# An Age Structured SEIR Model to Evaluate Public Health Interventions on Irish Covid-19 Incidence

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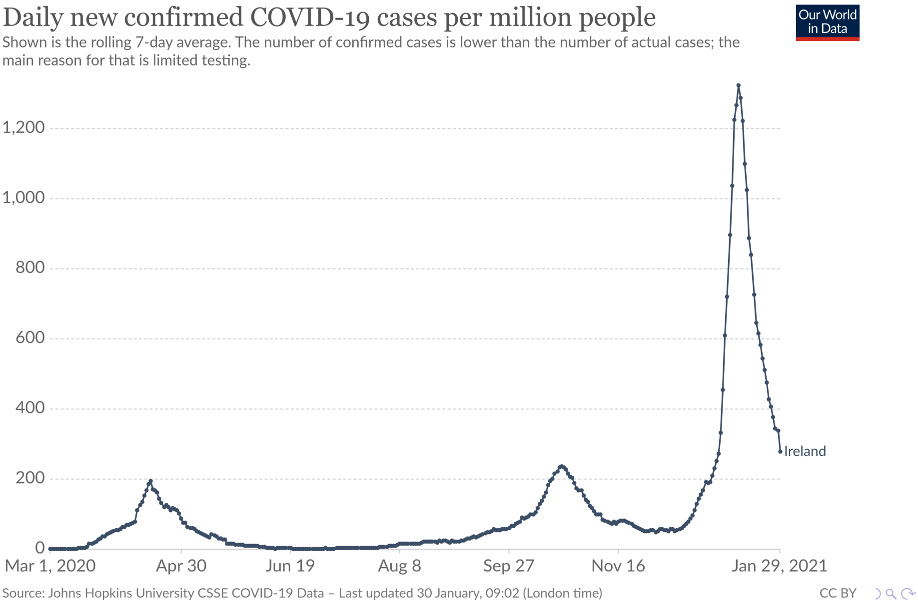
# Objectives

The main idea is to measure the effect of lockdowns on the number of COVID-19 cases.

- Forecast future cases under different lockdown scenarios.
- Economic component - how much does each lockdown cost?

# Confirmed Cases in Ireland



# SEIR Model

We want to try put a number on the lockdown effect.

We use a *compartmental model*; specifically, a *SEIR* model.

A SEIR model is a system of ODEs.

# SEIR Model

$$\frac{dS_i}{dt} = -\beta S_i \sum_j (C_{ij} I_j^p + \alpha C_{ij} I_j^a + k C_{ij} I_j^k + C_{ij} I_j^{t1} + m C_{ij} I_j^{t2} + C_{ij} I_j^n)/N_i$$

$$\frac{dE_i}{dt} = \beta S_i \sum_j (C_{ij} I_j^p + \alpha C_{ij} I_j^a + k C_{ij} I_j^k + C_{ij} I_j^{t1} + m C_{ij} I_j^{t2} + C_{ij} I_j^n)/N_i - \frac{1}{\tau_L} E_i$$

$$\frac{dI_i^p}{dt} = \frac{(1 - f_a)}{\tau_L} E_i - \frac{1}{\tau_C - \tau_L} I_i^p$$

$$\frac{dI_i^a}{dt} = \frac{f_a}{\tau_L} E_i - \frac{1}{\tau_D} I_i^a$$

$$\frac{dI_i^k}{dt} = \frac{f_k}{\tau_C - \tau_L} I_i^p - \frac{1}{\tau_D - \tau_C + \tau_L} I_i^k$$

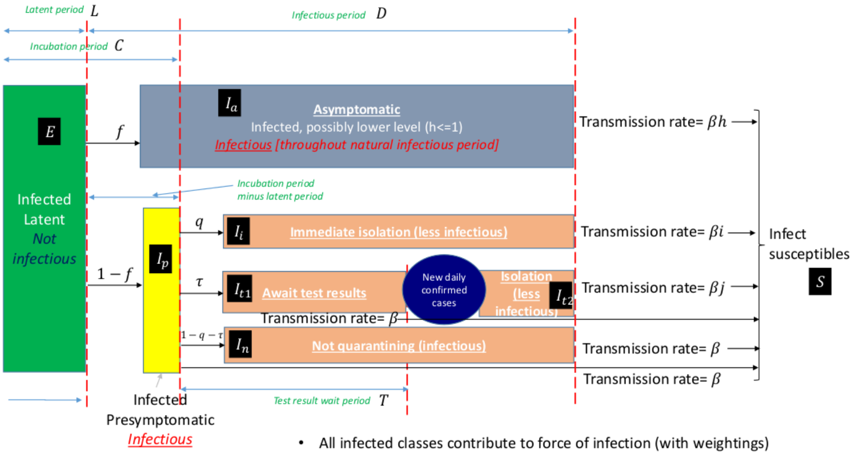
$$\frac{dI_i^{t1}}{dt} = \frac{f_t}{\tau_C - \tau_L} I_i^p - \frac{1}{T} I_i^{t1}$$

$$\frac{dI_i^{t2}}{dt} = \frac{1}{T} I_i^{t1} - \frac{1}{\tau_D - \tau_C + \tau_L - T} I_i^{t2}$$

$$\frac{dI_i^n}{dt} = \frac{1 - f_k - f_t}{\tau_C - \tau_L} I_i^p - \frac{1}{\tau_D - \tau_C + \tau_L} I_i^n$$

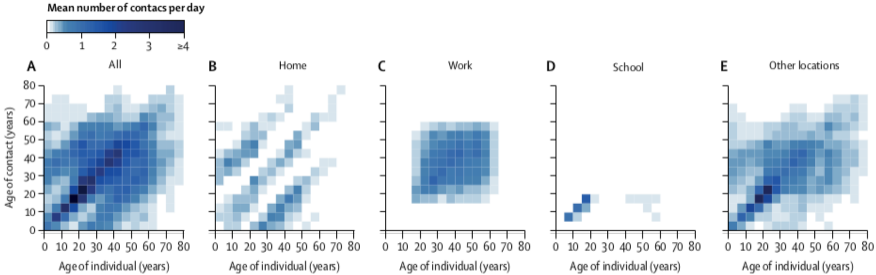
$$\frac{dR_i}{dt} = \frac{1}{\tau_D} I_i^a + \frac{1}{\tau_D - \tau_C + \tau_L} I_i^k + \frac{1}{\tau_D - \tau_C + \tau_L - T} I_i^{t2} + \frac{1}{\tau_D - \tau_C + \tau_L} I_i^n$$

# SEIR Model Graph (taken from IEMAG)




- All infected classes contribute to force of infection (with weightings)
- Infected individuals move from the infected classes to Removed (not shown)

# Contact Matrices



# Lockdowns

The purpose of lockdowns are to reduce social contact.

So a reasonable proxy for lockdown effect can be a scalar applied to the contact matrices.

We can fit these scales to the data using the following relationship with the case count:

$$\frac{dX_i}{dt} = \frac{1}{T} I_i^{t1}$$

# Uncertainty Measurement

Two major sources of uncertainty:

The fitted contact matrix scalars.

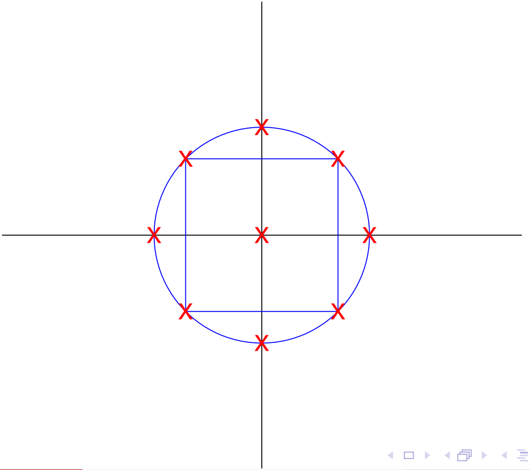
- Use parametric bootstrapping.

The "fixed" SEIR parameters.

- Re-fit model to a number of parameter values selected by controlled design.

# Central Composite Design (CCD)

Points for the SEIR parameters are selected by inscribing a cube inside a sphere in parameter space.



# Project Outcomes

1. Breakdown of lockdown strategy for next (say) 2 months (ideally with some estimate of economic costing for each).

2. A Shiny app that can visualise SEIR output.