The stakes of mismanaging COVID-19: Modelling the possible health system and long-term economic impacts in New Zealand using Treasury's CBAx method

Dr Matt Boyd
Adapt Research Ltd
matt@adaptresearchwriting.com

(DRAFT: not peer reviewed)

DRAFT

Background

The human and economic cost of pandemic disease can be substantial. Standardised economic analysis tools such as the New Zealand Treasury's CBAx spreadsheet[1] can be tailored to estimate the long-term (50-year, 5-year) cost impact of epidemics to New Zealand as well as the potential cost-effectiveness of mitigation measures. Previous research using CBAx has argued that complete border closure by New Zealand could be a cost-effective intervention under some catastrophic biological threat scenarios.[2] Emerging zoonotic disease is one of only a few categories of bio-threat that might ever warrant full border closure. Therefore, CBAx was used to provide estimates across a range of plausible epidemiological assumptions for the net present value (NPV) of the long-term cost impact of COVID-19 disease to New Zealand, and to provide cost-effectiveness estimates for complete border closure to guide emergency financing decisions, but also to assist in contemplating future scenarios.

Method

A previous method[2] to estimate the cost-effectiveness of border closure in a generic severe pandemic was updated using epidemiological data for COVID-19 from the China CDC[3] and National Institute of Infectious Diseases (Japan).[4] Inputs including case fatality rate (CFR), age-distribution of deaths and proportion of cases requiring hospitalisation and intensive care (ICU) were applied to the New Zealand population of Dec 31, 2019. Input parameters are listed in **Table 1** below.

The CBAx 2020 worksheet was used, including updated costs as per 2020 for impacts such as hospitalisation events, ICU costs per day, lost productivity due to an assumed 14 day illness/isolation (only for symptomatic cases, not for others quarantining), future lost productivity, health and superannuation commitments offset due to deaths, and monetised value of a quality adjusted life year (QALY). For the border closure scenario, lost tourist revenues (visitor spend), the cost of accommodation and cost of repatriating stranded visitors was calculated. The discount rate was 6%. Further model details and assumptions can be found in the previously published CBAx analysis and in the discussion below.[2]

Data from the China CDC suggest one in five symptomatic COVID-19 cases required hospitalisation, with 25% 'critical', and CFR ranging from 0.2% in those under 40 years, to 8–15% in those over 70, with overall CFR 2.3%. The median hospital stay of COVID-19 patients is 13 days,[5] half of these days were assumed to require ICU for critical patients. The WHO situation report Feb 29, 2020 data suggests a CFR for cases in China outside of Hubei province of 0.88%.[6] Up to 48% of infections may be asymptomatic.[4] Given uncertainties around case finding, the CFR could plausibly be even lower. Setting plausible parameters on a COVID-19 online epidemiological model[7] indicates the eventual proportion of the New Zealand population infected could be as high as 72–84%. However, previous pandemics appear to have infected about 40% (influenza 1918)[8] and 18% (H1N1 2009)[9] of the population.

Given these uncertainties, scenarios modelled included all combinations of: CFR 0.5%, 0.9%, and 2.3% with proportion infected 18%, 40%, and 72%, to deduce (a) the long-term cost to New Zealand of a local epidemic (excluding business disruption and impacts on trade other than tourism) and (b) the cost-effectiveness of successful full border closure for 180 days that averts an epidemic. Imports and exports were not included in the analysis, given the very uncertain impact of COVID-19 on trade and supply. However, results are expressed as percentages of import/export value so that assessment of costs and benefits can be estimated.

Results

Results are displayed in **Table 2** below. Itemized break down of costs and savings for the base case (CFR 0.9%, 40% infected) are displayed in **Table 3**. Results indicate that with CFR 0.5% and 18% infected, the NPV long-term cost of COVID-19 could be $2.3 billion with a 50-year horizon or $2.1 billion (5-year). This rises to $6.1 billion (50-year) and $5.0 billion (5-year) with CFR 0.9%, 40% infected; and $16.9 billion (50-year), $11.9billion (5-year) with CFR 2.3%, 72% infected.

Successful border closure results in NPV losses for all scenarios where 18% are infected. At 40% infected, a CFR of over 0.9% results in slightly positive NPV of the intervention at $80 million in savings, rising to a 50-year NPV benefit of $3.4 billion at CFR 2.3% compared to no border closure. However, this represents only 5.75% of trade for a 180-day period. Border closure has a positive NPV in all scenarios with 72% infected, but still provides benefits equivalent to only 18.5% of trade over a 180 day period, hence actual losses are likely to be incurred when trade impacts of complete border closure are taken into account.

Discussion

This analysis suggests that the potential cost of COVID-19 to New Zealand, *excluding* disruption to business and lost trade (apart from lost visitor spend, which is included), and depending on epidemiological assumptions, ranges from NPV $2.3b–$16.9 billion in 2020 dollars, across 50 years, using a 6% discount rate. The potential costs are driven largely by up front ICU costs ($1.9 billion) and productivity lost due to illness ($1.2 billion) in the short term, and by ICU costs and monetised QALYs lost due to deaths ($2.3 billion) in the long term. These costs are offset somewhat by reduced future government commitments in terms of health and superannuation (for those who have died). Tourist revenue forgone in the border closure scenario is over $7.4 billion.

Importantly, some hospital and ICU costs may not materialise given the possibility of complete saturation of services (by an order of magnitude in the case of ICU beds). This means that the theoretical total maximum cost of ICU is about $270 million (if all ICU and HDU/CCU beds are occupied by COVID-19 patients continuously for 180 days). However, this limited upfront cost would be offset by increased deaths due to inadequate care. If just one quarter of those who need ICU beds, but cannot access them, die as a result, then with CFR 0.9%, infected 40%, this more than doubles total deaths (from 9,166 to over 20,000),

DRAFT

and vastly increases costs. It is worth noting that for COVID-19 the costs of future lost productivity are kept down due to the age distribution of deaths, with predominantly older people dying.

This analysis is limited by the high degree of uncertainty around epidemiological parameters for COVID-19. This analysis ignores excess primary care costs, assuming that people are told to stay home. Of note the value of a QALY in CBAx 2020 (based on Pharmac's recent funding decisions) is $33,306, which is substantially lower than the value in the 2018 version of CBAx. Importantly, recent debates around funding for cancer pharmaceuticals in New Zealand implies that the general public value a QALY at a far higher figure. Imputing a much higher value per QALY will substantially increase the long-term costs of COVID-19.

Conclusion

In conclusion, COVID-19 may inflict very major costs on New Zealand across many years. This justifies investment in a substantial response to keep the proportion of the population infected as low as possible, and we have seen dramatic steps taken in some countries with some success. It appears that complete border closure is unlikely to be economically justified in the COVID-19 situation even under the worst assumptions based on present information and this analysis. However, this health and productivity focused analysis should be supplemented with outputs from business and trade focused general equilibrium models.

[The worked CBAx model is available from the author.]

DRAFT

Table 1: Input Parameters (that are not already defined in CBAx)

Parameter	Value	Source
NZ Population 2020	4,918,820	StatsNZ national population estimate Dec 31, 2019
Labour force participation rate (20-65 year olds)	0.8	StatsNZ (rounded up as estimate from graph)
Proportion of population infected	0.4	Assumed global proportion infected by Spanish flu. Also used 72% calculated in Covidsim, and 18% from 2009 pandemic seropositivity NZ
Proportion infected asymptomatic	0.48	Diamond Princess cruise ship data [National Institute of Infectious Diseases Japan]
Proportion infected symptomatic (cases)	0.52	Calculated in model
Proportion of symptomatic mild	0.815	China CDC Report (includes 0.6% 'missing' data)
Proportion of symptomatic severe (hospital)	0.137	China CDC Report
Proportion of symptomatic critical (ICU & hospital)	0.047	China CDC Report
Case fatality rate (age distribution used is from China CDC data)	0.009	Wilson et al. 2020; also used 2.3% China CDC cohort, and 0.5% as lower bound estimate assuming widespread unidentified community transmission
Days spent in ICU on average	6.5	Guan 2020: median stay for severe CoV = 13 days (IQR 11.5-17.0) assume 1/2 is ICU = 6.5 days; could be much longer.
Disability weight (DW) mild disease	0.0001	Salomon et al 2012 Global Burden of Disease Study
DW severe disease (hospital)	0.0121	Salomon et al 2012
DW critical disease (ICU)	0.0121	Salomon et al 2012
Visitors in NZ on a given day (as proportion of NZ Population 2020)	0.041	Derived from NZ Ministry for Business, Innovation and Employment
Accommodation costs for international visitors stranded in NZ (per day, NZD)	193	https://www.coffeys.co.nz/resources/file/blog/5d1e6b2d032366.18671164.pdf
Repatriation costs (return airfare to Australia per visitor and/or air force flights, NZD)	775	Cost of Air NZ return flight Wellington to Sydney, with bag, booking 14 days in advance, special offers ignored (airline website accessed: March 1, 2020)
Duration (days) to apply accommodation costs for visitors	28	Assumes repatriation flights possible within 28 days
Reduced downstream health system costs for those dying (p.a.)	1488	per annum in 2011 dollars (inflated in CBAx), median values for the 21 age groups, regardless of proximity to death, $1,518 per year for males and $1,457 per year for females [Blakely et al 2015]
Life expectancy	81	World Bank data 2015
Days of border closure (in closure scenario – ignored in base case)	180	Assumed length of border closure
Value of trade per month (billions)	9.8	$4.73b exports, $5.07b imports (Jan 2020): http://archive.stats.govt.nz/infoshare/
Value of trade for duration closure	58.8	Calculated in model
Average length of stay Tourists (days)	19	https://www.stats.govt.nz/news/record-breaking-3-7-million-visitors-to-new-zealand
Visitor arrivals NZ per year	3,888,473	2019: StatsNZ

DRAFT

Table 2: Estimated costs of COVID-19 in New Zealand and cost-effectiveness of complete border closure as an intervention

	Cost of epidemic[1] (NPV) (excluding short-term downturn in trade)			**Cost-effectiveness of border closure for 180 days (NPV, if successfully averts cases)**		
	Proportion infected 18%	Proportion infected 40%	Proportion infected 72%	Proportion infected 18%	Proportion infected 40%	Proportion infected 72%
CFR 0.5%	50-year **$2.3b** 5-year **$2.1b**	50-year **$5.2b** 5-year **$4.6b**	50-year **$9.3b** 5-year **$8.2b**	50-year **-$3.7b** % trade[1] **NA**	50-year **-$0.9b** % trade[1] **NA**	50-year **$3.3b** % trade[1] **5.6%**
CFR 0.9%	50-year **$2.7b** 5-year **$2.3b**	50-year **$6.1b** 5-year **$5.0b**	50-year **$11.0b** 5-year **$9.0b**	50-year **-$3.3b** % trade[1]: **NA**	50-year **$0.09b** % trade[1]: **0.15%**	50-year **$5.0b** % trade[1] **8.46%**
CFR 2.3%	50-year **$4.2b** 5-year **$3.0b**	50-year **$9.4b** 5-year **$6.6b**	50-year **$16.9b** 5-year **$11.9b**	50-year **-$1.8b** % trade[1] **NA**	50-year NPV **$3.4b** % trade[1] **5.75%**	50-year NPV **$10.9b** % trade[1] **18.54%**

[1] Cost of epidemic includes: hospital and ICU costs, monetised lost QALYs from illness and death, future health system costs and superannuation avoided (due to deaths), future lost productivity and tax.
[2] Percentage of trade is the proportion of the total value of 180 days of imports and exports that is equivalent to the NPV of the intervention (which excludes trade).

Table 3: How the costs are attributed

CFR 0.9, pInfected 0.40	**50-year NPV**	**5-year NPV**
Hospital Costs	$757,223,184	$757,223,184
ICU Costs[1]	$1,936,165,129	$1,936,165,129
Lost QALYs (due to illness)	$76,385,124	$76,385,124
Future health system costs avoided (due to deaths)	-$106,520,203	-$40,153,299
Superannuation avoided (due to deaths)	-$934,544,540	-$418,894,152
Productivity lost (due to deaths)	$882,728,080	$441,031,819
Productivity lost (due to illness)	$1,220,858,863	$1,220,858,863
Lost QALYs (due to deaths)	$2,275,518,615	$1,050,038,838
Total Cost of Epidemic	**$6,107,814,252**	**$5,022,655,508**

[1] Note: unrealistic excess costs, as ICU capacity will be saturated, max cost at full capacity is $270 million

DRAFT

References

1. New Zealand Treasury. The Treasury's CBAx Tool. 2019. Wellington: New Zealand Treasury. Available at: https://treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/plan-investment-choices/cost-benefit-analysis-including-public-sector-discount-rates/treasurys-cbax-tool

2. Boyd M, Mansoor O, Baker M, Wilson N. Economic evaluation of border closure for a generic severe pandemic threat using New Zealand Treasury methods. *Aust N Z J Public Health* 2018; **42**(5): 444–6.

3. The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) — China, 2020. *China CDC Weekly* 2020.

4. National Institute of Infectious Diseases. Field Briefing: Diamond Princess COVID-19 Cases. NIID (Government of Japan). 19 February 2020. Available at: https://www.niid.go.jp/niid/en/2019-ncov-e/9407-covid-dp-fe-01.html.

5. Guan W, Ni Z, Hu Y, Liang W, Ou C, He J, Liu L, Shan H, Lei C, Hui DSC, Du B, Li L, Zeng G, Yuen K, Chen R, *et al.*, for the China Medical Treatment Expert Group for Covid-19. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med* 2020. DOI:10.1056/NEJMoa2002032.

DRAFT

6. World Health Organization. Coronavirus disease 2019 (COVID-19) Situation Report – 40. 2020;(29 February). [cited 2020 Feb 29]. Available at: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200229-sitrep-40-covid-19.pdf?sfvrsn=7203e653_2.

7. Eichner M, Brockmann S, Schwehm M. CovidSIM v1.0. 2020. Available at: http://covidsim.eu/

8. Wilson N, Summers J, Baker M. The 2009 influenza pandemic: a review of the strengths and weaknesses of the health sector response in New Zealand. *N Z Med J* 2012;125(54-66)

9. Bandaranayake D, Huang S, Bissielo A, Wood T. Seroprevalence of the 2009 influenza A (H1N1) pandemic in New Zealand. 2010. Wellington: ESR. Available at: https://www.health.govt.nz/system/files/documents/publications/seroprevalence-flu-2009.pdf

DRAFT