Confidential Report

Potential Worse Case Health Impacts from the COVID-19 Pandemic for New Zealand if Eradication Fails: Report to the NZ Ministry of Health

Prepared for the Ministry of Health

by
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NOTE

Although this report was correct at the time of writing, the information it presents may no longer be current because of continuing evolution of the COVID-19 pandemic and our understanding of it.
Unless otherwise indicated, peer review and full consultation with relevant agencies was not always possible in the timeframe available for producing this report.

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24 March 2020

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Aim: To provide plausible worse case estimates for the COVID-19 pandemic on population health if eradication fails in New Zealand (as requested by the NZ Ministry of Health).

Method: As per the Modelling Report provided to the Ministry of Health on 23 March 2020, albeit with changes to selected parameters as per Table 1 below (as agreed with Dr Ian Town, Chief Science Advisor for Health on 24 March).

Results: In this worse case scenario the epidemic would be expected to peak in early July 2020 (assuming undetected spread since 1 March 2020, see Figure 1). A total of 3.32 million New Zealanders would be expected to get symptomatic illness; 146,000 would be sick enough to require hospital admission; 36,600 would be sick enough to require critical care (in an ICU); and 27,600 would be expected to die. As per previous reports, 89% of deaths would be in the 60+ age-group and there would be likely mortality gradients by ethnicity (higher in Māori and Pacific peoples) and by socio-economic position (higher in those living in deprived areas). This death toll would far exceed the death toll for NZ from World War One (18,000 deaths) and from the 1918 influenza pandemic (9000 deaths). Not considered here also are all the deaths from people who don't receive normal care (eg, for heart attacks) due to re-orientation of the health system to deal with COVID-19.

Comment: This plausible worse case analysis still assumes a functioning ICU capacity that saves 25% of those who need ICU care. This may still be optimistic as in severe overload situations there may be rate limiting steps such as the supply of ventilators. In other worse case scenarios hospital staff could go on strike if shortages of personal protective equipment (PPE) developed – further disrupting care.

Figure 1: Symptomatic cases in a worse case scenario of COVID-19 spread in NZ if eradication fails (R_0 = 3.5, uncontrolled spread begins on 1 March and epidemic peaks in early July 2020).

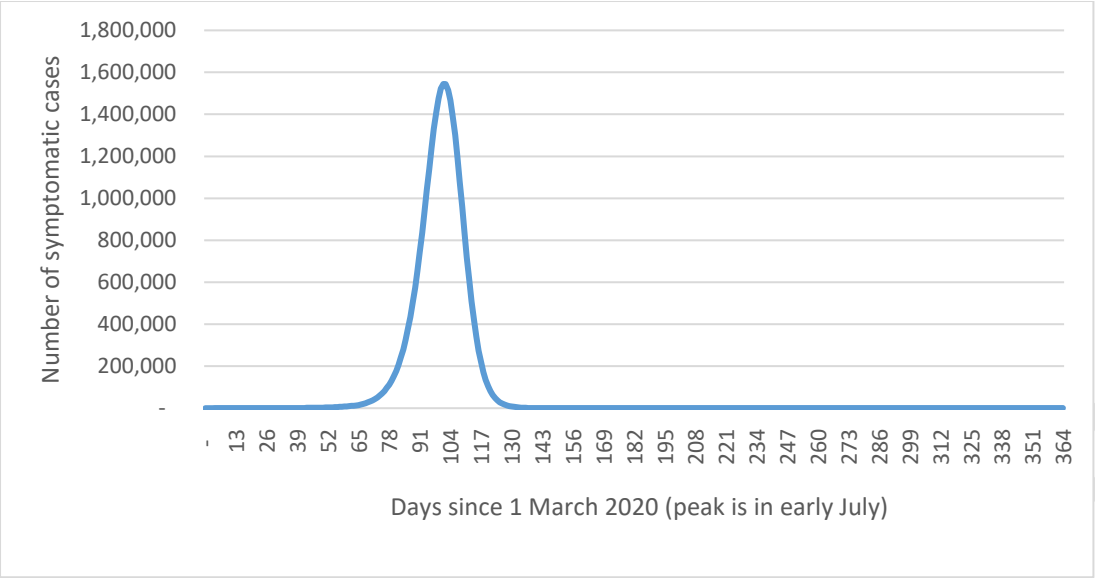

Table 1: Input parameters for modelling the potential health impacts of the COVID-19 pandemic in the New Zealand setting if eradication fails (with worse case values in red font)

Parameter	Baseline value/s used	Worse case values	Details for inputs into the CovidSIM model and additional Excel-based analyses (for the baseline analyses in the 23 March Report for the Ministry of Health)
Population size	5 million	No change	NZ population as per December 2019 was rounded up from 4,951,500 [1]. Indeed, the 5 million figure is probably more accurate as per March 2020 due to both population growth and the return of New Zealanders from overseas.
Incoming infected people from outside of NZ	1 per day (from 1 April)	10 per day (from 1 March)	To simulate the start of uncontrolled silent spread in the modelling, we assumed that this began on 1 April 2020 as a result of an asymptomatic traveller entering the country. For the remaining course of the one year simulation, we assumed that this level of introduction persisted (given NZ's commitment to allow its citizen's to return and the potential for home isolation to fail).
Infections that lead to sickness	67%	No change	This figure is still uncertain but we used the same estimate as per modelling by Imperial College at "two thirds of cases being sufficiently symptomatic to self-isolate" [2]. Of note is that another modelling study used a 50% value [3]. Nevertheless, some proportion of asymptomatic cases is consistent with the findings of a very large Chinese study [4], where 81% of cases of COVID-19 did not involve severe illness.
Sick people seek medical help (including telephone and internet consultations)	40%	No change	We used the default value in the CovidSIM model, which is based on medical consultations for influenza-like illness (ILI). During a pandemic there might be a shift away from face-to-face consultations with health workers, so that some of these consultations may be either telephone or internet-based. This parameter is not used for determining subsequent outcomes like hospitalisations and deaths. We further assume that cases only seek medical help once.
Sick people need hospitalisation	1%	4.4% as per UK	This estimate is highly uncertain. We have multiplied by 5 the percentage which has been observed for seasonal influenza

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		modelling	and is the default setting in the CovidSIM model (ie, 0.2%), to account for the apparent increased severity of COVID-19. The high uncertainty for this parameter is due to the likely under-diagnosis of mild cases in many settings (impacting the size of the denominator). It also may vary between countries given the use of hospital facilities to isolate mild cases. Modellers in the United Kingdom (UK) have used 4.4% (of all infected cases) [2], and for modelling in the United States 3%, 5% and 12% have been proposed [5]. However, we consider these to be potential over-estimates in the NZ setting where homecare for mild to moderate pneumonia may be promoted in the community in pandemic circumstances. The length of hospitalisation was assumed to be 10 days which is similar to other modelling work eg, 10.4 days for the UK [2].
Hospitalised cases need intensive care (ICU admission)	25%	No change	We used the data from a very large Chinese study for the ratio of "critical" to "severe" cases (ie, 4.7%/(13.8% + 4.7%) = 25.4%) [4]. This is similar to the Chinese case series reported by Wang et al at 26.1% [6]. Nevertheless, it is higher than reported in a smaller case series from Singapore at 11% (2/18) [7]. A UK modelling study used a proportion of 30% "based on early reports from COVID-19 cases in the UK" [2]. Of note is that this value is also higher than the NZ experience for the 2009 influenza pandemic at 9.1% (102/1122) [8]. ICU bed capacity: We used the reported number of ICU ventilated beds in NZ at 221 and an estimate from an ICU expert that these could be doubled (ie, to 442) in "extreme circumstances" [9].
Intensive care cases requiring mechanical ventilation	50%	No change	We use the same value as per a US model of 50% [10] for additional calculations outside of CovidSIM. This proportion is around that reported in a Chinese study of 47% (17/36 ICU admissions) [6], but is less than in another Chinese study at 71% (37/52) [11].
Sick people die from the disease (case fatality risk)	0.45%	0.83% (based on 75% of those needing ICU dying due to ICU overload (ie, 4.4%*25 %*75% =0.83%)	Given the relatively high quality of the healthcare systems in NZ, we considered the lower end of the range reported by the WHO for the infection fatality risk (IFR) of 0.3% to 1% (based on 3 publications) [12]. This IFR was then adjusted by the proportion assumed to be symptomatic (at 67%, as above) to give a case fatality risk (CFR) of 0.45% (ie, 0.3% x 100%/67% = 0.45%). Nevertheless, we note that higher estimates exist, including a CFR for "China outside of Hubei Province" of 0.81% (95%CI: 0.67 to 0.98; and adjusted for the time delay in reporting deaths) [13]. Another CFR for "China outside of Hubei Province" was similar, at 0.9% (95% credible interval: 0.6-1.3%; also adjusted for the time delay in reporting deaths) [14]. A value used in UK modelling was an IFR of 0.9% [2], equivalent to a CFR of 1.3% (assuming 67% of cases are symptomatic).
Basic reproduction number (R_0)	1.5, 2.5 and 3.5 (3 scenario analyses)	3.5	On 6 March 2020, the WHO reported that this number was likely to be in the range of 2.0 to 2.5 [15]. But given persisting uncertainty, we used the same three values as in the modelling work by Hellewell et al [16]. Of note is that an earlier review of 12 studies [17], suggested estimates that ranged from 1.4 to 6.49, with a mean of 3.28, a median of

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			2.79 and interquartile range of 1.16. But this review also noted that in more recent studies, R_0 estimates seem to have stabilised at around 2–3. Recent UK modelling used an estimate of 2.4 (range: 2.0 to 2.6) [2]. Of note is that in the NZ setting R_0 values may be lower than estimated in other settings. This is because relative to many other countries population density is relatively low, mass transit use is low (especially crowded mass transit such as subways), and susceptibility to respiratory viruses might also be reduced (due to relatively low smoking prevalence and low air pollution exposure in NZ).
Relative contagiousness in the prodromal period	50%	No change	There is uncertainty around this value but we used the same estimate as in recent UK modelling [2]. This has biological plausibility as while there is similarity in viral loads between asymptomatic and symptomatic COVID-19 patients [18], it would be expected that those who are fully symptomatic (with a cough etc.) would be more likely to transmit infection. Of note is an estimate from the Diamond Princess cruise ship outbreak, that 17.9% of COVID-19 infections were from asymptomatic individuals (95% credible interval 15.5-20.2%) [19]. But it is unclear how generalisable this finding is given the crowded cruise ship conditions and the typically elderly nature of the passengers.
Latency period	4 days	No change	We used an average duration of 4 days as per Read et al [20], with a standard deviation of 25% (calculated using 16 stages; Erlang distribution). This is similar to the estimate in a Chinese study which reported a median latent period of 3.69 days [21].
Prodromal period	1 day	No change	There is as yet insufficient data on this for COVID-19, so we used an assumed value for influenza (SD = 25%, Erlang distribution).
Symptomatic period	10 days	No change	The WHO-China Joint Mission report stated that “the median time from onset to clinical recovery for mild cases is approximately 2 weeks and is 3-6 weeks for patients with severe or critical disease” [22]. But given that mild cases may have been missed in this particular assessment, we used a slightly shorter time period of 10 days (SD = 25%, Erlang distribution). During this symptomatic period, cases were considered infectious. We note that there is evidence from COVID-19 cases of shedding of viral RNA from sputum that has outlasted the end of symptoms [23]. However, the significance of this for disease transmission is unknown.
Interventions			
General contact reduction	Two scenarios (25%, 50%) and threshold analyses	25% for 2 months and then people & governme nt give up	This variable covers the summated impact of a potentially wide variety of different interventions: people may adopt enhanced personal hygiene measures (hand washing, cough etiquette etc); they may decide to have fewer contacts (physical distancing); and governments may close venues and schools, restrict mass transit, curtail mass gatherings, and restrict travel (within and between countries). **Scenario “25%”:** This scenario is our approximation of a modest level of the above listed interventions. **Scenario “50%”:** This scenario assumed an intensification of the measures being adopted (relative to the above scenario).

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			Threshold analyses: This was where we increased the level of "general contact reduction" to a level which pushed the epidemic peak into the following year (ie, past day 365 after the first day of assumed uncontrolled spread of COVID-19 in NZ on 1 April).
Contact reduction begins	1 April 2020	No change	For the purposes of this modelling we assumed that the cases of COVID-19 detected in NZ during March 2020 triggered the process of contact reduction so that this was in place by the time the simulation of uncontrolled spread began on 1 April (see above). Indeed, during March 2020 there was NZ Government advice on hygiene promotion, physical distancing and constraints imposed on the upper size of mass gatherings etc. Multiple organisations also increased provision of hand sanitisers and local government closed some venues.
Contact reduction duration	6 months (9 months and "rest of year" in scenario analyses)	2 months (60 days)	This 6 month period was selected for demonstration purposes and was varied in threshold analyses (Table 1). As further discussed in the main text the feasibility of such sustained interventions for any country is highly uncertain and may not be realistic at high levels for long periods given the adverse social and economic implications.
Seasonality effect	Variation in R_0 of 25%	50% (ie, accelerating the epidemic further in the NZ winter; peak on day 137)	Winter conditions are known to accelerate transmission of influenza and also the other coronaviruses which cause common cold like symptoms [24]. Enveloped viruses show strong seasonality with winter peaks [25], and SARS-Cov-2 is an enveloped virus. Even though there are many uncertainties relating to seasonality and this novel coronavirus [26], it seems prudent to assume some seasonal fluctuation so we increased the average by 25% in winter and reduced it by 25% in summer (with a sinusoidal variation throughout the simulated year), using a mid-winter peak for NZ of 15 July (ie, day 106 of the simulation).
Case isolation (only used in the threshold analyses)	Varied in threshold analyses (Table 1)	Not considered	We set the following values in threshold analyses (while setting 0% for "general contact reduction" – see above): • Probability that a sick person is isolated = varied in threshold analyses • Maximum capacity of isolation wards = 3 per 10,000 population (ie, 1,500 in total in NZ, see below). • Contact reduction for cases in home isolation = 50% (this occurs when hospital isolation capacity is exceeded) • Beginning of case isolation measures = the 1 April date used for the start of the simulation (ie, assuming increased clinician awareness from the cases in NZ detected during March 2020). • Duration of case isolation measures = 6 months (183 days), or 9 months (274 days) or the rest of the simulated year. For isolation capacity in NZ hospitals we assumed that 10% of hospital beds could be converted for this use during the pandemic, with NZ having 2.61 hospital beds per 1000 population in 2018 [27]. If 10% of these were used for isolation purposes, then this is 2.6 per 10,000 (rounded to 3 per 10,000 for use in CovidSIM, or 1,500 beds in total).

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