An agent-based model of COVID-19 Epidemic

A case study of Barking and Dagenham, London, UK

Bayi Li
02/26/2022

Contents

Contents

Research Background

- Lockdown (strict suppression interventions) is effective but at great cost
- The infections are mostly driven by individual interactions within space
- Human mobility has been measured by big data technology
- Transmission dynamics can be explained by mathematical model

Research Objectives

1. Evaluate the effectiveness of lockdown intervention
2. Better understanding of the transmission dynamics
3. Observe and advise the duration and intensity of the NPIs

Barking and Dagenham, a borough of London, houses more than 200, 000 residents.

Compared to other boroughs, it has more cases and higher infection rate.

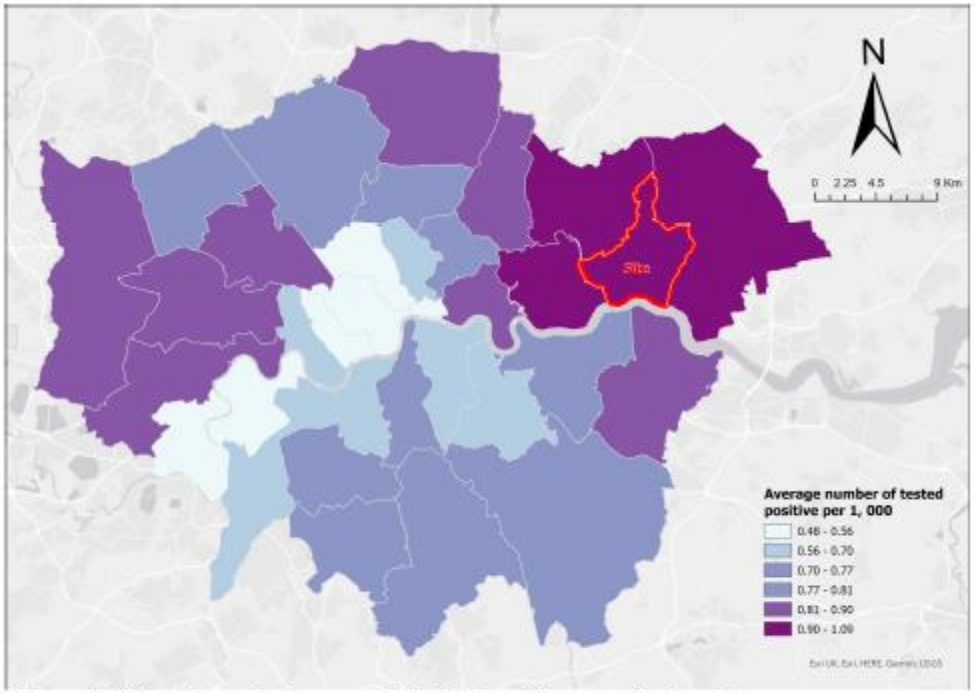

Figure 1. The choropleth map of COVID positive rate in London.
Cumulative positive cases to date, 31 December 2020.

Contents

Epidemiological models

Different equation (SIR, SEIR model, etc.)	collecting feedback from **a broader boundary**, but the population within one compartment is **homogeneous**
Agent-based	ability to examine **a smaller behavior unit** and **wider coverage of scenarios**, but requires a **heavier computing power**

Agent-based modeling:

- Contains numerous heterogenous agents
- Guided by choice framework

SEIR+D:

- Agents will be divided into five stages (susceptible, exposed, infected, recovered and deceased)
- The agent will transfer from one stage to another according to the characteristics and location

Research Approach

Infection Rule

Age-dependent

- Visiting frequency of Places
- Mortality for COVID
- Susceptibility for COVID

Age groups	Population Fraction (%)	Mortality* (%)	*AgeSus* (susceptibility**, scale: 0 to 1)
0-19	32.163	<0.001	0.4
20-29	13.643	0.002	0.79
30-39	16.481	0.007	0.86
40-49	13.869	0.023	0.8
50-59	10.816	0.066	0.82
60-69	6.519	0.193	0.88
70-79	3.840	0.554	0.74
80+	2.670	2.376	0.74

Location-dependent

- Activity Susceptibility

Category	*ActivitySus* (susceptibility, scale: 0 to 1)
Retail and Recreation	0.74
Grocery and Pharmacy	0.3
Parks	0.44
Transit stations	0.7
Workplaces	0.6

Research Approach

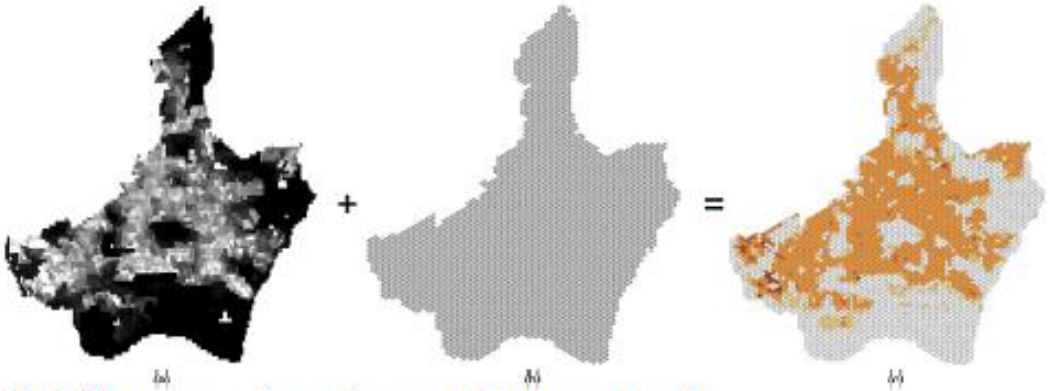

Fig 7. The process of mapping population count to grids.
(a) Raster of population count (resolution: 100m); (b) Grid of hexagons (size: 100m); (c) Grid with population count attribute.

Research Approach

Infection Rule

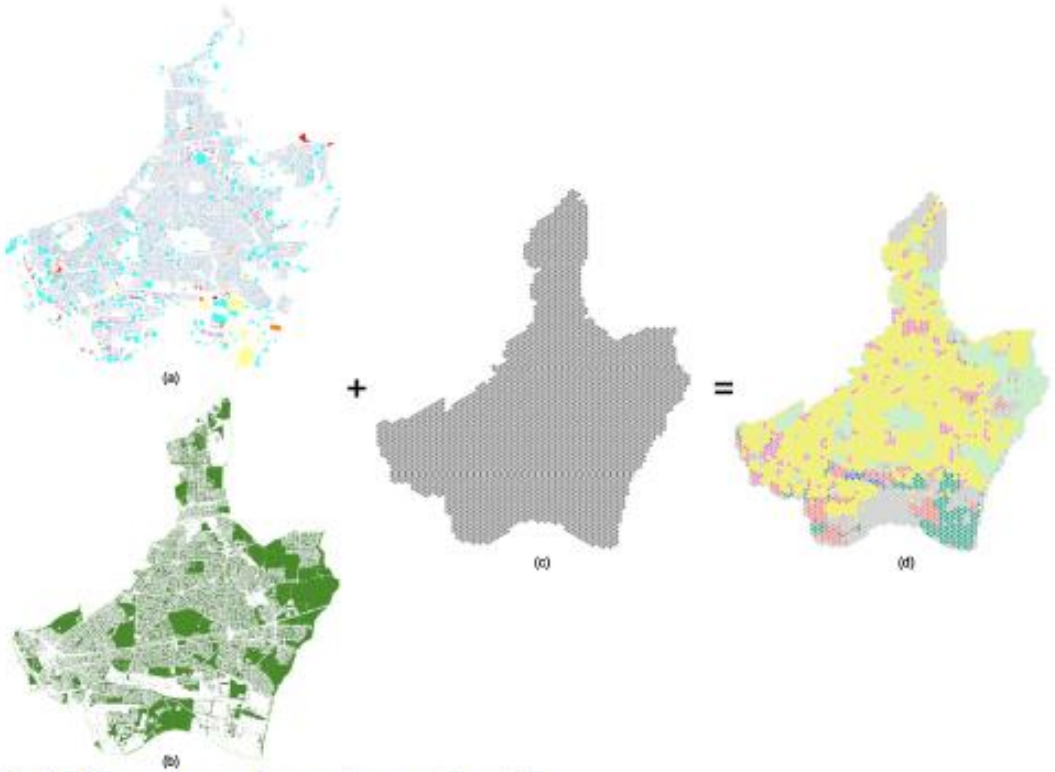

Fig 8. The process of mapping use to grids.
(a) Geomni building outline with use attribute; (b) OS MasterMap Greenspace; (c) Grid of hexagons (size: 100m); (d) Grid with use attribute.

Research Approach

Infection Rule

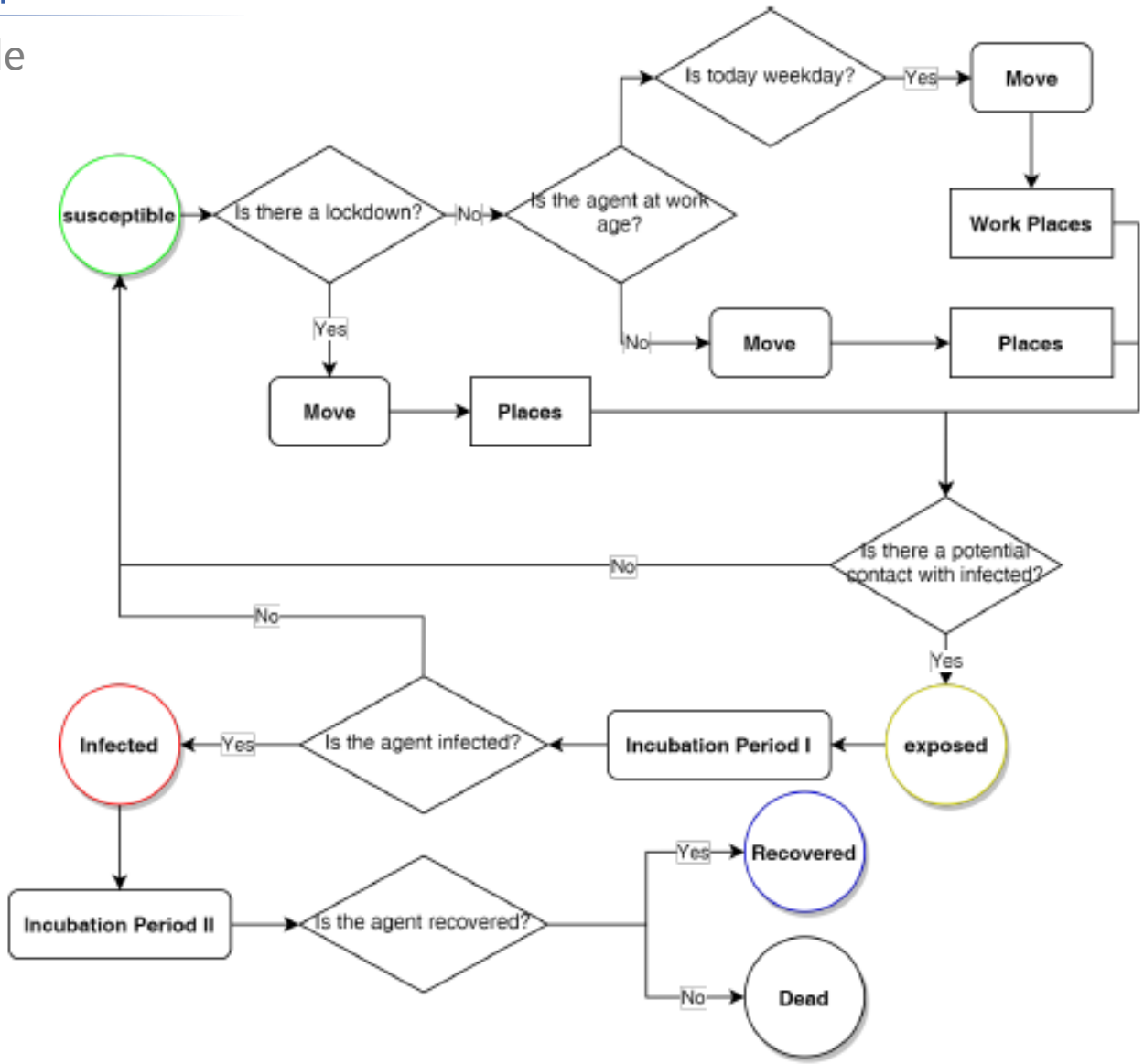

Figure 5. Flow diagram for the infection rules that describe COVID-19 propagation among individuals.

Contents

Research Result

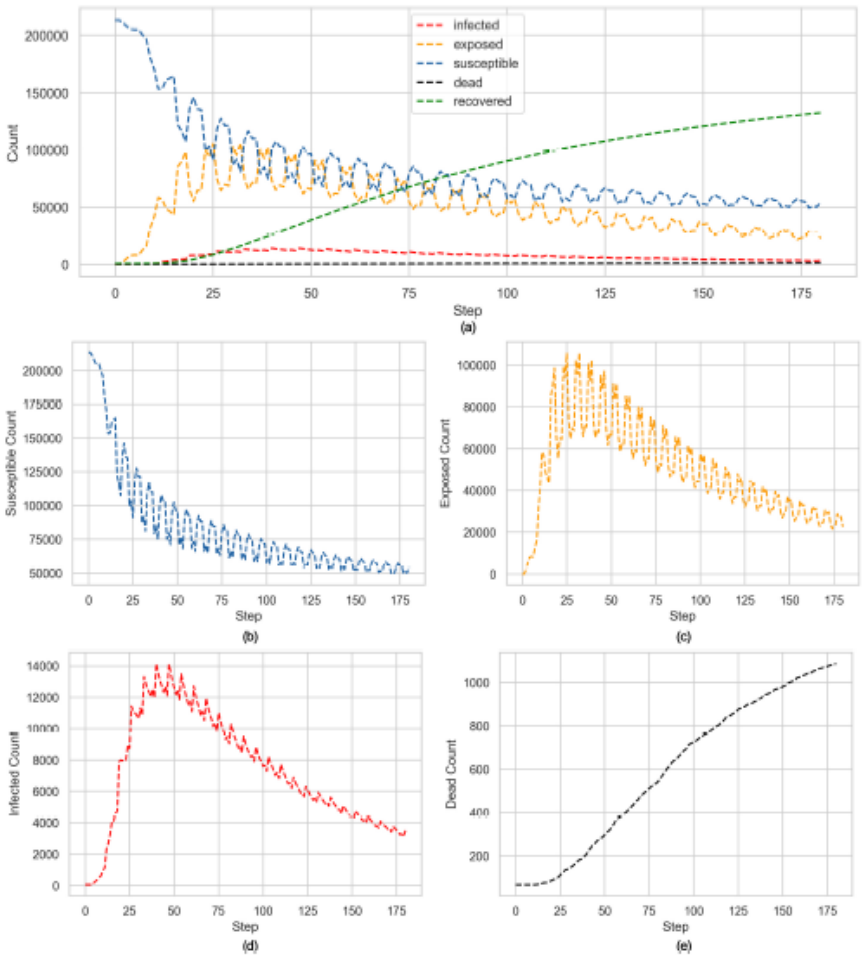

Figure 7. Count changes for agent groups of SEIR + D (dead) stages (lockdown-eased scenario).

(a) Counts for SEIR + D stages agents throughout the simulation; (b) count changes for susceptible agents; (c) count changes for exposed agents; (d) count changes for infected agents; (e) count changes for dead agents.

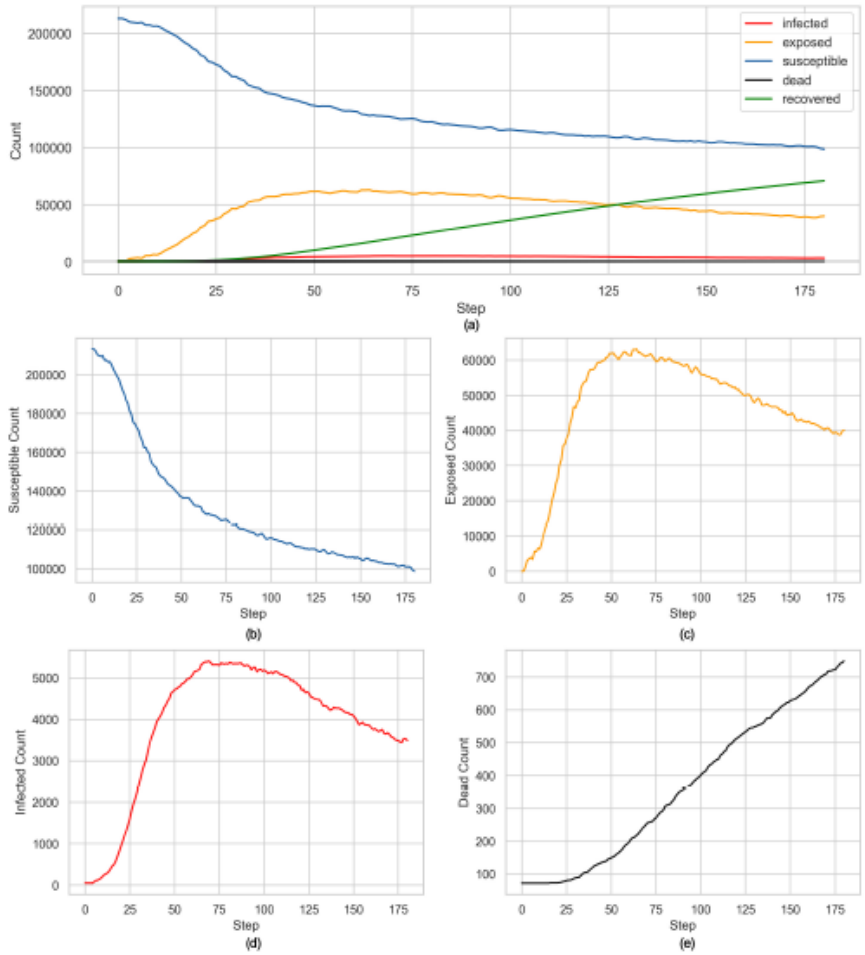

Figure 10. Changes of count for agent groups of SEIR+D (dead) stages. (lockdown scenario)

(a) Counts for SEIR + D stage agents throughout the simulation; (b) count changes for susceptible agents; (c) count changes for exposed agents; (d) count changes for infected agents; (e) count changes for dead agents.

Research Result

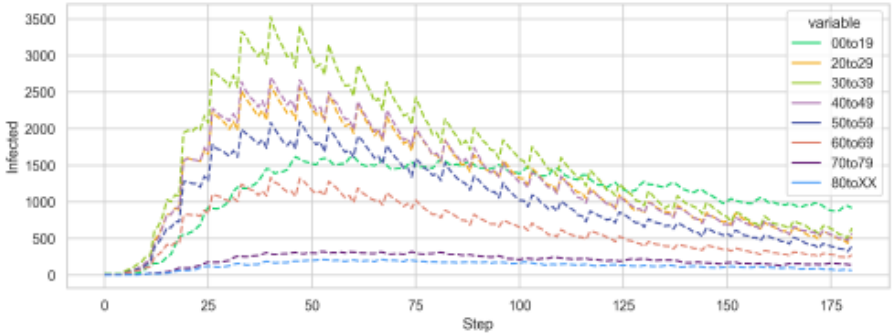

Figure 8. Changes of infected cases by age group. (lockdown eased scenario)

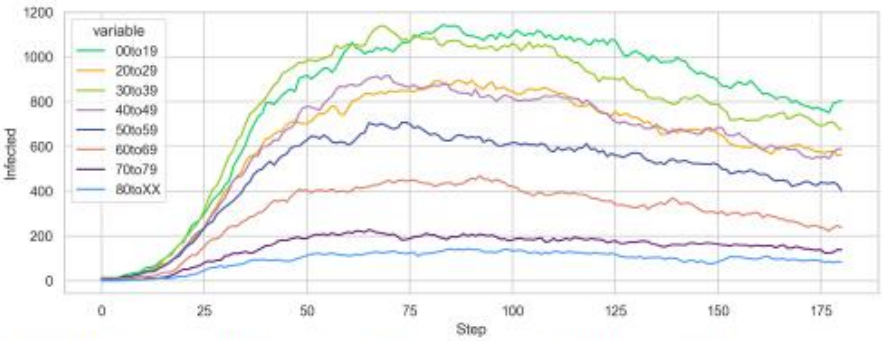

Figure 11. Changes of infected cases by age group. (lockdown scenario)

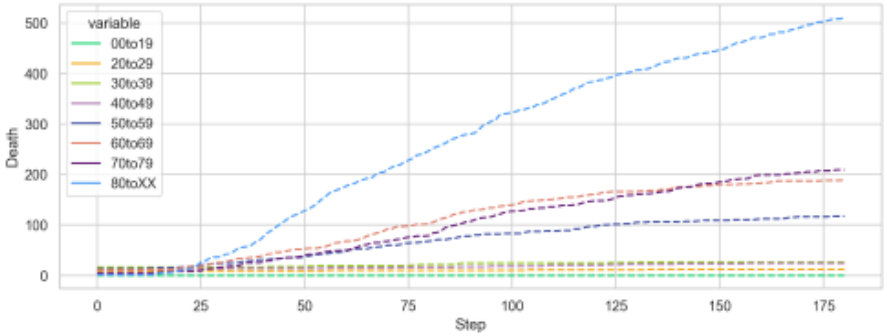

Figure 9. Changes of death cases by age group. (lockdown eased scenario)

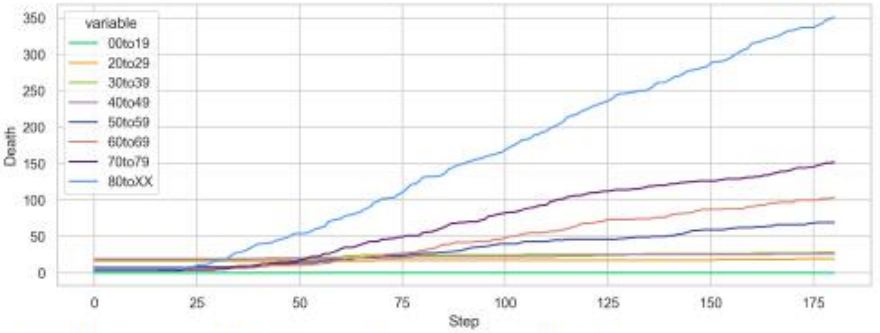

Figure 12. Changes of death cases by age group. (lockdown scenario)

Research Summary

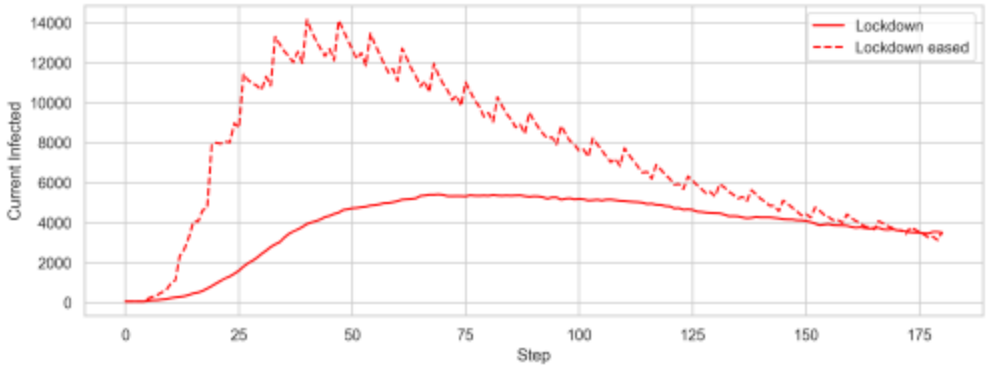

Figure 13. Changes of current infected cases in both scenarios.

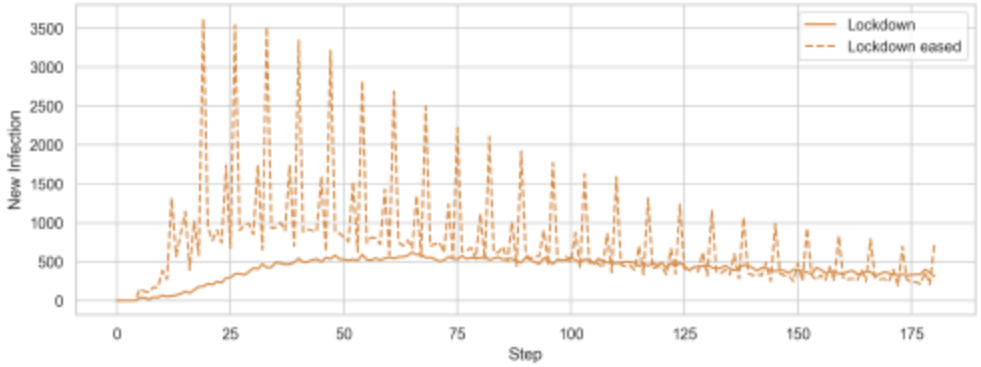

Figure 14. Changes of new infected cases in both scenarios.

Contents

Conclusion:

- Younger age group accelerate the transmission
- Lockdown should be introduced at the early stage
- Lockdown should not exceed three month
- Lockdown alone could not eliminate the transmission

Application & Significance：

- Advise the policy-making for epidemic interventions
- Adaptative model for other communicable disease

Limitation：

- Closed system without including migration across it
- Absence of other NPIs and vaccination
- Uncertainty of resident's choice

Future Direction：

- Test the combination of NPIs and advise accordingly

THANKS

Contact: barryli081@gmail.com