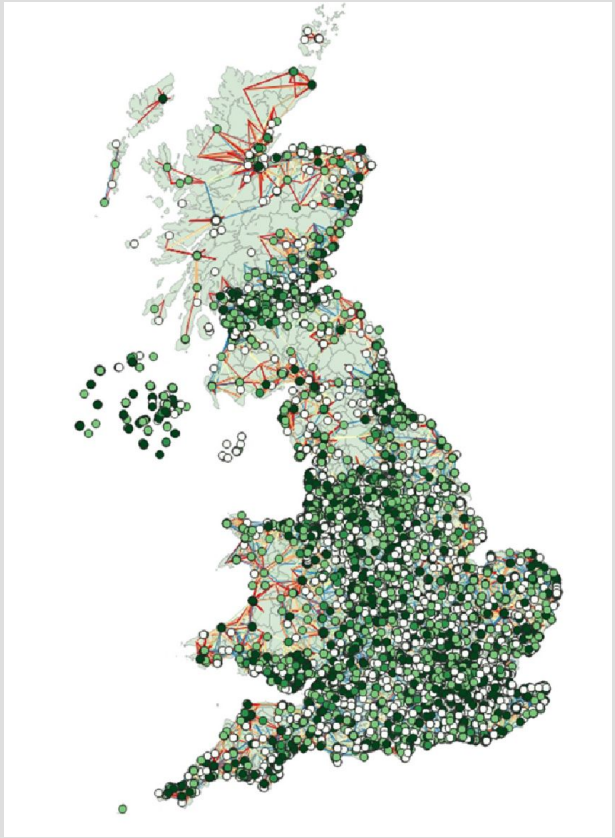
RAMP UA – Microsimulation & PSM

Attributes for the synthetic population from SPENSER and propensity score matching.

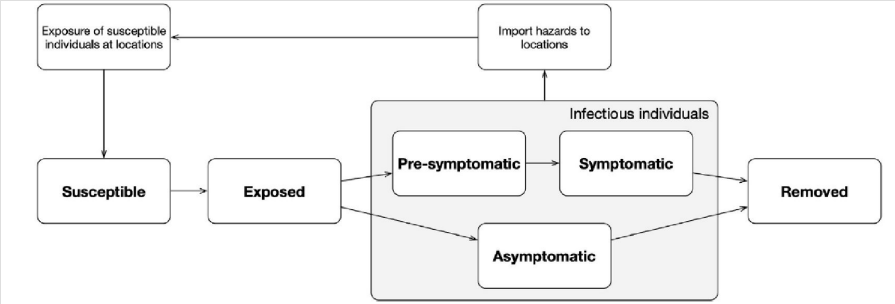
Variable	SPENSER	Time Use Survey	Health Survey of England
Individual			
Sex	X	X	X
Age	X		X
Ethnicity	X	X	X
National Statistics Socio-economic Status (NS-SEC) of household reference person	X	X	X
Number in household	X		
Time use data (proportion of time doing different activities)		X	
(CVD, high blood pressure, diabetes, COPD, BMI>40)			X
In-work status		X	
Standard Industrial Classification of economic activities (SIC)		X	
Household			
Type of dwelling inhabited	X		
(e.g. semi-detached house)	X		
Tenure (e.g. rented, mortgaged)	X		
Household Composition (e.g. cohabiting couple)	X		
Number of occupants	X		
Number of rooms	X		
Presence of central heating	X		
Type of dwelling	X		
Number of cars in household	X		



RAMP UA – Spatial Interaction

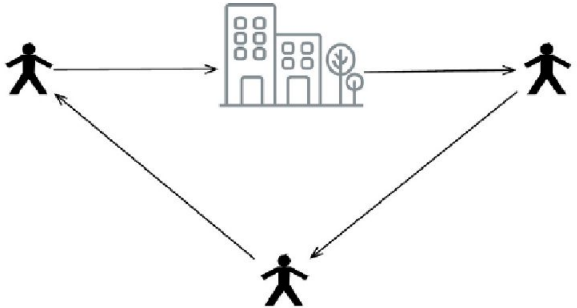


RAMP UA – Hazards and Transmission



Stage 1. *Hazard* Allocation
Individuals visit different locations (homes, schools, shops, workplaces.). If they are infected they contribute to the *hazard* in the locations they visit.

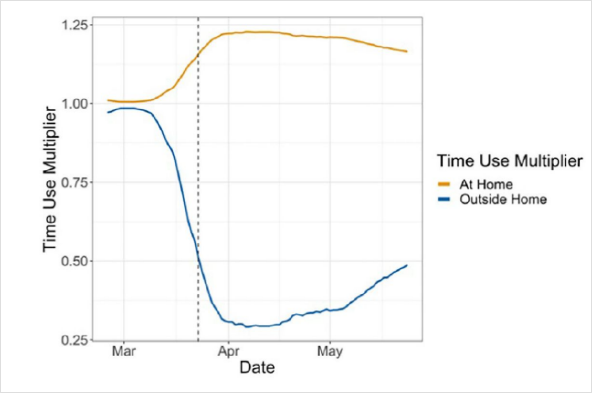
Stage 2. *Exposure* Estimation
Individuals are exposed to a hazard from the locations that they visit. These exposures cumulate so contribute to their overall exposure score



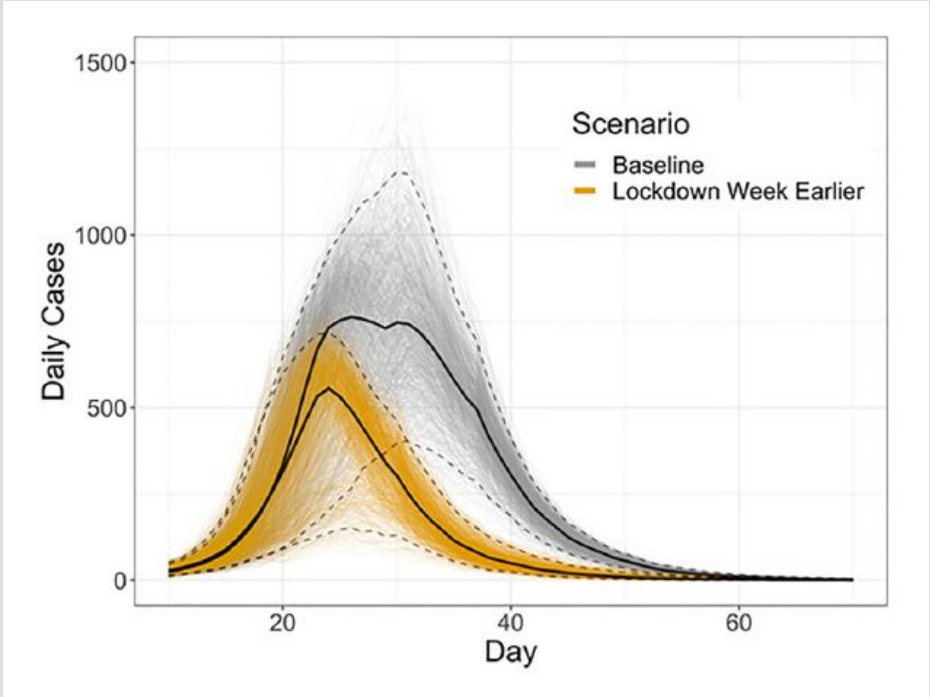
Stage 3. Disease Status Estimation
Exposure scores are used, amongst other attributes, to estimate the new disease status for all individuals

Age Group (Years)	Probability of Symptomatic Infection	Probability of Symptomatic Infection if BMI _ 25	Probability of Mortality if Infected	Probability of Mortality if Infected and BMI _ 30
0–4	0.21	0.21	0.0000	0.0000
5–9	0.21	0.21	0.0001	0.0001
10–14	0.21	0.21	0.0001	0.0001
15–19	0.21	0.21	0.0002	0.0002
20–24	0.45	0.66	0.0003	0.0004
25–29	0.45	0.66	0.0004	0.0006
30–34	0.45	0.66	0.0006	0.0009
35–39	0.45	0.66	0.0010	0.0015
40–44	0.45	0.66	0.0010	0.0024
45–49	0.45	0.66	0.0024	0.0036
50–54	0.45	0.66	0.0038	0.0056
55–59	0.45	0.66	0.0060	0.0089
60–64	0.45	0.66	0.0094	0.0139
65–69	0.45	0.66	0.0147	0.0218
70–74	0.69	0.96	0.0231	0.0342
75–79	0.69	0.96	0.0361	0.0534
80–84	0.69	0.96	0.0566	0.0838
85–89	0.69	0.96	0.0886	0.1311
90+	0.69	0.96	0.1737	0.2571

RAMP UA – Scenario Modelling



Age Group	Baseline	Experimental	Percentage Decrease
0–18	4967	4076	18%
19–30	2662	1045	61%
31–65	8017	2190	73%
66+	1757	569	68%
Total	17,221	7880	54%



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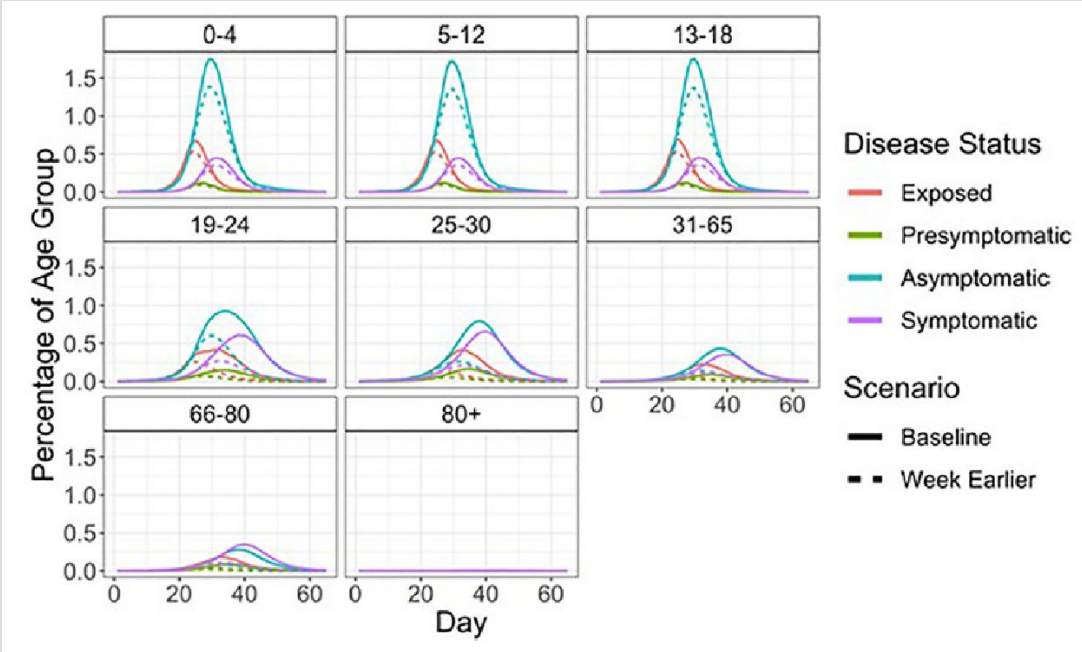
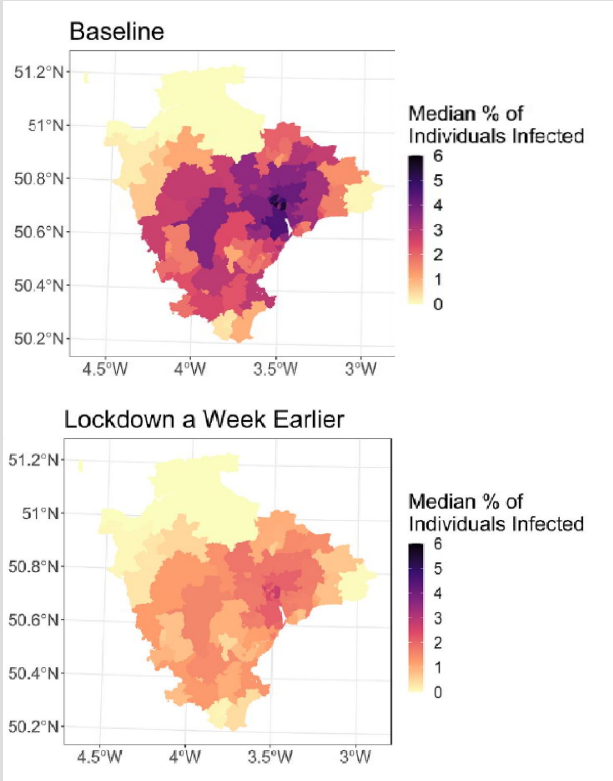
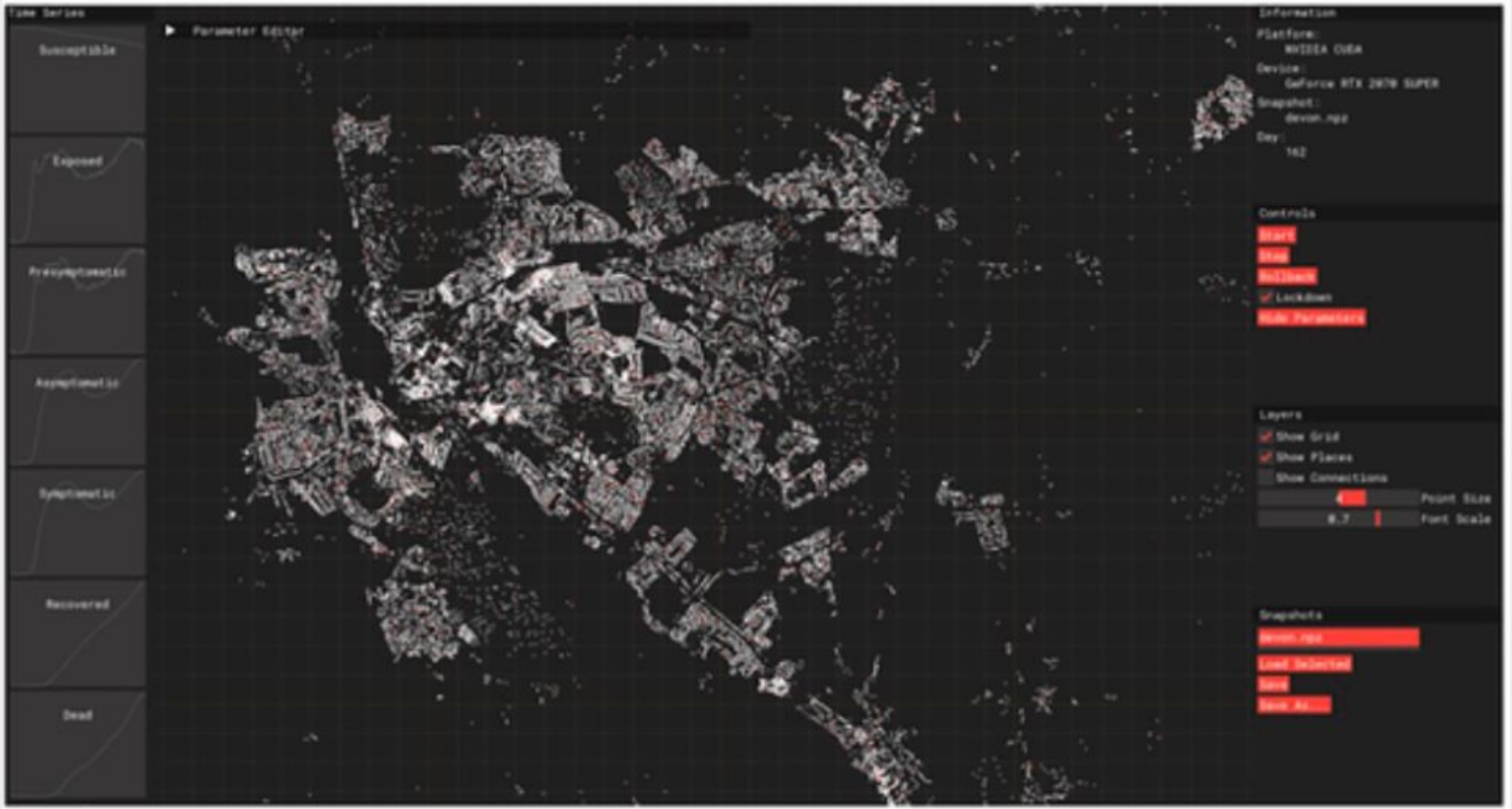




RAMP-UA Demonstrator



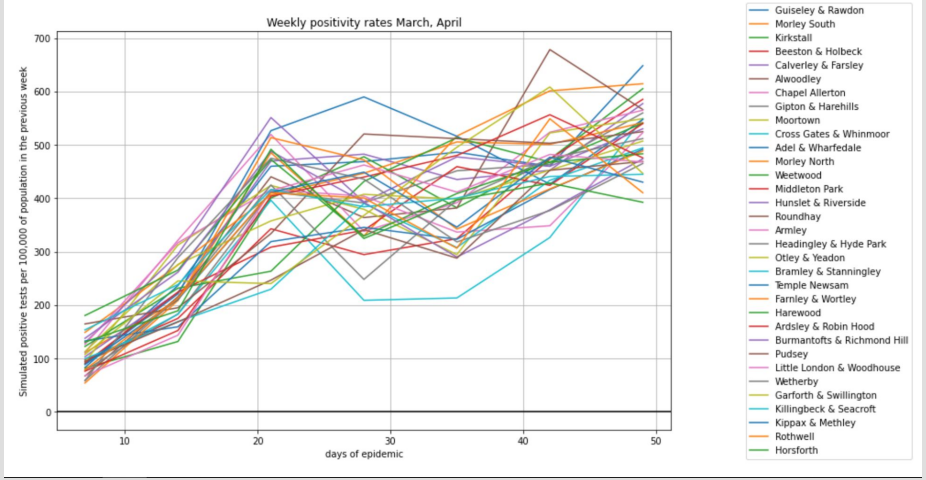
Features of the RAMP-UA model

- Spatial refinement to MSOA
- Mobility and social interaction calibrated to real behaviour patterns drawn from blue chip surveys and novel ‘big data’ sets
- Activities encompassing retail, leisure, transport, hospital visits as well as schools and workplaces
- Demographic profiling includes employment and labour market status, health attributes, and socio-economic variables such as ethnicity, car ownership and deprivation, as well as age-sex-marital status and household composition

Some reflections from this group…

- Behavioural models are an important complement to epidemiological perspectives.
- Greater use of scenario analytics and ‘what if’ simulations could be vital in promoting more effective policy interventions.
- Higher level of granularity, including spatial detail, is required in the context of pandemics (and elsewhere).
- Models developed and shared in open source by members of a multi-skilled and distributed team.
- The level of practical *assistance* provided in *modelling the pandemic* was relatively limited (and not especially *rapid*!).
- Data which provide crucial insights into social interaction and mobility need to be mobilised much more effectively in the future.

Future and Extensions



- Modelling events and activities
- Targeting of interventions across social and demographic groups or local areas
- Economic modelling and impact assessment
- Capacity planning

"I do not think that we have very good models of the impact of different environments and different locations. I don't think anyone has"

(Sir Patrick Vallance, House of Commons Select Committee (09/12/20), responding to questions around the necessity and impact of restrictions in the hospitality sector, the value of tiers, and following specific discussion of the vaccine roll-out, its impacts on behaviour and relaxation of lockdown policies).

- Infrastructure investment/ National Transport Digital Twin
- EnergyFlex
- DyME Climate, Heating and Health

More details

- Spooner, F., Abrams, J.F., Morrissey, K., Shaddick, G., Batty, M., Milton, R., Dennett, A., Lomax, N., Malleson, N., Nelissen, N., Coleman, A., Nur, J., Jin, Y., Greig, R., Shenton, C. and Birkin, M., 2021. A dynamic microsimulation model for epidemics. Social Science & Medicine, 291, p.114461.

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- https://www.turing.ac.uk/research/research-programmes/urban-analytics

- https://improbable.io/blog/improbable-synthetic-environment-technology-accelerates-uk-pandemic-modelling