A network modelling approach to assess non-pharmaceutical disease controls against SARS-CoV-2 in a worker population

Edward Hill, Ben Atkins, Matt Keeling, Louise Dyson, Mike Tildesley.

Zeeman Institute: SBIDER, School of Life Sciences & Mathematics Institute, University of Warwick, UK.
Joint UNIversities Pandemic and Epidemiological Research, https://maths.org/juniper/.

Demonstrates the utility of **network model frameworks** to capture **heterogeneity of demographic attributes** across worker roles and the **individual nature** of non-pharmaceutical interventions.

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Edward.Hill@warwick.ac.uk

@EdMHill

https://edmhill.github.io

1. Motivation & aims

Globally, many countries have employed **social distancing measures** and **non-pharmaceutical interventions (NPIs)** to curb the spread of SARS-CoV-2 [1].

As part of a collective effort to protect public health by disrupting viral transmission, businesses also need to act appropriately by taking all reasonable measures to **minimise exposure** to coronavirus in workplaces and premises open to the public [2]. Adjustments in working practices can result in changes to the amount, duration, and/or proximity of interactions, thereby **altering the dynamics of viral spread**.

Study objectives:

i. Parameterise an **individual-based** network model of workers, stratified into work sectors, using a **data-driven** approach;

ii. Study **epidemic spread of SARS-CoV-2** amongst a population of workers and analyse the impact of **NPIs** targeted towards working practices.

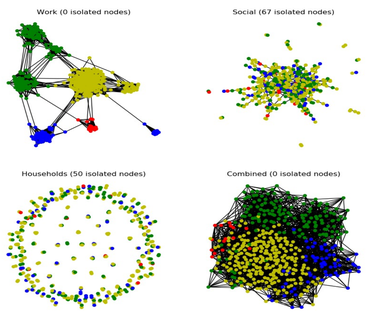
2. Network model description

- Network model construction with **nodes representing workers** and **connections representing contacts** that can result in disease transmission in distinct settings: workplace, household and social (Fig. 1).
- Ran a SARS-CoV-2 outbreak upon the network, with **transmission scaled** according to setting and symptomatic status.

Simulation overview:

- **Population & time horizon:** 10,000 workers, 365 days.
- **Simulation count:** 1000 runs
  - 50 distinct network realisations
  - 20 runs per network realisation
- **Initial disease state conditions:**
  - Ten individuals in an infectious state.
  - All other individuals began in a susceptible state.
- **Default worker pattern:** Assumed all workers had the same working pattern of five days at the workplace (Monday-Friday) and two days off (Saturday and Sunday).
- **Intervention implementation:** Assumed that all NPIs implemented from day 15, including isolation and test-and-trace (default assumption of 70% adherent).

Fig. 1: **Illustration of the structured layers of the worker network model.**

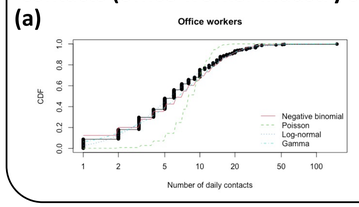


3. Contact parameterisation

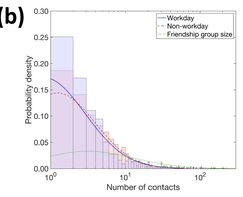
- Contact distributions and risk parameterised by the Warwick contact survey [3-5].
- We generated static contacts using a "configuration model" style algorithm, specifying a desired degree distribution for each of 41 work sectors.
- Lognormal distributions consistently provided stronger correspondence to the data, across different occupations, than alternative distribution choices (Fig. 2).

Fig. 2: Parametric distribution fits to empirical data on number of: (a) work contacts (office worker industry sector as an example), (b) social contacts.

(a)



(b)



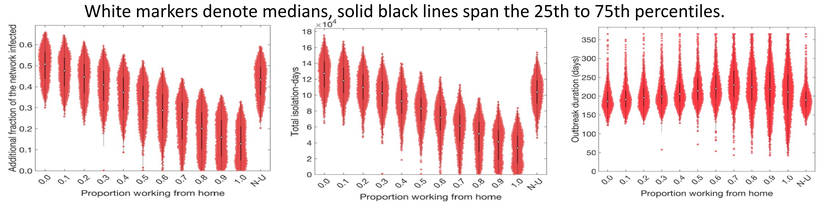
Friendship group size	Lognormal(3.14,1.141)
Social contacts (workday)	Lognormal(1.40,1.27)
Social contacts (non-workday)	Lognormal(1.54,1.15)

4. Results: Workplace targeted interventions

- A large proportion of the workforce working from home **stunts outbreaks** (Fig. 3).

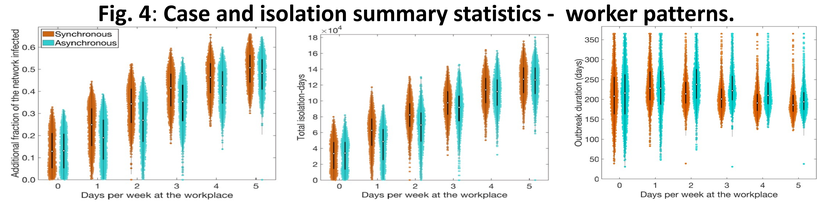
Fig. 3: **Case and isolation summary statistics - proportion working from home.**

White markers denote medians, solid black lines span the 25th to 75th percentiles.



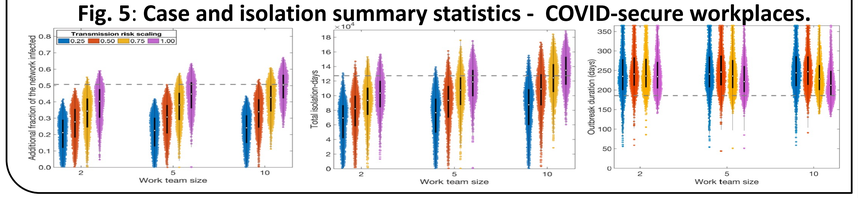
- **Asynchronous work patterns reduces** infections compared with scenarios where all workers work on the same days, particularly for longer working weeks (Fig. 4).

Fig. 4: **Case and isolation summary statistics - worker patterns.**



- **Smaller work teams** and a greater reduction in transmission risk lessened the probability of large, prolonged outbreaks (Fig. 5).

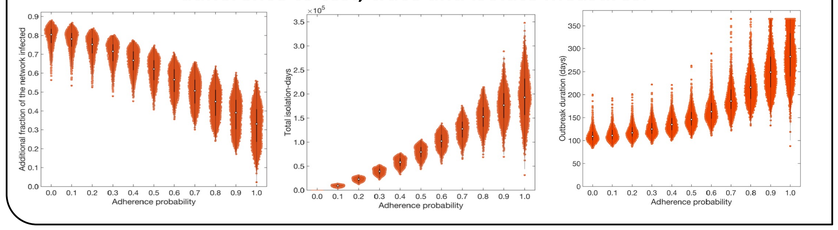
Fig. 5: **Case and isolation summary statistics - COVID-secure workplaces.**



5. Results: Adherence to test, trace & isolation

- **Absence of sufficient adherence** to non-pharmaceutical interventions **increases** the chance of SARS-CoV-2 spreading widely in the population (Fig. 6).

Fig. 6: **Case and isolation summary statistics under differing levels of adherence to test, trace and isolate measures.**



6. Possible model developments

- Augment model with **age structure**.
- Allow for **clustering of individuals** within individual workplaces.
- Inclusion of **part time workers**.
- Explore **sensitivity** to alternative epidemiological and intervention assumptions, e.g. presence of other respiratory infections and impact on test capacity when levels of cough and fever are high due to non-COVID-19 causes.
- Application to **other countries**, given availability of associated data to parameterise the model framework.

Acknowledgements

The Social Contact Survey data are available from https://wrap.warwick.ac.uk/54273/.
The code repository for the study is available at:
https://github.com/EdMHill/covid19_worker_network_model.
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