Shaun C. Hendy

Integrating Science into Policy
experiences during the pandemic

Abstract

The Covid-19 pandemic has posed enormous challenges to governments worldwide, but New Zealand's government in particular has been praised for a science-based approach to decision making. In this article I review the way in which several scientific work streams were integrated into decision making and consider the advantages that this offered New Zealand's response. As one of the scientists who was closely involved with this, I offer a personal perspective on how this came about and some observations for future crises.

Keywords science advice, policy, modelling, genome sequencing, Covid-19

The Covid-19 pandemic has posed enormous policy and operational challenges to governments worldwide. Most governments have drawn on scientific advice in navigating these challenges, but New Zealand's government, in particular, has been praised for 'following the science' (Geoghegan, Moreland et al., 2021). Indeed, the effective use of scientific advice by the New Zealand government has been credited with producing one of the most effective national pandemic responses (Manning, 2021), resulting in a lower healthcare burden (Alyssa and Hervé, 2021) and superior economic performance (IMF, 2021) than almost all other advanced economies. This is perhaps surprising, given that the 193-page pandemic plan (Ministry of Health, 2017) that was in place in March 2020 devotes only a single sentence to science advice.

In this article, I discuss several of the instances in which New Zealand's science community supported decision making in the Covid-19 response. These efforts included research scientists working at universities, Crown research institutes and private organisations, but also involved scientists employed in, or seconded into, policy or operational roles within the Ministry of Health and other agencies. Here I will focus on several examples where advice from research scientists was integrated into significant decision papers put to the New Zealand Cabinet.

This article is necessarily informed by my personal perspective as one of a team that provided advice based on mathematical modelling to the government (Hendy et al., 2021). While I was involved closely in some parts of the response, there will be gaps and omissions in my understanding of what took place in such a complex policy

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environment. This article is not intended to be an exhaustive account of the ways in which science was involved; rather, I have chosen to focus on aspects where I had first-hand experience.

The plan

New Zealand's influenza pandemic plan, first published in 2010 in the aftermath of the 2009 H1N1 influenza pandemic, was last updated by the Ministry of Health in 2017 (Ministry of Health, 2017). The plan outlines what would now be described as a 'flatten the curve' or mitigation strategy, albeit with stage-gates: e.g., 'keep it out', 'stamp it out' and 'manage it'. Influenza typically has an incubation period of one–three days (sometimes less than a day) and a generation time[1] of between two and four days, so it was thought that interventions such as contact tracing and lockdowns would be unlikely to allow an outbreak to be eliminated (Huang et al., 2021). This suggested a mitigation strategy, which would slow growth in cases so as to avoid overwhelming healthcare capacity.

Nonetheless, the plan acknowledged that there would be a need for rapid decision-making and implementation at early stages, in an environment with a great deal of uncertainty. This was the case early in 2020 as details began to emerge about the SARS-CoV-2 virus. As remains the case today, much of the early science that emerged was shared informally using preprint servers and social media. For instance, a link to the first complete genome sequence of the virus was released to Twitter on 11 January, just 12 days after it had been identified (Holmes, 2020). Estimates of the severity would remain contested for some time, although it was clear from media reports that healthcare systems had been under stress in China (Verity et al., 2020).

This kind of uncertainty is not surprising at the early stages of a pandemic, but the science that was starting to emerge suggested that SARS-CoV-2 was a very different pathogen than envisaged in the New Zealand influenza pandemic plan. In particular, SARS-CoV-2 seemed to have a higher reproductive number,[2] which had implications for the size of the final outbreak. It was also not going to be a rerun of the 2003 SARS-CoV-1 outbreak, as a significant fraction of transmission seemed to be occurring before the onset of any symptoms, making it difficult to screen individuals without the use of much slower, laboratory-processed diagnostic testing. The need to test the pandemic plan against this emerging science was very clear.

Early scientific advice

The New Zealand influenza pandemic plan designates Environmental Science and Research (ESR), a Crown research institute, as the lead agency for scientific advice. However, while ESR has substantial capability in infectious disease surveillance, it does not have the mandate to fund, coordinate or direct a broader national research effort. Moreover, recent decades have seen significant underinvestment in infectious disease research in New Zealand. Indeed, in the selection of the National Science Challenges in 2013, Peter Gluckman's panel explicitly ruled out investment in infectious disease research (Gluckman, 2013). Several attempts to establish a centre of research excellence with an infectious disease focus had also failed.

Nonetheless, during Gluckman's tenure as the prime minister's chief science advisor, he had established a network of government science advisors (Jeffares et al., 2019). His successor, Juliet Gerrard, had continued this network, and strengthened it, by appointing several Māori researchers. The Ministry of Health's chief science advisor, Ian Town, along with Gerrard, would play an important role in coordinating science advice from across the research sector. The Ministry of Health also established several technical advisory groups, which covered a range of expertise, and seconded a number of public health researchers to its staff early on in the response.

An early challenge for these groups was to consider the fit of the 'flatten the curve' strategy described in the influenza pandemic plan for Covid-19. Although influenza has a lower reproduction number than Covid-19, its shorter generation time[3] means that cases can still grow rapidly. The lower reproduction number means that an influenza virus will typically have a lower population immunity threshold.[4] Thus, the plan envisioned a rapidly growing but nonetheless solitary wave of infection that would eventually extinguish itself. Covid-19 would be more challenging: the higher reproduction number suggested a population immunity threshold of 60–70%. This early data suggested that Covid-19 was going to generate a much taller curve to be flattened.

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In February the Ministry of Health commissioned the University of Otago's School of Public Health to model the outcome of a mitigation strategy for Covid-19. To do this the Otago group worked with collaborators in Germany, who had developed a deterministic mathematical model for just this purpose (Wilson et al., 2020). The results suggested that New Zealand's healthcare system was unlikely to cope under such a strategy, and this has been reported to have had a significant impact on decision makers. In mid-March our team at Te Pūnaha Matatini[5] provided similar modelling via Juliet Gerrard's office, examining the extent to which the outbreak could be broken into waves with rolling interventions (James, Hendy et al., 2020). Despite the sobering picture that was emerging, the longer generation time of SARS-CoV-2 suggested that interventions such as contact tracing might be more effective against it than would be expected against influenza.

These early modelling efforts were influential in the country's pivot towards an elimination strategy, as was the fact that several East Asian countries, such as Singapore and Taiwan, were also signalling this approach. Furthermore, China's response was also demonstrating that elimination might be possible (World Health Organization, 2020). It remained to be seen whether a Western government such as New Zealand's could gain public consent for the sort of stringent measures that were being reported as effective in China. Nonetheless, from mid-March much of the available science advice was in strong support of elimination (Baker et al., 2020).

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The elimination strategy

New Zealand's decision to adopt an elimination approach in late March meant that it would need to develop and use scientific tools in a different way from other parts of the world, where mitigation held sway. Forecasting caseloads for operational planning would become relatively less important, while providing real-time advice on the timing and stringency of interventions would become much more important. For instance, a successful elimination approach will reduce case numbers to the point where chance events become important, requiring the use of stochastic mathematical methods that are different from those used early on to model mitigation (Hendy et al., 2021). The combination of this modelling approach with whole genome sequencing of SARS-CoV-2 would later become pivotal in government decision making.

In late March, a Covid-19 modelling work stream was formally established with the aim of providing modelling to support operational decision making for managing a large outbreak (ibid.). At that stage a very significant outbreak was still considered possible, pending the effectiveness of the alert level system. By mid-April the modelling work stream was divided into two parts. The first focused on providing daily (and later weekly) operational advice, while the second would investigate the outcomes that might result from future policy decisions. For policy purposes, scenarios for modelling were developed via an iterative process of close engagement and feedback between the modelling team, departmental science advisors and officials. This process was later formalised via a modelling steering committee chaired by officials. In the event, the stringent alert level 4 controls introduced in late March proved very effective, with domestic transmission of the virus likely being eliminated at the start of May (James et al., 2021).

Genome sequencing of the virus did not become fully integrated into the response until later in the year. Initially there were logistical challenges in obtaining samples and making them available to researchers. By July 2020 the virus from around half of the confirmed cases in New Zealand had been sequenced by a team of ESR scientists (Geoghegan et al., 2020). The results were of clear value for research purposes, demonstrating, for instance, that the shift to alert level 4 in late March had sharply arrested the growth of a cluster of cases associated with a wedding celebration in Bluff. However, sequencing was not yet contributing directly to decision making to the extent that would be needed to justify the dedicated collection and same-day delivery of samples to ESR's laboratories.

On 29 July 2020, the modelling steering committee hosted a workshop attended by officials, modellers and epidemiologists at the Treasury in Wellington to review progress on the response to date and to plan future work. One of the key resolutions at the meeting was to start developing models for a scenario where the virus was reintroduced into the country via a returnee in managed isolation and quarantine (MIQ). There had been several scares in previous months, so it seemed inevitable that at some stage a larger outbreak would be seeded in the community, requiring a rapid response. A brief from the Department of the Prime Minister and Cabinet formally commissioning further modelling work on incursion scenarios was received by the modelling team on 10 August.

The August 2020 outbreak

On the evening of 11 August we received a follow-up message from the department saying that this request had 'become more urgent'. We were told that an individual in South Auckland with no known connection to the border had just tested positive and our task was to estimate how many other cases might be in the community, information that would be needed for Cabinet's decision on an alert level change later that night. We had already developed the modelling tool envisioned in July, even though the formal commissioning had arrived just a day earlier. If close contact with an international returnee or border worker could not be identified, we estimated that there would be between 10 and 40 other cases, indicating that a large established outbreak was probably under way. We sent a report with this information by 7.36pm, ahead of the Cabinet decision to move Auckland to alert level 3 for three days, which was announced at 9.30pm.

Our modelling was based on the assumption that there had been at least two steps in the chain of transmission between a (possibly undetected) case that had arrived from overseas and the diagnosed case in South Auckland. This was a reasonable assumption, as initial contact tracing interviews had failed to establish any link. If sequencing of the virus genome were to provide a close link to a known case in MIQ, then our estimates would be revised down and Auckland may have returned quickly to alert level 1. However, by 13 August no connection had been found.[6] It would eventually be established that there were upwards of 60 cases in the community on 11 August. This grew to a cluster of 179 cases before the outbreak was once again eliminated after 19 days. During this period the ESR team generated SARS-CoV-2 genomes in real time for 78% of the cases, sometimes identifying connections that were not apparent through contact tracing (Geoghegan, Douglas et al., 2021).

On 12 November, when a young woman in central Auckland tested positive for Covid-19, this approach paid dividends. Once again there were no known links to the border, but the government decided to delay its decision on an alert level shift until genome sequencing results were returned the next morning. Again, this proved to be a good decision, as the next day the sequencing linked her case to a Defence Force worker who had recently been infected at a central Auckland MIQ facility. In this case we estimated that there were likely to be fewer than a dozen other cases, a cluster that could probably be handled by testing and tracing. Auckland was spared a three-day alert level shift, avoiding shut-down costs estimated at around $130 million to the Auckland economy (Treasury, 2020).

This last example may suggest that explicit cost–benefit frameworks could have been used more generally in decision making, as some have argued (Heatley, 2021). However, there are considerable technical challenges in constructing appropriate counterfactuals for such analyses. In the November 2020 example, the counterfactual is straightforward, as the science advice was that the decision would not have an impact on health outcomes. However, a cost–benefit analysis by the New Zealand Productivity Commission of the decision to extend alert level 4 rather than move to alert level 3 in late April 2020 used counterfactuals based on a simple deterministic model of disease spread (ibid.). Using a more sophisticated stochastic model and ex post information about the effectiveness of alert level 3, our team subsequently came to significantly different conclusions from those of the commission (James, Binny at al., 2020). It is not clear that the cost–benefit frameworks proposed to date would have added significant value to the complex value judgements that were needed during the pandemic.

The August 2021 outbreak

Towards the end of 2020 it started to become apparent that highly effective vaccines would be available to New Zealand in the following year. This outlook darkened during the first quarter of 2021, as the more transmissible Alpha variant of the virus became prevalent globally, only to be followed by an even more transmissible Delta variant. To achieve population immunity against Delta, models suggested that in excess of 95% of the total population would need to be vaccinated (Steyn, Planck et al., 2021; Nguyen et al., 2021), far higher than was thought possible. New Zealand's exit from its elimination approach was going to be complicated and politically fraught. What followed was a period of very close collaboration between ministers, ministries and the science community, including the modelling teams, to plan a reopening at the completion of the vaccination programme but with a suite of moderate and sustainable public health measures left in place.

This planning was interrupted on 17 August 2021, when an Auckland man with no known connection to the border tested positive for Covid-19. Genome sequencing would quickly confirm it was the highly transmissible Delta variant, linked to the outbreak that New South Wales was struggling to control. At the time of detection there were several hundred people infected, so it was already a much more significant outbreak than that eliminated in August 2020. Our models suggested that even alert level 4 might struggle to contain the Delta variant, but it did appear effective in extinguishing several branches of the outbreak, and may even have come close to eliminating them all (Steyn, Hendy et al., 2021). Unfortunately, the virus spread into a marginalised and under-vaccinated South Auckland community dependent on emergency housing, where it could not be eliminated.

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When our team briefed ministers about the implications of Delta for New Zealand's reopening strategy in May 2021, we emphasised that there was no 'magic' vaccination coverage threshold above which life could return to normal (Steyn, Planck and Hendy, 2021). Instead, we noted that any reopening plan was going to require a sequence of value judgements that balanced a range of consequences. This plan could be informed by science, but science was no longer going to provide a set of clear directions that de-risked decisions for policymakers in the way it had since March 2020. These political risks were made more acute by the failure to eliminate the August 2021 outbreak, particularly as this became entrenched in

Māori communities, which are at more severe risk from Covid-19 and had not been sufficiently prioritised in the vaccination roll-out (Steyn, Binny et al., 2021; Waitangi Tribunal, 2021).

At the time of writing, New Zealand is in its first few weeks under the Covid Protection Framework, a system that relies heavily on the use of vaccine passes that allow access to hospitality and other close contact services. The framework drew considerable criticism from the scientific community when it was released, particularly regarding its potential impacts for Māori (Gerrard and Town, 2021). It remains to be seen whether the framework will be effective in managing Delta through winter 2022, although the growing dominance overseas of the Omicron variant, which seems to exhibit immune escape, means that another shift in strategy will likely be needed.

Discussion

New Zealand's pandemic response has been judged a success on many metrics, including by economic, social and health measures (Philippe and Marques, 2021). While New Zealand's isolation was also an advantage, this needed to be supported by good decision making; other isolated territories experienced considerably worse outcomes where not following an elimination strategy (Heinzlef and Serre, 2021). Indeed, the integration of science into New Zealand's decision-making processes during the Covid-19 pandemic has been judged a critical part of that success (Manning, 2021).

Nonetheless, it is curious that this integration took place in the absence of any coordinating infectious disease research centre or institute, as might have occurred in an overseas jurisdiction. Instead, the government science advisory network filled this role, taking advantage of other, less formal networks of researchers around the country. These research networks, such as those supported by Te Pūnaha Matatini, played key institutional roles in the pandemic response.

The technical advisory groups established by the Ministry of Health were also important, although researchers appointed to these sometimes reported finding the decision-making processes in which they were embedded rather opaque. This can also be the case for officials, but they are trained to work in such environments. In contrast, without effective feedback from the decision-making process, expert but inexperienced advisors may struggle to deliver or adapt to meet the needs of decision makers. The experience of the technical advisory groups is to be contrasted with that of the modelling teams, which were closely engaged with officials in the Department of the Prime Minister and Cabinet. They were able to develop a clear understanding of needs, sometimes anticipating these before formal commissioning.

An urgent hearing of the Waitangi Tribunal during the week of 6 December 2021 highlighted the lack of Māori input into key aspects of the Covid-19 response, especially the design of the vaccination roll-out in the second half of that year (Waitangi Tribunal, 2021). Mātauranga Māori played a key role in Te Pūnaha Matatini establishing its modelling programme in early March 2020, with an advisory board member sharing his iwi's devastating experiences in the 1918 influenza pandemic. This was ahead of any formal commissioning by central government and led to several pieces of work that focused on the impacts for Māori. This suggests that funding could have been allocated directly to Māori organisations to enable commissioning of work, although mechanisms would be needed to ensure that any outputs were taken into account in decision making.

Finally, considerable effort was made to communicate results publicly via mainstream media and social media. This sometimes came with 'no surprises'-type constraints, so that ministers were briefed ahead of the release of outputs. Officials occasionally requested that scientific reports be released at short notice where they had been of consequence for important decisions. This was generally managed well, despite the challenges present in such a rapidly moving crisis, but it did rely on considerable previous experience and expertise in science communication among the teams involved.

1 The generation time is the mean interval between a primary infection and subsequent secondary infections.
2 The number of secondary cases generated by an infected individual was estimated to be around 2.5–3.5 for Covid-19, around twice that of influenza (Wilson et al., 2020).
3 The generation time for influenza is typically two–four days compared to five–six days for Covid-19.
4 For influenza the population immunity threshold would be around 30–40% of the population.
5 Te Pūnaha Matatini is a centre of research excellence funded by the Tertiary Education Commission. It supports a network of more than 100 researchers employed across 12 different research organisations.
6 At this stage not all cases in MIQ were routinely being sequenced.

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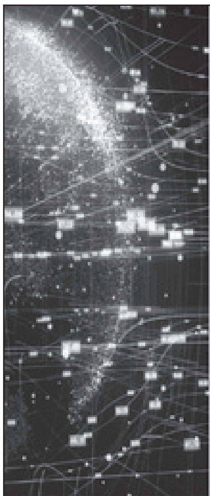

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