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Adaptave Linear Fit to Covid-19 Data: Methods and Results Report 2

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Estimating the actual start of the infection in the UK and determining the initial (pre-lockdown) infection rate

Abstract

We observe that in the UK during the last 10 days of March (21-31 March) the number of deaths related to Covid-19 and reported by the health services (in-hospital deaths) shows an exponential growth with a constant growth rate of 0.2 day-1. Since these deaths are most probably caused by a free transmission (un-affected by social distancing and/or lockdown measures), this growth rate is a good approximation for the free transmission rate predating social distancing. We use this rate, the number of deaths on 31 March and a 50% correction as reported by the ONS to estimate the date when the first cases occur and, subsequently, when free transmission starts in the UK. We fix the fatality rate to 1% and the delay between infection and death to 14 days; using these parameters we determine the first cases that triggered free community transmission occured in the first week of February, which is also confirmed by medical records.

Model

We use a simple mathematical model to fit exponential functions to both reported cases and mortality data and obtain relevant parameters. The model is described in detail in Report 1.

ONS correction to numbers of deaths

- ONS report and FT followup
- Main finding: virus-related deaths, as reported by the ONS, are, on average 50% higher than the ones reported by health services

Analysis

We have plotted the evolution of both reported cases and deaths in March in the UK:

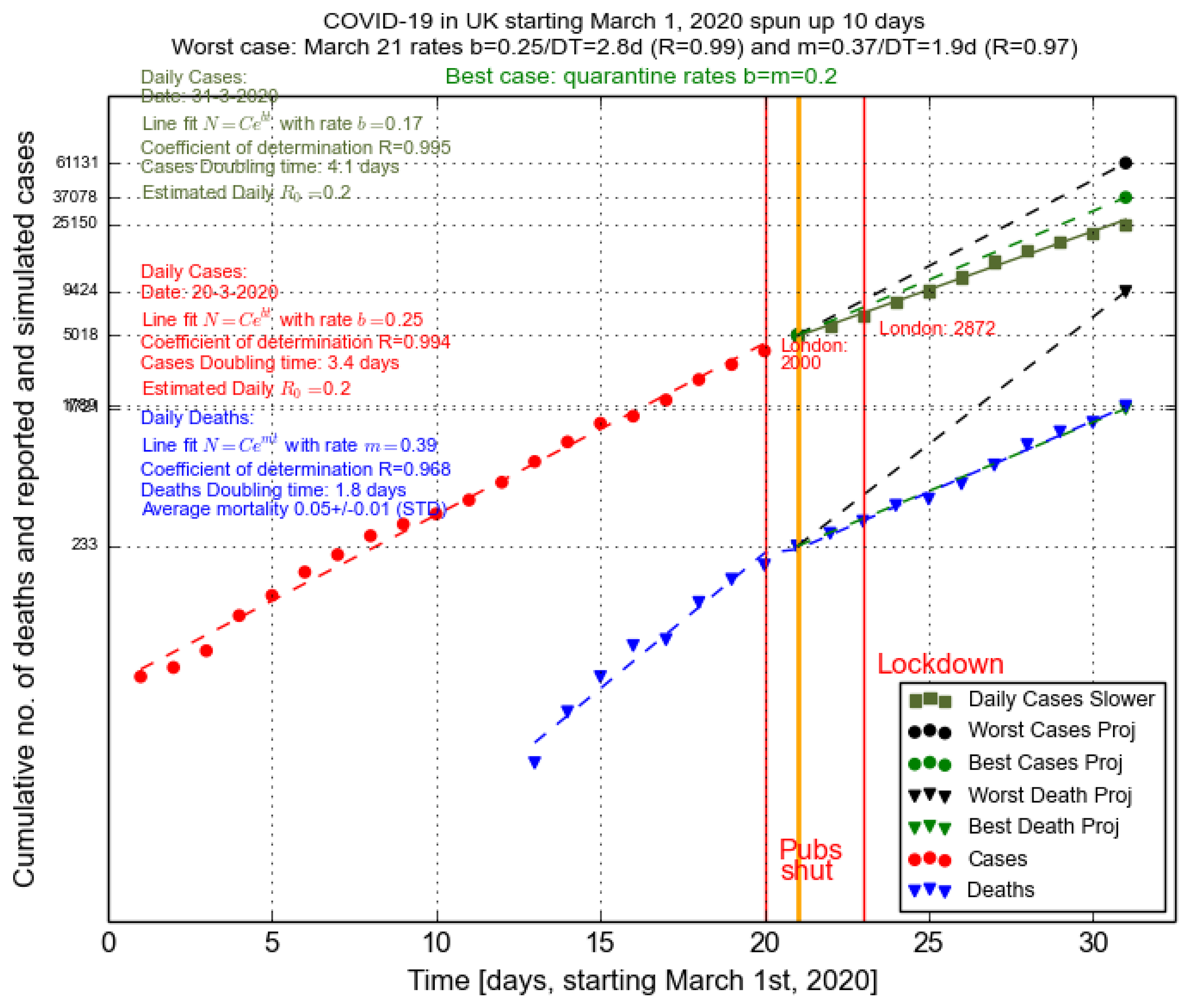

Figure 1 Evolution of reported cases and deaths in the UK in March: from 21 March to 31 March the linear fit to the exponential curve of numbers of deaths gives a constant daily increase of 20% (equivalent to the exponential growth rate of 0.2 day-1). We use this constant growth rate as the real cases growth rate before the effects from social distancing/lockdown are reflected as decreasing number of cases.

Key points:

- constant daily increase rate for deaths between 21/03 and 31/03 at 20% (0.2 day-1) (Figure 1);
- 1789 deaths on 31 March (as reported by health services) -> 2700 in actuality (corrected for by ONS reporting)
- assume fatality M=[0.5, 1, 2]% and delay of 10, 14 and 20 days:
- Compute delayed-projected cases `C(M)` using:

```
C(M, Delay) = 2700 x 1/M x 1/exp(0.2 x Delay)   (1)
```

- Compute time from initial `Ci` to 100 and to 3 cases using:

```
t100 = ln(Ci(M=1%, Delay=14)/100)/0.2   (2a)
```

and

```
t3 = ln(Ci(M=1%, Delay=14)/3)/0.2   (2b)
```

Results

Table 1 we use equation (1) to obtain actual cases `C(M)` for different `M` and delays `Delay`. We list the actual date `Act. Date` when the number of cases `C(M=1%)` was officially reported. We notice a delay of reporting the actual cases of 8-11 days (in other words, the reported cases of today were the actual cases 8-11 days ago).

Delay	C(M=0.5%)	C(M=1%)	C(M=2%)	Act. Date
10 days (21 Mar)	73000	36500	18250	29 Mar
14 days (17 Mar)	`Ci` =32800	`Ci` =16400	`Ci` =8200	28 Mar
20 days (11 Mar)	9900	4950	2500	21 Mar

Table 2 we use equations (2a) and (2b) to find the dates when there were 100 and 3 actual cases (using `Ci` from Table 1, row Delay=14 days); like in Table 1, we also list the date `Act. Date` when 100 and 3 cases were reported.

Simulated No. cases	Date(M=0.5%)	Date(M=1%)	Date(M=2%)	Act. Date
100 cases (Delay=14)	17 Feb	21 Feb	02 Mar	05 Mar
3 cases (Delay=14)	31 Jan	04 Feb	13 Feb	06 Feb

Conclusions

- The first three cases were reported in the UK on 06 February, 2020; the estimated actual number of cases for 04 February is 3 (considering a fatality of 1% and a delay between onset of infection and death of 14 days, a constant exponential daily growth rate for new cases of 0.2 day-1). This returns a delta of 2 days between the reported date and estimated date using our model; we consider this to be a plausible time delta for such a small number of cases;
- The first 100 cases were reported on 05 March; our model (fatality M=1%, Delay=14 days) places a date for an actual number of cases of 100 at around 21 February; this gives a delay in reporting of 13 days (by 05 March, based on our model, there are about 900 actual cases);
- The ONS-adjusted death figures are in good accord with an onset of the epidemic in the first week of February (free transmission) and provide evidence that a fatality M=1% and Delay=14 days is a plausible set of parameters; it also shows that by 05 March there is already considerable underreporting, explained by free community transmission within the one month between the first week of February and the first week of March.

Software

- Package
- Usage example: `python cov_model/cov_lin_wrapper.py --countries COUNTRIES --regions REGIONS --month MONTH`
- Command line args:
  - `--countries` : list of comma-sep strings or file (example: Italy,Germany)
  - `--regions` : list of comma-sep strings or file (example: California,Georgia)
  - `--month` : int (example: 3 (for March))
- Requirements:
- `python2.7` or higher (ok with `python3.x`);
- Package `xlrd` available from PyPi via `pip install xlrd` ;
- Package `scipy` : for an easy installation I recommend using `miniconda/anaconda` ; for a `pip` installation on an older architecture and `python2.7` you will have to install the `lapack` and `blas` libraries, a Fortran compiler and `python-dev` :
  - `sudo apt-get install python-dev`
  - `sudo apt-get install gfortran`
  - `sudo apt-get install libblas3 liblapack3 liblapack-dev libblas-dev`
  - `sudo pip install scipy==0.16`

Data

- UK Data: official data source
- Worldwide Data: Johns Hopkins University CSSE gitHub repository
- ONS report