Coronavirus (Covid-19) Forecast Assumption Notes

Craig Kolb

16 May 2020

These notes relate to the forecast slide decks provided here

Overview

- What is the SIR model?
- Assumptions used for the Coronavirus (Covid-19) forecasts.
- How does South Africa differ?

SIR model

The SIR model is a compartmental model. Transistions between compartments are governed by differential equations. Two key parameters are estimated – beta and gamma – from daily estimates of infectious. Beta indicates the rate of infection and gamma the rate of recovery per unit time.

$$dS = -beta/N * I * S$$
$$dI = beta/N * I * S - gamma * I$$
$$dR = gamma * I$$

Differential equations are with respect to time

Model parameter assumptions

CFR and IFR estimates are derived from data updated daily. Estimates of CFR rely on estimates of the duration from confirmation of case to fatality / recovery. This is assumed to be 14 days and is **used to correct the denominator** in estimating CFR.

Parameters for forecasting active infectious, new infections, new cases and fatalities are estimated from official new daily case data. In order to do this, new infections and the number of currently infected (Infectious) must be estimated. These estimates in turn rely on:

- Infection to case ratios. Sero surveys are used to estimate this.
- Infectious window estimates. This is assumed to be 10 days based on the literature.
- Susceptible population – assumed to equal total country population.

Of the above, the infection to case ratio estimate is the most difficult to estimate, and so the following slides examine this in more detail.

Infection to case ratio notes

Due to a lack of rigorous surveys of the population (using probability sampling) reliable estimates of actual infection numbers are unavailable. In order to obtain '<u>ballpark</u>' estimates of infections, case numbers are adjusted by a factor. The following assumptions are made in estimating and applying the adjustment factor in the model.

- Even though there is likely to be drift in the ratio of infected to cases, this is held constant as a simplification.
- Indications are that around **50%** of cases are symptomatic at the time of testing, based on estimates from the Diamond Princess cruise liner and Icelandic research. *Of course the proportion who are symptomatic may increase with time, but this number is accepted as for the time being until more accurate data is available. As a simplification in the model, it is assumed that only those who become symptomatic may consider seeking medical attention and therefore may potentially be classified as a 'case' in the average 14 day case duration.*
- Of those who have symptoms, only a certain percentage are likely to seek medical attention. How do we estimate this in order to estimate infection to case ratios? Since testing thus far has focused on identifying current cases, and not those who may already recovered from infection, it has been hard to estimate what percentage of infections present as cases. However early antibody surveys provide a way to obtain **ballpark** estimates. The Diamond Cruise Ship case also provides some useful indicators.

Alternative infection to case ratio estimates

1. Santa Clara California

It is likely infection estimates from this survey are on the high end due to the sampling method (self-selection bias and not weighted for age) and test kits used. Estimated infections were **50** fold higher than official cases. A possible path to presentation would be: 50% symptomatic, of which 4% present as cases – meaning 2% of total infections present as cases (50 to 1). The estimated IFR was 0.12%-0.2%.

2. New York

It is possible that infection estimates from this survey are also slightly higher due to the sampling method (intercept method targets those in public who may travel more) and test kits used. Estimated infections were **12.5** fold higher than official cases.

Alternative infection to case ratio estimates

3. Diamond princess

While it would not make sense to compare cases to infections in this case due to artificial social dynamics in the closed environment of a ship, we can compare the IFR to the general population CFR. For instance, South Africa's CFR is around 4.1% which is **3** fold higher than the 1.3% IFR on Diamond Princess. ***However*** *the extremely skewed age distribution on Diamond Princess means '**3** fold 'is likely on the **low** side when comparing to South Africa. Given time contraints, no attempt has been made to adjust this, though this could conceivably be done with some modelling. Therefore this estimate has been excluded.*

Alternative infection to case ratio estimates

4. Gangelt

The Gangelt study has an advantage in that the researchers used a probability sample. Using the study data the researchers estimated that infections were 5 fold higher than cases in the town of Gangelt. *However, this statistic is of less interest given local conditions that likely increased the probability of case presentation making this a less reliable statistic.* Of more interest is the IFR estimate of 0.36%.

Using this IFR estimate and comparing it to the CFR (4.9%*) nationally in Germany we can estimate the infection to fatality ratio as being as between **13.61** (which is similar to the New York sero survey result of around 12.5).

*Estimated using ECDC data – excluding the previous 14 days to account for illness duration.

Infection to case ratio estimates derived from sero surveys

*According to the authors of the Santa Clara study, earlier studies had ratios ranging from 1 and 5. See: https://www.medrxiv.org/content/10.1101/2020.04.14.20062463v2.full.pdf

How does South Africa differ?

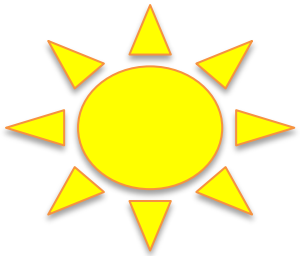
Case fatality and infection fatality rates are lower in younger age brackets. Given South Africa's lower average population age, it is expected this would exert downward pressure on fatalities.

IMPACT?

Diffusion

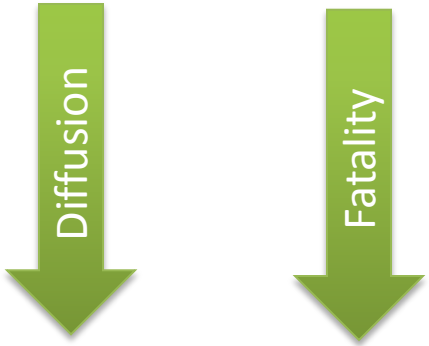
Fatality

How does South Africa differ?



Climate (temp and UV) is another factor. It may not only affect the diffusion of the disease (1) but the **likelihood of a serious infection** as the number of virus particles available to enter the human body may be reduced at the outset (2).

IMPACT?



1. A cross-national time series study by Berumen et. al (2020) of Covid-19 case diffusion determined that the rate was slowed in warmer climates.
2. A study by Memoli et. al (2014) demonstrated that virus particle dose related to the severity of illness. This may also apply to the Covid-19, although this has not been confirmed.

How does South Africa differ?

HIV prevalence is around 20% in South Africa. While intuitively one would guess that HIV would increase the likelihood of both a detectable infection gaining hold and fatality, there are no clear indications yet. High awareness of having HIV (90%) with 54% successfully suppressing the HIV virus through treatment.

IMPACT?

?

How does South Africa differ?

BCG
Vaccination history

South Africa has had BCG vaccinations against TB for decades. However, some older people may not have been innoculated. Some initial research suggests countries that have had widespread BCG vaccinations in the past may have lower case fatality rates. Two notable exceptions are the USA and Italy, both of whom have never had widespread BCG vaccination.

IMPACT?

?

How does South Africa differ?

Less likely to seek medical attention due to low medical insurance penetration and cultural preferences for traditional medicine in some areas. This is likely to increase the ratio of infections to cases relative to the developed nations.

IMPACT?

Disclaimer

- Use the information provided in this presentation at your own risk. Acentric Marketing Research (Pty) LTD makes no representation of warranty of any kind regarding the quality, accuracy or completeness of the information contained in this report. Acentric Marketing Research (Pty) LTD, its directors, employees and partners accept no liability whatsoever for losses or damages - whether direct or consequential - resulting from errors, inaccuracies or omissions.