Memo

Extending Second Booster Eligibility to Māori and Pacific Peoples aged 40 to 49 years: COVID-19 Vaccine Technical Advisory Group (CV TAG) recommendations

Date:	1 November 2022
To:	Dr Diana Sarfati, Director-General of Health
Copy to:	Dr Andrew Old, Deputy Director-General, Public Health Agency Dr Nick Chamberlain, National Director, National Public Health Service Dr Nicholas Jones, Director of Public Health, Public Health Agency Astrid Koornneef, Director, National Immunisation Programme (NIP), Te Whatu Ora Alison Cossar, Manager, Public Health Policy & Regulation, Public Health Agency
From:	Dr Ian Town, Chief Science Advisor
For your:	Consideration

Purpose of report

1. To summarise the COVID-19 Vaccine Technical Advisory Group's (CV TAG) recommendations on extending the eligibility of COVID-19 second booster vaccinations to Māori and Pacific Peoples aged 40 to 49 years.

Background

2. The report *"COVID-19 Mortality in Aotearoa New Zealand: Inequities in Risk"* (referred to hereafter as "the Mortality Report") was published by Manatū Hauora, Ministry of Health, on 30 September 2022. [1] Details of the findings of this report are described more fully below, but in brief, a higher risk of COVID-19 attributed death was found for Māori and Pacific Peoples compared to the "European and Other" group (respectively 2.0 and 2.5 times the risk). Vaccination status, specifically inequities in booster doses (not broken down by first or second booster doses) accounted for approximately a quarter of this increased risk. People with comorbidities had more than 6 times the risk than people without comorbidities, and in young Māori and Pacific Peoples, over half their excess risk was due to having an underlying health condition, when compared to people of European or Other ethnicity.

3. The Ministry of Health is now seeking clinical and scientific advice from CV TAG on the risks and benefits of extending the second booster dose eligibility to younger Māori and Pacific Peoples (specifically, those aged 40 years and older) and whether this would contribute to reducing these inequities.
4. Under Te Tiriti o Waitangi, the Ministry is required to meet its obligations in providing opportunities and active protection to achieve equitable health outcomes for Māori. [2] Extending eligibility of second booster doses to more Māori may be one factor that could assist in meeting these obligations and the inequities discovered in the Mortality Report.

Regulatory status of second booster doses and previous CV TAG advice

5. On 17 June 2021, Medsafe updated the provisional approval for the Pfizer vaccine to include "*A booster dose of Comirnaty may be given at least 6 months after the primary course for people 12 years of age and older*". This would be a third dose for most individuals.
6. Pfizer have not yet applied to Medsafe for approval of any further doses beyond the first booster dose.
7. CV TAG have issued a series of recommendations on second boosters:
    a. On 01 April 2022, CV TAG recommended that a second booster dose of the COVID-19 vaccine be offered to all people aged 65 years and older, Māori and Pacific Peoples aged 50 years and older, residents of aged care and disability care facilities aged 16 years and older, and severely immunocompromised people aged 12 years and older.
    b. On 21 June 2022, CV TAG updated recommendations to expand eligibility of the second booster doses to all people 16 years of age and older who have a medical condition that increases the risk of severe breakthrough COVID-19 illness, and to disabled people with significant or complex health needs, or multiple comorbidities which increases the risk of poor outcomes from COVID-19.
    c. On 23 June 2022, the Director-General authorised (under section 34a of the Medicines Act 1981) the expansion of second booster eligibility to people aged 50 years and older and to healthcare workers aged 30 years and older.
    d. In August 2022, CV TAG recommended against making second boosters available to healthy adults aged less than 50 years as it was considered unclear whether the benefits outweigh the risks in this population (see Appendix 2). For Māori and Pacific Peoples, CV TAG emphasised the importance of improving first booster coverage as the top priority for the National Immunisation Programme. CV TAG recommended expanding eligibility of second boosters for Māori and Pacific Peoples aged 40 to 49 years because of higher risk of adverse outcomes from COVID-19 (see Appendix 2).

e. The Director General has not yet authorised any changes to the second booster eligibility criteria and has requested a deeper analysis of the risks and benefits of expanding second booster eligibility to Māori and Pacific Peoples aged 40-49 years.

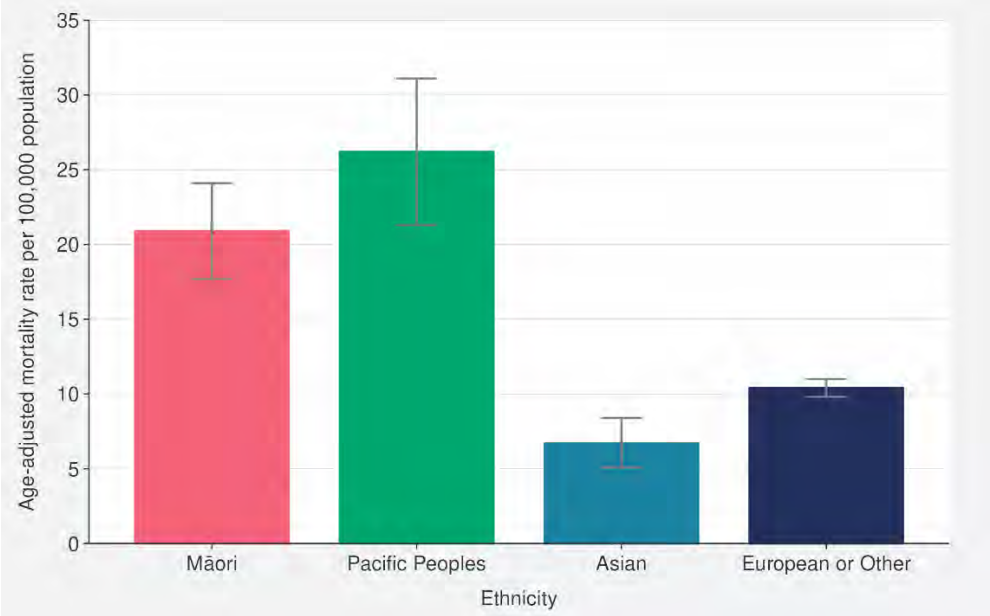
Evidence informing advice

Inequities in COVID-19 outcomes for Māori and Pacific Peoples

COVID-19 Mortality for Māori and Pacific Peoples

8. The *'COVID-19 Mortality in Aotearoa: Inequities in Risk'* report from September 2022 reviewed 1,797 deaths between 1 January and 26 August 2022. It clearly demonstrated a higher risk of COVID-19 mortality for Māori, Pacific Peoples, and people residing in highly socio-economically deprived regions, after accounting for the effects of age, comorbidity, and vaccination uptake.
9. The Mortality Report found that although COVID-19-attributed mortality was much lower in younger people than in older age groups, the age-adjusted estimates for those aged under 60 years showed that the risk was 3.7 times higher for Māori and 3.9 times for Pacific Peoples as compared to European and Other.
10. Comparison of age-standardised cumulative incidence of mortality from COVID-19 by ethnicity (Figure 1), shows that Pacific Peoples have had the highest risk, with 2.5 times greater risk than that of European and Other. This is followed by Māori with 2 times greater risk of death compared to European and Other. [1]
11. In total, the report covered 78 COVID-19 attributed deaths in those under the age of 60 (4% of all COVID-19 attributed deaths). A breakdown by COVID-19 infection being contributory or incidental by age group has not been reported.

Figure 1: Age-standardised cumulative incidence (and 95% confidence intervals) of mortality attributed to COVID-19 by ethnicity, 01 January 2022 to 18 September 2022



Source: NCTS/EpiSurv, NMDS, Inpatient Admissions dataset and CVIP population estimates, 01 January 2022 to 18 September 2022 [1]

12. Factors associated with COVID-19 mortality risk include:

    a. Age: The absolute risk increased with age across all ethnicities. However, in all age groups (grouped as 0-59 years, then in 10 year brackets up to 89 years, and 90 or more years) the risk was higher for Māori and Pacific Peoples than it was for the European and Other ethnicities.

    b. Comorbidities: Comorbidities accounted for approximately two-thirds of the increased risk for Māori (59% of risk) and Pacific Peoples (69% of risk) under 60 years of age. The presence of one or more comorbidity imparted 6.3 times the risk compared with those with no comorbidities when all age groups were considered together, and 78 times the risk when only those under 60 years of age were considered.

    c. Socio-economic deprivation: The mortality risk for Māori and Pacific Peoples was more likely to be mediated by socio-economic deprivation (half of the increased risk was explained by deprivation) for those aged under 60 than for all age groups considered together.

    d. Vaccination status: Vaccination had a strong protective effective. There was a 62% reduction in the risk of death for those who had received 2 or more vaccination doses compared with those who had received one dose or no doses (from population-based risk estimates). Furthermore, there was a

reduction in the risk of death by 23% for those who had received 2 doses (compared with those who had received one dose or no doses) and a 66% reduction in risk of death for those who had received 3 or more doses compared to those who had received one or no doses. For those under 60 years, a reduction in the risk of death of 55% was found for those who had received 2 or more doses, 31% for those who had received exactly 2 doses, and 73% for those who had received 3 or more doses (compared with those who had received fewer than 2 doses).

13. After adjusting for age, sex, comorbidities, and vaccination status (≤2 doses vs >2 doses), the mortality risk was 1.7 times higher Māori and 1.9 times higher for Pacific Peoples compared with "European/Other". [1]

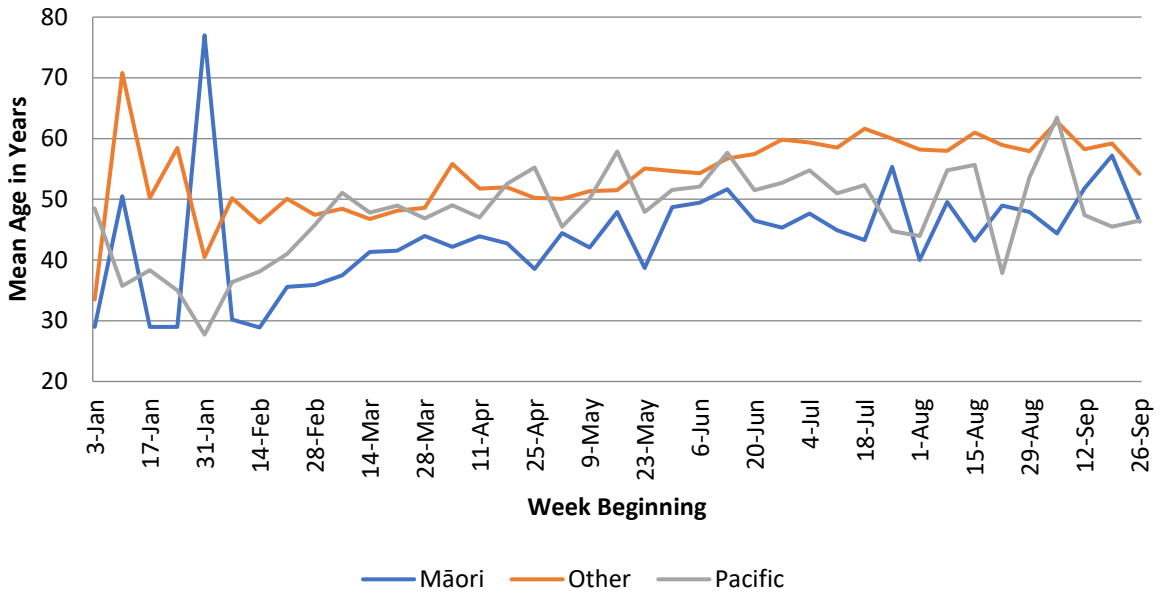
14. This highlights ethnic and socio-economic disparities in COVID-19 mortality. It aligns with findings from the CDC that ethnic minorities are more likely to be infected with COVID-19 and once infected, they are more likely to be hospitalised, admitted to ICU and die from COVID-19 at younger ages. [3]

COVID-19 Morbidity for Māori and Pacific Peoples

15. Preliminary analyses of Aotearoa New Zealand COVID-related-hospitalisation data for 2022 show that Māori aged 40-49 years have around twice the risk of COVID-related hospitalisation of their "European and Other" counterparts (see Table 1). Pacific Peoples aged 40-49 years were even more likely to be hospitalised, at around 2.5 times the risk of "European and Other" people in the same age group. It should be noted that primary clinical codes along with health speciality codes are used to determine whether each hospitalisation COVID-related for this data set. Further analyses of these data exploring comorbidities and other potential reasons for differences between ethnicities are unlikely to be available for at least several weeks.

16. These data are preliminary, and caution should be used when interpreting them. The central attribution of cause of hospitalisation is challenging, and these data represent a "first pass" of attribution to COVID-19. Further work will likely occur to refine attribution of cause of hospitalisation and assessment of variables (such as co-morbidities or length of stay) which might explain differences between ethnicities.
17. Analysis of 5,620 hospitalisation data from the Northern Region, (Figure 2) since 3 January 2022 show that both Māori (around 46 years) and Pacific Peoples are hospitalised with COVID-19 at a lower age than other ethnicities (49 years). [4]

Figure 2: Weekly mean age of hospitalised COVID-19 cases in the Northern region by ethnicity, 03 January 2022 to 26 September 2022 [4]



18. Beyond hospitalisations and deaths, infection and re-infection with COVID-19 has been associated with longer term adverse outcomes such as long COVID, increases in cardiovascular disease and long-term neurological disorders. [5]
19. Currently the prevalence of long COVID in Aotearoa New Zealand is unknown.
20. In New Zealand, Māori and Pacific Peoples make up an increasing proportion of COVID-19 cases, and therefore long COVID may have a particularly high burden in these populations. Long COVID appears to be more common among people who have severe COVID-19 symptoms during acute illness, [6] and with less vaccine protection. Therefore, Māori are likely to face a higher burden.
21. Preliminary analysis from Ngā Kawekawe o Mate Korona has found that 45% of Māori with symptoms consistent with long COVID say their usual activities have been

affected to a moderate or extreme level; about 20% have severe pain and about 10% have difficulty moving. [7]

22. Data based on a review of eight studies by UKHSA, indicates that vaccinated people were less likely to develop symptoms of long COVID following infection compared with unvaccinated people. [8, 9]

Inequities in COVID-19 vaccine coverage for Māori and Pacific Peoples

23. As detailed in 12.c above, across all analysis undertaken in all age groups in the Mortality Report, vaccination was found to have a protective effect on mortality.

Vaccine-related inequities

Vaccination eligibility and uptake

24. Data as of 05 September 2022 on the uptake of COVID-19 vaccines shows that primary course vaccination in those aged 12 years and older is high at 90% of the eligible population vaccinated to date. Primary course vaccination in Māori and Pacific Peoples is also high at 84% and 90% respectively. However, coverage of first booster doses is lower (particularly among Māori and Pacific Peoples, where 59% and 64% aged 18 years and older respectively have had a first booster compared with 79% of all other ethnicities) (see Table 2).

25. Inequities are also observed in second booster coverage, where only 34% and 33% of Māori and Pacific Peoples respectively, that are eligible for a second booster, have received it, as compared to 41% of other ethnicities.

Table 2: Booster eligibility and uptake using the HSU 2021 for denominators, removing those who have died and those under the age of 18

Ethnicity	Population 18+	Eligible 1st Booster	Received 1st Booster	Received 1st Booster %	Eligible 2nd booster	Received 2nd booster	Received 2nd Booster %
Māori	500,820	406,485	238,286	59%	118,586	40,638	34%
Pacific Peoples	256,417	218,000	138,744	64%	58,385	19,010	33%
Other ethnicity	3,161,862	2,783,152	2,202,440	79%	1,240,288	509,123	41%

26. Expanding the eligibility of second boosters to include Māori and Pacific Peoples aged 40-49 years (Table 3), would increase the eligible population for Māori by 29,705, and for Pacific Peoples by 19,658 (accounting for recent infection).

Table 3: Eligibility for booster 2 reduced to 40+, adjusted for recent infections (<3 months)

Ethnicity	Eligible 2nd Booster (adjusted for infections)	Change in population eligible (adjusted for infections)
Māori	137,228	+29,705
Pacific Peoples	73,605	+19,658
Other ethnicity	1,340,081	+242,386

27. Assuming that the second booster uptake for Māori and Pacific people aged 40-49 years (accounting for recent infection) would be similar to that of currently eligible groups (albeit, likely to be lower, with vaccination uptake decreasing with age), this would estimate to be approximately 11,300 more Māori and 7,000 more Pacific Peoples that are likely to receive the second booster. This can be considered a relatively marginal benefit, as compared to the benefit from improving first booster coverage for Māori and Pacific Peoples.

28. Analysis of first booster doses (Table 2) suggests that if Māori and Pacific Peoples uptake was to be brought up to that of 'Other ethnicity' (i.e. 79%), this would increase the number of Māori who receive their first booster dose by 81,297, and Pacific Peoples by 32,700 (not accounting for recent infection).

Overview of benefits from expanding eligibility criteria of second boosters to Māori and Pacific Peoples aged 40-49

Meeting obligations under Te Tiriti and equity

29. Māori historically have had significant barriers in accessing and engaging with healthcare services, with lower immunisation rates (or delayed vaccination) observed for Māori children than for non-Māori, non-Pacific children[10] and somewhat lower vaccination rates for influenza for Māori people aged 65 years or older.[11] In one survey conducted by the Evaluation and Behavioural Science in the Ministry of Health in August 2022, Māori were found to be more likely than Pacific Peoples and European participants (12% Māori, 8% Pacific, 7% European) to oppose vaccination in general (excluding COVID-19 vaccine). [12] Providing any opportunity to increase engagement of Māori with the healthcare system would be beneficial.

30. Surveys conducted by the Evaluation and Behavioural Science in the Ministry of Health in July 2022 have found that since June 2022 (during the Omicron wave), a greater proportion of Māori felt negatively treated by a healthcare professional (30% of Māori, 19% of Pacific Peoples, 19% of Europeans). [13] In addition, relatively more Māori

reported having delayed contact with a healthcare professional (46% of Māori compared to 37% of Europeans). The reasons for delays reported included difficulty in getting an appointment (30% of Māori), financial reasons (40% of Māori), and wanting an in-person appointment (33% of Māori).

31. In 'Haumaru: The Covid-19 Priority Report', the Waitangi Tribunal recommended the government to ensure that the booster vaccine rollout is equitable. [14] The report notes that due to comorbidities and the social determinants of health, younger Māori are about as vulnerable as older Pākehā and that in the initial COVID-19 response "*it is clear that an age adjustment would have made a measurable, equitable difference to Māori vaccination rates. If Māori had been prioritised through an age adjustment earlier as per public health advice, the inequity in the rollout would have been greatly reduced.*" [14]

32. Pacific Peoples are uniquely different in their culture and lived COVID-19 experiences but encounter similar issues as Māori when accessing healthcare during the Omicron wave. Surveys conducted by the Evaluation and Behavioural Science in the Ministry of Health in July 2022 found that since June 2022, Pacific Peoples encountered delayed contact with a professional at a higher rate compared to Europeans (45% of Pacific Peoples, compared to 37% of Europeans). [13] The reasons for delays reported included difficulty in getting an appointment (22% of Pacific Peoples), financial reasons (45% of Pacific Peoples), and wanting an in-person appointment (22% of Pacific Peoples).

Low rates of Serious Adverse Events from COVID-19 vaccination for cohort

33. Serious Adverse Events following immunisation are defined as medically important events that require hospitalisation, cause impairment or incapacity, cause birth defects, are life threatening or cause death. [15] For myocarditis and pericarditis following mRNA COVID-19 vaccination, the risk is highest among young male individuals following the second booster dose. The incidence ratio for people aged 40 to 59 years following a second booster in New Zealand is estimated at 3.62 per 100,000 population, in comparison to 25.84 for those aged 5 to 19 years of aged or 6.50 for those aged 20-39 years.

34. A case series study from New Zealand has been conducted using hospitalisation data to assess the risk of myocarditis and pericarditis after vaccination. Preliminary results indicate that there is no statistically significant difference when ethnicity is considered as the effect modifier. Further analysis will be performed in the coming weeks to stratify the incidence rates by different ethnic groups to confirm this. [16]

35. The Centre for Adverse Reactions Monitoring (CARM) have recorded a total [redacted] spontaneously reported cases of myocarditis and/or pericarditis following the Pfizer COVID-19 vaccine in individuals aged 40-49 years of age up to and including 04 October 2022. [redacted] these cases have been reported in Māori [redacted] cases in

Pacific Peoples in the same age bracket and time frame. This are too few cases to perform any analysis.

Immunogenicity of Pfizer vaccine not found to be associated with ethnicity

36. The Ka Mātau, Ka Ora study on the immunogenicity of the Pfizer BNT162b2 vaccine in adults, found that there was no effect of ethnicity on antibody responses to the vaccine. [17]

Overview of issues relating to expansion of eligibility criteria of second boosters to Māori and Pacific Peoples aged 40-49

Low mortality risk from COVID-19 infection for those aged under 60

37. The overall mortality risk from COVID-19 infection among those under the age of 60 is very low, as highlighted in previous advice from CV TAG, and as outlined in the Mortality Report. A total of 78 COVID-19 attributed deaths were counted between 1 January to 26 August 2022 among those under the age of 60.

Reduction in COVID-19 cases, hospitalisations and deaths in New Zealand and worldwide

38. In New Zealand, the epidemiological context has changed, with falling numbers of COVID-19 infections, and New Zealand having relatively high levels of hybrid immunity (from high proportions infected with Omicron and high vaccination rates). Therefore, most New Zealanders are likely well protected against current variants.

Association of comorbidities with COVID-19 mortality and morbidity risk

39. The Ka Mātau, Ka Ora study also found that Māori participants had high rates of pulmonary disease (primarily asthma) which may contribute to higher hospitalisation rates from COVID-19. Pacific Peoples participants were more likely to have diabetes which was associated with a reduction in antibody responses. [17]

40. One argument in support of keeping the existing eligibility criteria, is consideration in to the proportion of Māori and Pacific Peoples aged 40 to 49 that are already eligible for a second booster due to meeting the criteria under existing comorbidities. [18] As detailed above from the Mortality Report, co-morbidities can explain 2/3 of increased mortality risk for Māori and Pacific Peoples under the age of 60 years. Several studies have highlighted the higher rates of comorbidities among Māori and Pacific Peoples with one study finding these also emerged at earlier ages, and therefore also have a disproportionate impact on quality and quantity of life. [19] Strong disparities were also found in the prevalence of conditions that could exacerbate COVID-19, such as chronic pulmonary, liver and renal disease. [19] It is however important to caveat this with consideration to undiagnosed comorbidities, which are also more prevalent in these community.

Guidance from International bodies

41. Appendix 2 outlines current guidance from international bodies on expanding second booster eligibility.

Recommendations

42. CV TAG met to discuss this advice on 11 October 2022, and this memo has been ratified by email on 2

CV TAG noted:

43. **Improving first booster coverage needs to be the top priority of the National Immunisation Programme. Coverage of first booster doses remain low among Māori and Pacific Peoples**.

44. Failure to address the causes of low and inequitable coverage of first booster doses, will result in the same failures in the roll out of second boosters (regardless of the eligibility criteria for second boosters).

45. Analyses by Manatū Hauora indicate that Māori and Pacific Peoples are at higher risk of death attributed to COVID-19 than those of "European and Other" ethnicity in every age group, including those under the age of 60 years".

46. In the same analyses, [redacted] COVID-19 attributed deaths in under 60-year-olds (all ethnicities combined) were in people who had recorded comorbidities, of which [redacted] were amongst those classified as having severe (i.e. more than one) comorbidities. [19]

47. Manatū Hauora analyses of data about COVID-19 hospitalisation are not yet available. The absence of hospitalisation analysis does not, in itself, provide support for status quo for second booster dose eligibility criteria and a recommendation can still be made based on equity grounds. Inaction will compound existing inequities.

48. Lowering the age criteria for second booster eligibility to 40 years for Māori and Pacific Peoples would remove a substantial barrier (that is, the need for a prescription for a second booster dose) for those Māori and Pacific people aged 40-49 years. This could lead to higher overall uptake of second booster doses by those who are at higher risk of death due to COVID-19 among 40 to 49 year old Māori and Pacific Peoples.

49. CV TAG advice should be in line with co-design and "for Māori, by Māori" approaches. CV TAG, including Māori membership acknowledges that there is substantial support from Māori for an extension of eligibility to those aged 40 years and over. This extension would also align well with whānau-based approaches to vaccination: those aged 40-49 years with co-morbidities attending vaccination clinics with whānau could be offered vaccination immediately without the need for prescription.

50. The risk of myocarditis/pericarditis after vaccination in Māori and Pacific Peoples aged 40-49 years of age is not considered by CV TAG be a significant factor.

CV TAG recommendations:

51. **Addressing inequities in first booster coverage for Māori and Pacific Peoples, as well as first booster coverage across the whole population that are eligible for first boosters, needs to be the top priority of the National Immunisation Programme.**
52. In line with previous advice, CV TAG continues to recommend that the age eligibility criteria for second boosters among Māori and Pacific Peoples should be lowered to 40 years. This is because of a higher risk of severe outcomes from COVID-19 in Māori and Pacific Peoples, and the improved accessibility to second booster doses (through removal of the need for prescription) for those Māori and Pacific Peoples with comorbidities aged 40-49 years.
53. Any extension of eligibility will require clear communication to the public on the difference between those that are 'recommended' and those that are 'eligible' for a second booster dose and choose to receive it after considering their personal situation.
54. In line with previous recommendation made by CV TAG, the second booster dose should be offered from six months after a first booster dose, or after last infection, with some flexibility within the "Book my Vaccine" system.
55. Pfizer remains the preferred second booster vaccine for use in Aotearoa New Zealand.
56. If Pfizer is not considered suitable for that individual, other COVID-19 vaccines currently approved in New Zealand and in use within the National Immunisation programme (i.e. Nuvaxovid) can be used as an alternative second booster dose. All recommendations are subject to the conditions in which they have been approved by Medsafe, and therefore younger age groups may only receive a second booster of a vaccine for which the primary course has already been approved.
57. CV TAG will continue to monitor all relevant information and will update their recommendations as further evidence becomes available.

Dr Ian Town
Chief Science Advisor, Ministry of Health
Chair of the COVID-19 Vaccine Technical Advisory Group

Appendix 1: Second Booster Update CV TAG Memo 22 June 2022 (Updated 26 July 2022)

Memo
Second booster update: COVID-19 Vaccine Technical Advisory Group (CV TAG) recommendations

Date:	22 June 2022 (Updated 26 July 2022)
To:	Dr Ashley Bloomfield, Director-General of Health
Copy to:	Astrid Koornneef, Director, National Immunisation Programme (NIP) Allison Bennett, Manager, System Enablers, System Strategy and Policy Dr Jim Miller, Acting Director of Public Health
From:	Dr Dan Bernal on behalf Dr Ian Town, Chief Science Advisor
For your:	Consideration

Purpose of report

1 To provide the COVID-19 Vaccine Technical Advisory Group's (CV TAG) advice on the science rationale, safety and peak body guidance on use of a second booster dose in:

   a. individuals with underlying health conditions that are likely to increase the individual's risk of adverse outcomes from COVID-19 and/or

   b. those aged over 50 years and/or

   c. extension of eligibility for a second booster dose to healthcare workers.

2 This updated document is being re-issued on 26 July 2022 and provides clarification (particularly around use of a second booster dose in pregnant people) to ensure original intent is clear. Evidence provided and recommendations made on 22 June 2022 remain unchanged.

Background and context

3 On 8 November 2021 Medsafe updated the provisional approval for the Pfizer vaccine to state: "a booster dose of Comirnaty may be administered intramuscularly at least 6 months after completion of the primary course in individuals aged 18 years of age and older".

4 On 17 June 2021 Medsafe further updated the provisional approval for the Pfizer vaccine to include "A booster dose of Comirnaty may be given at least 6 months after the primary course for people 12 years of age and older".

5 Pfizer have not yet applied to Medsafe for approval of any further doses.

8 On 01 February 2022, CV TAG recommended that a booster dose of the COVID-19 vaccine should be given sooner after the primary course to all eligible people aged 18 years and over, including immunocompromised individuals and pregnant persons.

9 The Ministry of Health provided advice to Cabinet and it was agreed that eligibility for a first booster dose would commence from 3 months after the second (or third primary) dose.

10 As cases of COVID-19 climb globally due to outbreaks of the Omicron variant, and evidence has emerged on the waning of protection, some jurisdictions have rolled out second booster doses to populations who remain at highest risk of severe breakthrough disease despite receiving a first booster dose. Defining populations most at-risk of severe breakthrough COVID-19 differs across jurisdictions but includes people with various combinations of comorbidities, age and in a few jurisdictions, healthcare workers.

11 In discussion with the Prime Minister and other Ministers, the Director-General of Health has requested a further update on the science rationale and safety of a second booster dose, in addition to advice provided by international peak bodies around guidance of second booster doses. The Director-General has also asked for advice on consideration of extending eligibility criteria of a second booster dose to anyone over 50, those with underlying health conditions, and healthcare workers.

12 CV TAG previously met on the 01 March and 22 March 2022 to discuss the waning of protection after first booster doses, and the need for second booster doses.

a. CV TAG noted that:

12.a.1 There is evidence of waning of protection following the first booster dose. Protection also appears to wane faster in some populations, e.g., the elderly. People with other health conditions or comorbidities are at an increased risk of poor outcomes also, and may have a lower immune response to vaccines, though evidence is still emerging on the need for a further dose.

12.a.2 Booster doses began to be administered from 29 November 2021, and therefore the numbers of people who are now four months from receiving their first booster dose, are steadily increasing in late June as we approach winter.

12.a.3 The influenza immunisation programme commenced in April, and there is a risk of increased burden on the healthcare system from what

increasingly appears to be a record high influenza season from May 2022 with SARS-CoV-2 also circulating. Research from 305,000 people in hospital in the UK with COVID-19 between February 2020 and December 2021 found 6,965 people recorded as having another respiratory infection alongside COVID-19, 227 (3%) of which were influenza. The researchers estimated that people with COVID-19 and influenza combined were 2.4 times more likely to die and four times more likely to end up on a ventilator than if they only had COVID.[20]

12.a.4 Data on the reactogenicity, safety, immunogenicity, and efficacy of a second Pfizer booster dose is currently limited to three studies from Israel, which studied the immunogenicity and safety among healthcare workers and the elderly. A second booster of the Pfizer vaccine appears to be safe and effective at restoring protection against COVID-19, including Omicron but is a reactogenic vaccine, with 78.6% (95%CI: 71.2-84.8) of people who received a second booster dose reporting a local adverse event, and 42.9% (95%CI: 35-50.7) systemic adverse events. Most of these were mild and resolved quickly.

12.a.5 Some countries have begun rolling out second booster doses, with intervals varying from four to six months after the first booster dose.

12.a.6 The goal of the COVID-19 vaccination programme and offering a second booster dose in New Zealand is to prevent severe disease caused by SARS-CoV-2.

12.a.7 There are a number of equity considerations which are important to consider:

12.a.7.1. Māori and Pacific Peoples have been disproportionately affected in the current outbreak.

12.a.7.2. Māori and Pacific Peoples are at greater risk of COVID-19 hospitalisation and severe disease, having respectively a 2.5-fold and 3-fold higher odds of being hospitalised compared to non-Māori, and Māori are likely to spend 4.9 days longer in hospital [21, 22].

12.a.7.3. Māori and Pacific Peoples are more likely to live in multigenerational families housing in overcrowded conditions, increasing the risk of transmission [23, 24].

12.a.8 Medsafe are yet to approve the use of Pfizer as a second booster dose, and therefore these recommendations require Medsafe approval.

12.a.9 Data is limited on the safety and efficacy of a second booster dose in populations younger than 65 years of age, in healthy individuals, in people with medical or social risk factors, and in pregnant people. Young people (aged under 30) produce a strong immune response to three

doses, have a low baseline risk of severe disease and continue to be well protected.

b. CV TAG recommended that:

12.b.1 A second booster dose be offered to:

12.b.1.1. People aged 65 years and over

12.b.1.2. Māori and Pacific Peoples aged 50 years and over

12.b.1.3. Residents of aged care and disability care facilities

12.b.1.4. Severely immunocompromised people who received a three-dose primary course and a fourth dose as a first booster (noting this is a fifth dose for these people).

12.b.2 In general, the second booster dose should be offered from six months after a first booster dose. However, in the context of high influenza circulation and the need to also maximise influenza vaccine uptake, CV TAG believe it is appropriate to reduce the interval between the first and second booster doses to 4 months and allow COVID-19 vaccines to be given at the same time as the influenza vaccine. In this context, CV TAG also recommends bringing the age range eligibility for the funded influenza vaccine down to align with the age ranges recommended for the COVID-19 second booster vaccines.

12.b.3 A second booster dose, if due, should be postponed for three months after SARS-CoV-2 infection. People can be advised that following infection after the first booster dose, protection is increased but clinical discretion can be applied when considering vaccination prior to 3 months after infection. This may be appropriate for those individuals at highest risk of severe disease from COVID-19 re-infection and impaired immune responses.

12.b.4 The influenza, MMR, HPV, diphtheria/tetanus/pertussis combination vaccine (Boostrix), and other vaccines may be administered before, after, or at the same time as the Pfizer COVID-19 vaccine, without concern for the spacing of the vaccinations. The only exception to this advice is for the live-attenuated shingles vaccine (Zostavax) where a 7-day interval, before or after administering Pfizer COVID-19 vaccine, is advised.

Evidence informing advice

Waning of immunity after a first booster dose

13 Data from the United Kingdom and United States show that vaccine effectiveness (VE) against symptomatic infection and severe disease caused by Omicron wanes over time.

a. There is significant global data to show that VE against symptomatic infection and severe disease caused by COVID-19 wanes over time. Data from the UKHSA also shows that 2-4 weeks after a booster dose of the Pfizer vaccine, VE against symptomatic COVID-19 caused by Omicron is approximately 65% and moderately retains effectiveness with a VE of 45% from 10-14 weeks after the booster. [2]

b. A CDC study found the VE for Pfizer against Omicron *hospitalisation* after three doses wanes from 91% (95% CI: 88–93) at ≤2 months to 78% (95% CI: 67–85) at ≥4 months. [25] This trend is broadly in line with the UK Health Security Agency (UKHSA), who found VE after three doses of Pfizer against *hospitalisation* wanes from 85-90% at 2-4 weeks to approximately 75% at 10-14 weeks (~2-3 months).

14 *Pace of waning and at-risk groups:* Several studies evaluating antibody titres have shown that protection does not wane at the same pace for everyone, and appears to wane faster for the elderly, and for some people with other health conditions their immune response to the vaccine is lower. [26-29]

a. Immunogenicity data suggests that cancer, transplant, and dialysis patients, and those on immunosuppressant therapy, have a reduced response to a first dose of vaccine which can improve with a second dose,[30-37] although the response may still not be optimal, with both reduced antibody and T cell responses. [38-46]

b. A (non-peer reviewed) study of antibody responses following the second dose of Pfizer has been conducted using data from the UK's national COVID-19 Infection Survey. This study found that antibody responses can last for over a year, though they declined more rapidly in older people, males, and those with underlying health conditions. The greatest antibody half-life was observed among those previously infected by SARS-CoV-2. [47]

Safety, reactogenicity and efficacy of a second booster dose

15 Data on the reactogenicity, safety, immunogenicity, and efficacy of a second booster dose are predominantly from studies conducted in Israel, with a small number recently published from the UK.

a. Another study of Israeli healthcare workers aged 18 years and over evaluated a fourth dose of Pfizer or Moderna administered after three Pfizer doses (a two-dose primary course and a first booster). The study population were 1,050 eligible healthcare workers with no known history of SARS-CoV-2 infection, who received

the third dose of Pfizer at least 4 months earlier.[48] Of 1050 eligible, 154 and 120 (274 total) were enrolled to receive Pfizer and Moderna, respectively, and compared to 426 age-matched controls. Primary endpoints were safety and immunogenicity, and secondary endpoints were vaccine efficacy in preventing SARS-CoV-2 infections and COVID-19 symptomatic disease. 18.3% (95% CI: 11.9-24.2%) of participants that received a Pfizer second booster had breakthrough infection compared with 25.0% (95% CI: 17.3-30.1%) of the control group who had only had three doses. In the majority of cases (65-72%) symptoms were mild (without fever of ≥38°C).[48]

b. A preprint prospective observational study comparing the short-term effects of the first and second Pfizer boosters, was conducted in Israel. A total of 2,019 participants aged from 19 to 89 years, with a median age of 52 years, were issued a smartwatch (to record physiological measurements) and filled in a daily questionnaire on systemic reactions to the vaccine. 30% (615 participants) received a second booster during the study period. Receivers of the second booster experienced a considerable increase in heart rate and heart rate variability-based stress within 48 hrs of administration. However, this was transient and returned to baseline levels after 72 hrs. Comparison to those that received the first booster, revealed no significant difference in physiological measures between the second and first booster. 67.7% of participants that received the second booster, did not report any symptoms which is comparable to the 65.8% after the first booster. The most frequently reported reactions (i.e., fatigue, headache, muscle pain, fever, and cold) were similar after the first and second booster doses. [49]

c. A study conducted in the UK as part of the COV-BOOST trial, evaluated the effect of a fourth dose of the Pfizer vaccine on participants aged 30 years or older. 31 participants had previously received three doses of Pfizer as part of the trial, with a median age of 67.2 years old, before receiving a fourth dose of Pfizer. The median interval between the third and fourth doses was 208 days (29.7 weeks). Anti-spike IgG concentrations increased 11-fold 14 days after the fourth dose, showing a strong antibody response to the fourth vaccine. Furthermore, similar T-cell responses were seen, suggesting that a fourth dose of the Pfizer vaccine provides a substantial boost to both humoral and cellular immunity. [50]

16 *Safety and Reactogenicity:* In the trial of healthcare workers, most adverse events (AEs) were reported as mild and resolved within 2 days post booster dose. No serious AEs or hospital admissions were reported. Active reporting of local AEs were

common, and for Pfizer 78.6% (95% CI: 71.2-84.8) of second booster dose recipients reported an adverse event. Among Pfizer second booster dose recipients, more were reported by younger participants: 88% (95%CI: 80.6-95.3) compared with 69.6% (95% CI: 59.4-79.7) in those >60 years of age. Solicited systemic AEs were reported by 42.9% (95% CI: 35-50.7) of Pfizer second booster dose recipients. Systemic adverse events resolved within 2 days. The most common systemic AE reported was fatigue followed by myalgia and headache. Fever was relatively uncommon and usually resolved within 24-36 hours in either group. [48]

17 To date, no safety data have been reported separately (from first booster doses) for second booster doses. The most recent UK government report, with data to May 25th 2022, [51] states "review of third and booster dose reports does not raise any new safety concerns", and, in relation to myocarditis and pericarditis "the reports after booster doses are extremely rare and there is no indication that these events are more serious after boosters". [51] No data about safety of a second booster dose are available yet from the USA. Surveillance data for the first booster dose show "for myocarditis, the findings are consistent with those observed with primary series vaccination, but the risk appears to be lower following the first booster dose compared to dose 2 of primary series". [52]

18 There is particularly limited safety data on second boosters for those under the age of 30, with most safety and reactogenicity studies focusing on older age groups [50, 53]. It is also important to note that a smaller proportion of this age group are eligible for a second booster (given older populations worldwide have been prioritised for first booster uptake). Safety concerns remain high for those under the age of 30, given higher rates of myocarditis and pericarditis for younger age groups following the first and second Pfizer dose. [54, 55]

19 *Effectiveness:* Almost all studies report second booster doses as VE relative to a first booster dose only. Effectiveness of a second booster dose can therefore be interpreted as "there are x% fewer cases of infection/symptomatic infection/severe disease (as applicable) in those who received a second booster dose than in those who continued without this additional dose". All studies were conducted in the Omicron variant dominant period, and therefore reflect effectiveness against the Omicron variant.

20 Relative vaccine effectiveness of a second booster dose (relative to continuing with only a single booster dose) is substantial and sustained (within the period where data available) against severe disease, but less substantial and shorter lived against infection. For clarity, any relative VE value above 0% indicates increased protection in those who received a second booster dose compared to those who continued without this additional dose.

a. Severe disease

20.a.1 Severe disease (e.g., oxygen saturation of <94%) with or without hospitalisation: Weekly estimates of relative VE between 58% and 77% from

2-6 weeks after second booster dose with no signs of waning by the 6th week. Adjusted rate of severe disease in the fourth week after the fourth dose was 1.6 cases per 100,000 person-days (95% CI: 1.2-2.0) compared to 5.5 (95% CI: 5.2-2.9) in the three-dose group. [56]

20.a.2 Hospitalisation: Relative VE 68% in first month (1-4 weeks after vaccination) which correlated to a risk reduction of 180.1 (95% CI: 142.8-211.9) hospitalisation events per 100,000 persons. [57] Second and third studies (which included deaths and hospitalisations) estimated relative VE at 78% 1-3 weeks after the second booster and at 87% 7-10 weeks after, [58] and 40% (time since second booster unclear). [57, 59] Second and third studies (which included deaths and hospitalisations) estimated relative VE at 78% 1-3 weeks after the second booster and at 87% 7-10 weeks after, [58] and 40% (time since second booster unclear). [59]

20.a.3 Death: Relative VE 76% in first month which correlated to a risk reduction of 23.4 (95% CI: 11.8-34.6) COVID-19-related deaths per 100,000 persons. [57]

20.a.4 Mechanical ventilation or death among those already hospitalised with COVID-19: Relative VE 49%. [60]

b. Symptomatic infection

20.b.1 Relative VE 43-55% in first month (approximately 1-4 weeks after vaccination) in 2 studies. [48, 57] Another study estimated relative at VE 31% (time since second booster unclear). [48, 57, 59] Another study estimated relative at VE 31% (time since second booster unclear). [59]

c. Infection

20.c.1 Relative VE 30-45% in first month (7-30 days after vaccination) in 2 studies. [48, 57] Another study estimated relative at VE 19% (time since second booster unclear). [48, 57, 59] Another study estimated relative at VE 19% (time since second booster unclear). [59]

20.c.2 Weekly estimates of relative VE between 33-50% in the period 2-6 weeks after the second booster, declining to 10% by 8 weeks in one study. [56] Another study estimated relative VE at 55-65% in the 2-6 weeks after the second booster with a decline to 22% by 10 weeks. [61]

21 *Limitations:* More data is required to understand the relative effectiveness of a second booster against infection and severe disease, as the sample sizes for many of these studies are small. Despite this, the second booster dose could be beneficial for people at higher risk of severe illness, particularly during periods of surge and rising infections, while emphasising the urgency of next generation development. [62]

22 *Equity considerations:* In addition to equity considerations outlined above (Para 8a vii), it is important to take into account the following factors for targeting younger age groups (those aged 50+) for Māori and Pacific populations:

a. While New Zealand in general has an ageing population, the age structures for Māori and Pacific Peoples are relatively young. Māori and Pacific Peoples on average have a much lower life expectancy, compared to the rest of the New Zealand population. The average life expectancy at birth was 73.4 years for Māori males in 2017–2019, compared to 80.9 years for non-Māori males. [63]

b. Māori and Pacific Peoples face disproportionately higher levels of comorbidities, and that these conditions have emerged at earlier ages, affecting both quality and quantity of life. [19]

c. These disparities include, higher prevalence of conditions linked to exacerbating the impact of COVID-19, such as chronic pulmonary, liver or renal disease. [19]

d. Lower access to healthcare, also results in many Māori and Pacific Peoples with comorbidities remaining undiagnosed.

23 Although the initial Omicron peak has passed, New Zealand is currently experiencing a 'long tail' of COVID-19, with risk of COVID-19 infection remaining high. Among potential reasons for this, it is possible that individuals that have previously reduced their social contact due to being at a higher risk of severe COVID-19 may be increasing their level of social contact due to a sense of lower risk and the peak having already occurred. Additionally, a combination of waning immunity (due to being in excess of 3 months since prior booster), and multiple variants circulating with higher immune escape and infectivity (i.e. BA.2.12.1, BA.4 and BA.5) could contribute to a potential further peak due to these variants.

International recommendations from peak bodies and rollout of second booster doses

24 Given the potential for waning immunity following a first booster, particularly against severe disease (as measured by hospitalisation), some countries have begun recommending the administration of a second booster dose to elderly populations or individuals at increased risk of severe disease or exposure.

a. *Australia:* The Australian Technical Advisory Group on Immunisation (ATAGI) issued recommendations about second booster doses on 25 March 2022. ATAGI recommended an additional booster dose of COVID-19 vaccine to increase vaccine protection before winter for selected population groups who are at greatest risk of severe illness from COVID-19 and who have received their primary vaccination and first booster dose (link). These groups are:

24.a.1 Adults aged 65 years and older

24.a.2 Residents of aged care or disability care facilities

24.a.3 People aged 16 years and older with severe immunocompromise (as defined in the ATAGI statement on the use of a 3rd primary dose of COVID-19 vaccine in individuals who are severely immunocompromised)

24.a.4 Aboriginal and Torres Strait Islander people aged 50 years and older.

b. After continuing to review evidence on the need for other population groups, ATAGI recommended on 25 May 2022, a second booster dose for people at higher risk of severe illness from COVID-19, who have already had their first booster dose 4 months ago. (link)

c. The second booster is **additionally recommended** for people aged 16-64 of increased risk who have:

24.c.1 A medical condition that increases the risk of severe breakthrough COVID-19 illness (see **Table 1** in appendix 1 for expanded groups)

24.c.2 People with disability with significant or complex health needs or multiple comorbidities which increases risk of poor outcomes from COVID-19.

d. The following groups are currently **not recommended** to receive an additional booster dose:

24.d.1 Healthy people aged 16 to 64 years, who do not have a risk factor for severe COVID-19, as their risk of severe illness after their first booster dose is likely to remain very low.

24.d.2 People from occupational groups, such as healthcare workers, who do not have any other comorbidity that increases their risk of severe COVID-19

24.d.3 People who are pregnant without any other comorbidity that increases their risk of severe COVID-19.

e. *Australia*: Victorian Premier Daniel Andrews has signalled his intention to push the federal government to supply a fourth dose for all healthcare workers in hospitals across Victoria, following a recent spate of COVID-19 outbreaks in hospitals by infected staff. (link)

f. *Israel***:** In January 2022, Israel began administering a fourth dose of the Pfizer vaccine to people aged over 60 years and at-risk populations who had received a third dose at least 4 months earlier. An Israeli hospital is also conducting a trial of the second booster dose in healthcare workers. (link) Early data from Israel's rollout of a second booster dose is presented below. On 22 January 2022, Israel's vaccine advisory committee recommended that those aged 18 and over be offered a fourth vaccine dose at least five months after their third dose or after recovering from the disease. (link). Israel's Ministry of Health has since approved use of a fourth dose in healthcare workers and those who are at high risk of exposure to COVID-19 in their line of work. (link)

g. *UK***:** The Joint Committee on Vaccination and Immunisation (JCVI) has advised an additional spring booster dose be given for the most vulnerable individuals

in the population. (link) As a precaution, a further booster dose is advised 6 months after the last vaccine dose for adults aged 75 years and over, older residents in a care home, and individuals aged 12 years and over who are immunosuppressed.

h. *Ireland*: Media reports have mentioned that the National Immunisation Advisory Committee (NIAC) is currently considering a second booster for those aged 65 and under, after advising in April that people aged over 65 and those who are immunocompromised should get their second booster dose. (link)

i. *US*: Pfizer applied for authorisation to the US FDA on 15 March 2022 for adults 65 years and over, (link) and the US FDA has been reviewing data to authorise a second booster dose of vaccines from Pfizer and Moderna. (link) On 29 March 2022, the FDA authorised second boosters for peopled aged 50 and over, and immunocompromised people. (link)

j. *Europe:* According to a joint statement released by the European Medicines Agency and the European Center for Disease Prevention and Control, people over the age of 80 should receive a fourth booster dose of mRNA vaccine due to their weakened immune system, decreased response to vaccination, and increased risk of serious disease. (link)

k. *Spain:* Spain will offer a fourth dose of a COVID-19 vaccine to its entire population, most likely at the end of the year, Health Minister Carolina Darias said on June 16th 2022. (link)

l. *Chile*: Media reports have stated that from 7 February 2022, eligibility for a fourth dose will be extended to people aged over 55 years who had a third vaccine dose at least 6 months prior. (link) The fourth vaccine regimen has not been specified.

m. *Colombia:* Colombia's vaccine advisory committee recommended a second Covid-19 booster dose for people aged 12-49, but only under medical order. The second booster shot, or a fourth vaccine dose, is currently available for immunocompromised people, those with transplants and comorbidity, as well as seniors over 50 years old. (link)

n. *Hungary*: In January 2022, Hungary made a fourth COVID-19 vaccine shot available to people who ask for it, after a consultation with a doctor, to combat growing Omicron infections. (link)

o. *South Korea*: In February 2022, populations that are at increased risk of severe disease (the elderly and immunocompromised) or at increased risk of exposure (healthcare workers) became eligible for a fourth dose, however authorities are not currently considering expanding it more widely. (link)

p. *South Africa*: On 03 June 2022 the national health department announced that from 07 June 2022 all people over the age of 50 years are eligible to receive a second booster dose of Pfizer. (link)

Recommendations

25 CV TAG met on 21 June 2022 to update and further discuss their recommendations for second booster doses.

26 CV TAG noted:

a. There is an increasing need for second boosters, given waning immunity from the first booster.

b. There is limited data to date on the safety profile of the second booster, particularly among younger people.

c. The safety profile of the second booster appears similar to the safety profile of the first booster, providing no indication that there would be a different response, albeit based on relatively limited data to date.

d. In consideration of risk-benefit of the second booster, and limited safety data, there is not sufficient evidence to make a broad recommendation for a second booster, at this time, to young people without comorbidities (particularly those aged under 30 years).

e. It is recognised that COVID-19 infection during pregnancy can have severe outcomes for parent and baby. COVID-19 vaccines have consistently been found to be effective in pregnancy and reduce the chance of severe illness, ICU admission and death from COVID-19 illness.[64] Millions of COVID-19 vaccine doses have been given during pregnancy with no pregnancy-specific safety concerns being identified. [64]

f. There are limited data on the second booster in healthy pregnant people because the studies and roll-out thus far have prioritised older people. However, additional safety concerns after a second booster dose are not expected. Moreover, because a second booster is given at least 6 months after the first (and at least 9 months after completion of a primary course), a second booster dose would be either the first or second dose during the pregnancy. There is substantial worldwide experience with 1 or 2 doses of COVID-19 vaccines during pregnancy, as 2-dose primary courses were administered to pregnant people in initial vaccine roll-out. As noted above, no pregnancy-specific safety concerns have been identified (including for the foetus) when the pregnant person receives 2 doses during one pregnancy.

g. Data on increased benefits from healthcare workers receiving a second booster remains marginal. There is no evidence within the available New Zealand data to suggest healthcare workers (particularly if young and without comorbidities) have a higher risk of acquiring and transmitting infection at their place of work.

h. In consideration of the updated ATAGI advice and limited international evidence, CVTAG does not currently make a specific recommendation related to healthcare workers who do not otherwise meet the criteria stated below. Further recommendations for this group may be made in the future.

i. When compared to other COVID-19 vaccines, there are more data available for the Comirnaty (Pfizer) vaccine, especially in relation to safety, and effectiveness of second boosters.

j. Given the limited safety and effectiveness data, particularly for younger populations, CV TAG would not support any further mandates with regards to second boosters.

27 CV TAG recommended:

a. Maximising efforts to ensure that at-risk populations receive their first booster dose, as this remains the priority, as advised on 1 April 2022.

b. In accordance with ATAGI recommendations, and previously issued advice, a second booster dose be offered to:

- People aged 65 years and over
- Māori and Pacific Peoples aged 50 years and over
- Residents of aged care and disability care facilities aged 16 years and over
- Severely immunocompromised people (people aged 12 years and older) who were eligible for and received a three-dose primary course, with the first booster as a fourth dose (noting this is a fifth dose for this group).

c. That additional groups recommended to receive a second booster include people aged 16 years or older, who have:

- A medical condition that increases the risk of severe breakthrough COVID-19 illness (see **Table 1** in appendix for expanded groups)
- Disabled people with significant or complex health needs, or multiple comorbidities which increases the risk of poor outcomes from COVID-19.

d. A second booster is recommended for younger people (including those who are pregnant) who fall within the eligibility criteria above. Those who don't meet the eligibility criteria currently remain well protected from severe disease with their first booster, and a second booster is not yet needed.

e. In line with recommendation made by CVTAG in the memo dated 1st April 2022 ("Fourth dose (second booster): COVID-19 Vaccine Technical Advisory Group

(CV TAG) recommendations"), the second booster dose should be offered from six months after a first booster dose.

f. The recommendations outlined above apply to all COVID-19 vaccines currently approved in New Zealand and in use within the National Immunisation Programme i.e. Comirnaty (Pfizer), Nuvaxovid (Novavax) and Vaxzevria (AstraZeneca). All recommendations are subject to the conditions in which they have been approved by Medsafe, and therefore for younger age groups may only receive a second booster from a vaccine for which the primary course has already been approved. CV TAG will continue to monitor all relevant information and will update their recommendations as further evidence becomes available.

Dr Dan Bernal (Manager, Science and Technical Advisory, Deputy Chair CV TAG)
acting on behalf of
Dr Ian Town, Chief Science Advisor and Chair of the COVID-19 Vaccine Technical Advisory Group

Table 1 (of appendix 1): ***ATAGI*** - *Additional groups recommended for a winter booster dose as of 25 May 2022*

People in these groups are likely to have an ongoing increased risk of severe COVID-19 even after primary vaccination. These examples are not exhaustive, and providers may include individuals with conditions similar to those listed below, based on clinical judgment

Category	Examples
Immunocompromising conditions	
Cancer	Non-haematological cancer including those diagnosed within the past 5 years or on chemotherapy, radiotherapy, immunotherapy or targeted anti-cancer therapy (active treatment or recently completed) or with advanced disease regardless of treatment. Survivors of childhood cancer.
Chronic inflammatory conditions requiring medical treatment with disease modifying anti-rheumatic drugs (DMARDs) or immune-suppressive or immunomodulatory therapies.	Systemic lupus erythematosus, rheumatoid arthritis, Crohn's disease, ulcerative colitis, and similar who are being treated.
Chronic lung disease	Chronic obstructive pulmonary disease, cystic fibrosis, interstitial lung disease and severe asthma (defined as requiring frequent hospital visits or the use of multiple medications).
Chronic liver disease	Cirrhosis, autoimmune hepatitis, non-alcoholic fatty liver disease, alcoholic liver disease.
Severe chronic kidney disease (stage 4 or 5)	
Chronic neurological disease	Stroke, neurodegenerative disease (e.g dementia, motor neurone disease, Parkinson's disease), myasthenia gravis, multiple sclerosis, cerebral palsy, myopathies, paralytic syndromes, epilepsy.
Diabetes mellitus requiring medication	
Chronic cardiac disease	Ischaemic heart disease, valvular heart disease, congestive cardiac failure, cardiomyopathies, poorly controlled hypertension, pulmonary hypertension, complex congenital heart disease.
People with disability with significant or complex health needs or multiple comorbidities which increase risk of poor outcome from COVID-19	Particularly those with trisomy 21 (Down Syndrome) or complex multi-system disorders.
Severe obesity with BMI ≥ 40 kg/m^2	
Severe underweight with BMI < 16.5 kg/m^2	

Appendix 2:

Extending second booster eligibility to 30 to 49 year olds: COVID-19 Vaccine Technical Advisory Group (CV TAG) recommendations

Date:	10 August 2022
To:	Dr Diana Sarfati, Director-General of Health
Copy to:	Dr Andrew Old, Deputy Director-General, Public Health Agency Dr Nick Chamberlain, National Director, National Public Health Service Rachel Mackay, Acting Director, National Immunisation Programme (NIP) Allison Bennett, Group Manager, Public Health System, Health System Settings Alison Cossar, Manager, Public Health Policy & Regulation, Public Health Agency
From:	Dr Ian Town, Chief Science Advisor
For your:	Consideration

Purpose of report

58. To summarise the COVID-19 Vaccine Technical Advisory Group's (CV TAG) recommendations for the use of COVID-19 second booster vaccinations in 30–49 year olds.

Background

59. On 17 June 2021 Medsafe updated the provisional approval for the Pfizer vaccine to include "*A booster dose of Comirnaty may be given at least 6 months after the primary course for people 12 years of age and older*". This would be a third dose for most individuals.

60. Pfizer have not yet applied to Medsafe for approval of any further doses beyond the first booster dose.

61. On 01 April 2022, CV TAG recommended that a second booster dose of the COVID-19 vaccine (recognising that this would be a fourth dose for most individuals) should be offered to:

    a. People aged 65 years and over,

b. Māori and Pacific Peoples aged 50 years and over,

c. Residents of aged care and disability care facilities aged 16 years and over,

d. Severely immunocompromised people (people aged 12 years and older) who were eligible for and received a three-dose primary course, with the first booster as a fourth dose (noting this is a fifth dose for this group).

62. On 26 June 2022, CV TAG recommended that eligibility for a second booster dose of the COVID-19 vaccine be extended (see **Appendix**) to include people aged 16 years or older, who have:

    a. A medical condition that increases the risk of severe breakthrough COVID-19 illness (see Second Booster Update CV TAG Memo 22 June 2022, for expanded groups)

    b. Disabled people with significant or complex health needs, or multiple comorbidities which increases the risk of poor outcomes from COVID-19.

63. The Director General further authorised (under section 34A of the Medicines Act 1981), on 23 June, the expansion of eligibility of a second booster dose to people aged 50 years and older, and to healthcare workers over the age of 30 years.

    a. The expansion to those over 50 years of age was advised because people without pre-existing conditions between the ages of 50 to 64 years may also be at similar risk to those in the priority groups.

    b. Expansion to health care workers aged over 30 years was advised because health care workers experience higher infection rates than other monitored occupational groups and the additional dose could provide further protection to individuals as well as helping to preserve health service delivery during a high demand period.

64. The Ministry of Health has now sought clinical and scientific advice from CV TAG on extending the second booster dose eligibility to those aged 30 years and older.

Evidence informing advice

Waning of VE after a first booster dose

65. Data from the United Kingdom and United States show that vaccine effectiveness (VE) against symptomatic infection and severe disease caused by Omicron wanes over time.

66. Data from the UK Health Security Agency (UKHSA) showed that VE against symptomatic infection from Omicron is around 65% from 2-4 weeks following a booster dose of the Pfizer vaccine and decreases to 45% from 10-14 weeks. [65] The UKHSA noted that VE is generally slightly higher in younger compared to older age groups but did not state the age categories used.

67. A CDC study of individuals aged 18 years or older found that the VE of Pfizer against Omicron hospitalisation after three doses was reduced from 91% (95% CI: 88–93) at ≤2 months to 78% (95% CI: 67–85) at ≥4 months.[25] This trend is broadly in line with the UKHSA, who found VE after three doses of Pfizer against hospitalisation reduced from 85-90% at 2-4 weeks to approximately 75% at 10-14 weeks (~2-3 months).[65] Further analysis by the UKHSA found that VE against hospitalisation (via Emergency Department admission) among 18-64 year olds, peaked at 82.4% 2-5 weeks after a first booster but dropped to 53.6% after 15 weeks.[66]. To be noted here that the age group examined is very broad and limited hospitalisations in the age group in question (30-49) is likely primarily based on people with significant comorbidities.

Waning of antibody titres after a first booster dose

68. Several studies evaluating antibody titres have shown that protection does not wane at the same pace for everyone, and appears to wane faster for the elderly, and for some people with other health conditions their immune response to the vaccine is lower. Waning in younger populations is less rapid. [26-29]

69. A (non-peer reviewed) study of antibody responses following the second dose of Pfizer has been conducted using data from the UK's national COVID-19 Infection Survey. This study found that despite waning, antibody responses can remain elevated for over a year, though they declined more rapidly in older people and those with underlying health conditions. The greatest antibody half-life was observed among those previously infected by SARS-CoV-2. [47]

New Zealand data on COVID-19 mortality

70. The total number of deaths where COVID-19 is either an underlying cause or contributing factor overall for those aged under 50 years have been low (Table 1, Table 2). However, the death rates (based on small numbers) are higher among Māori and Pacific Peoples in this age group than for those of other ethnicities.

71. For Māori aged 40-49 years, when examining COVID-19 as a **contributory** factor (no deaths recorded for COVID-19 as the underlying cause), death rates are 24 per 100,000 cases, and 7 per 100,000 population ([redacted]). For Pacific Peoples aged 40-49, when examining COVID-19 as an **underlying** factor, death rates are 18 per 100,000 cases, and 6 per 100,000 population ([redacted]). For Pacific peoples aged 40-49, when examining COVID-19 as a **contributory** factor, death rates for Pacific Peoples aged 40-49, these values are 6 per 100,000 cases, and 2 per 100,000 population ([redacted]).

Table 4: Deaths where COVID-19 is the underlying cause, by counts, deaths per 100,000 population and deaths per 100,000 cases, stratified by age and ethnicity. Data from March 2020 to 27 June 2022. Not for sharing or public release as contains potentially identifiable information

Source: COVID-19 Mortality Reporting and Analysis in Aotearoa Briefing, 01 July 2022, Ministry of Health

Table 5: Deaths where COVID-19 was a contributory factor, by counts, deaths per 100,000 population and deaths per 100,000 cases, stratified by age and ethnicity. Data from March 2020 to 27 June 2022. Not for sharing or public release as mortality data are identifiable information

Source: COVID-19 Mortality Reporting and Analysis in Aotearoa Briefing, 01 July 2022, Ministry of Health

Reactogenicity, safety, immunogenicity and efficacy of a second booster dose

72. Background information on safety and efficacy of second boosters have been provided in the previous CVTAG memo (included in the **Appendix**) entitled "Second booster update: COVID-19 Vaccine Technical Advisory Group (CV TAG) recommendations" issued on 26 June 2022.

73. Data from additional studies are provided below. However, it should be noted that data on the reactogenicity, safety, immunogenicity, and efficacy of a second booster dose in individuals under the age of 50 remain limited.

74. A study of healthcare workers in Mexico evaluated the immunogenicity, safety and reactogenicity of a second booster compared to a first booster of Pfizer. The study included 112 participants, with an average age of 43 years. Anti-S1-S2 IgG antibody levels were measured 21-28 days post-vaccination after either their third or fourth dose. Median IgG levels were 3,020 (IQR: 2,330) 21-28 days after the third dose and 4,230 (IQR: 3,393) 21-28 days after the fourth dose. Comparison of antibody levels from third and fourth doses found a statistically significant 1.4-fold increase conferred by the fourth dose. [67]

75. In the same study, they reported fewer adverse events following administration of both the first and second boosters, compared to the primary course. Adenopathy was reported more frequently after the second booster, than with the prior doses. [67]

76. A study of Israeli healthcare workers aged 18 years and over evaluated a fourth dose of Pfizer or Moderna administered after three Pfizer doses (a two-dose primary course and a first booster). The study population included 1,050 eligible healthcare workers with no known history of SARS-CoV-2 infection, who received the third dose of Pfizer at least 4 months earlier. [48] Of 1050 eligible, 154 and 120 (274 total) were enrolled to receive Pfizer and Moderna, respectively, and compared to 426 age-matched controls. Primary endpoints were safety and immunogenicity, and secondary endpoints were vaccine efficacy in preventing SARS-CoV-2 infections and COVID-19 symptomatic disease. 18.3% (95% CI: 11.9-24.2%) of participants that received a Pfizer second booster had breakthrough infection compared with 25.0% (95% CI: 17.3-30.1%) of the control group who had only had three doses. In the majority of cases (65-72%) symptoms were mild (without fever of ≥38°C). [48]

77. In the trial of healthcare workers, most adverse events (AEs) were reported as mild and resolved within 2 days post booster dose. No serious AEs or hospital admissions were reported. Active reporting of local AEs was common, and for Pfizer 78.6% (95% CI: 71.2-84.8) of second booster dose recipients reported an adverse event. Among Pfizer second booster dose recipients, more AEs were reported by younger participants: 88% (95%CI: 80.6-95.3) compared with 69.6% (95% CI: 59.4-79.7) in those >60 years of age. Solicited systemic AEs were reported by 42.9% (95% CI: 35-50.7) of Pfizer second booster dose recipients. Systemic adverse events resolved within 2 days. The most

common systemic AE reported was fatigue followed by myalgia and headache. Fever was relatively uncommon and usually resolved within 24-36 hours in either group. [48]

78. The evidence outlined above are limited to the Comirnaty (Pfizer) vaccine. There is limited evidence on safety and effectiveness of other vaccines (e.g. Nuvaxovid (Novavax) and Vaxzevria (AstraZeneca)) as a second booster. The safety and efficacy of Nuvaxovid as a booster is detailed in CVTAG memo issued on 6 May 2022, "Use of Novavax (Nuvaxovid) COVID-19 vaccine as a heterologous booster".

International recommendations from peak bodies and rollout of second booster doses

79. *World Health Organization:* The WHO published an interim statement on 17 May 2022 on the use of additional booster doses of an mRNA vaccine against COVID-19 and stated: '*Data to support an additional dose for healthy younger populations are limited; preliminary data suggest that in younger people, the benefit is minimal. Moreover, follow-up time after the additional booster dose was limited, thereby precluding conclusions about duration of protection after this dose.*' [68]

80. *Australia:* The Australian Technical Advisory Group on Immunisation (ATAGI) updated its recommendations about second booster doses on 07 July 2022.[69] ATAGI recommended that adults aged 30 to 49 years be eligible for an additional winter booster dose of COVID-19 vaccine but acknowledged that the benefit for people in this age group is less certain. ATAGI has amended the interval recommended between a recent SARS-CoV-2 infection or the first booster dose and a winter booster dose to 3 months.

    a. ATAGI states that it "recognises that some people aged 30 to 49 years **would also like to reduce their risk of infection from COVID-19** and therefore may consider a winter booster dose. While rates of hospitalisation, severe disease, and death from COVID-19 are low in this age group, other factors such as time off work and the risk of long COVID may influence an individual's personal decision to have a winter booster dose. **The impact of vaccination on transmission and maintenance of healthcare capacity in this age group is uncertain but likely to be limited**".

    b. This statement from ATAGI demonstrates that the decision to expand eligibility of a second booster dose to 30 to 49-year-olds is not based on strong evidence of a public health benefit but is to allow those who are within this age bracket and consider themselves at high risk of exposure to COVID-19 (or are particularly concerned with becoming infected), to be able to receive an additional dose of an approved COVID-19 vaccine.

81. *Canada:* Ontario has expanded its eligibility for a second booster to all individuals aged 18 and older, on 13 July 2022. However, Ontario's Chief Medical Officer Dr Kieran Moore said "most Ontarians under 60 have strong protection against the virus more than six months after their first booster but expanding fourth-dose eligibility will ensure they can make an "informed decision" based on their personal situation,

pointing to risk factors like smoking or diabetes." [70] New Brunswick has also expanded second booster dose eligibility to those over the age of 18 on 12 July 2022, if at least five months have passed since their previous dose. [71] British Columbia will be expanding their second booster to ages 12 or older in September. [72]

Recommendations

82. This draft memo was distributed to CV TAG on 5 August 2022 for their feedback which has been incorporated in this final advice.

83. **CV TAG noted**:

    a. Improving first booster coverage needs to be the top priority of the National Immunisation Programme. Coverage of first booster doses remain to be low among Māori and Pacific Peoples (i.e., 31% of Māori aged 18-34 and 48% of Māori aged 35-49 have had a first booster). [73] It is unclear whether offering vaccination to younger age groups for these populations will improve their outcomes, and rather, there is a need for more targeted delivery of immunisation to reach at-risk groups.

    b. There is limited evidence to support the need for a second booster among those under the age of 50, who are otherwise healthy. New Zealand has a particularly unique and complex situation, where a large proportion of the population has recently been infected with Omicron, and therefore the protection inferred from this needs to be considered. There is also some evidence that immune imprinting by infection in vaccinated individuals can influence the response to subsequent infections. [74]

    c. People who have experienced a symptomatic SARS-CoV-2 infection, will have had their immunity substantially boosted and may have negligible additional protection from a second booster dose. Infection after the first booster should influence decision making on timing of second boosters.

    d. The benefits of expanding eligibility for a second COVID-19 vaccine booster dose to those under 50 years of age would have on severe COVID-19 in New Zealand are uncertain but likely to be low. New Zealand data on deaths assessed as being attributable or contributed to by SARS-CoV-2 virus infection since March 2020 identify 20 deaths in the 30-to-49-year age group [redacted] compared with 124 ([redacted]) in the 50-to-69-year age group. However, Māori and Pacific Peoples over 40 years of age, are at a higher risk of other severe outcomes and are more likely to benefit from a second booster than other ethnicities within this age group.

    e. It is recognised that COVID-19 infection during pregnancy can have severe outcomes for unimmunised parents and occasionally for their baby. COVID-19 vaccines have consistently been found to be effective in pregnancy and reduce the chance of severe illness, ICU admission and death from COVID-19 illness.[64]

Millions of COVID-19 vaccine doses have been given during pregnancy with no pregnancy-specific safety concerns being identified. [64]

f. There are limited data on second boosters in healthy pregnant people because the studies and roll-out thus far have prioritised older people. However, additional safety concerns after a second booster dose are not expected. Moreover, because a second booster is given at least 6 months after the first (and at least 9 months after completion of a primary course), a second booster dose would be either the first or second dose during the pregnancy. There is substantial worldwide experience with 1 or 2 doses of COVID-19 vaccines during pregnancy, as 2-dose primary courses were administered to pregnant people in initial vaccine roll-out. As noted above, no pregnancy-specific safety concerns have been identified (including for the foetus) when the pregnant person receives 2 doses during one pregnancy.

g. Emerging evidence indicates a longer dosage interval for currently available vaccines is likely to lead to an improved response and less adverse events overall. In one study that compared shorter intervals (i.e. 1 month after 2nd dose), to prolonged intervals (i.e. 4 months after 2nd dose), found that a longer interval between the second dose and the booster appears to result in higher neutralising antibody titres against all variants tested.[75] This suggests broader protection against variants. Findings from a pre-print case-control study from France suggest that longer intervals between each consecutive dose (including booster doses) are likely to decrease occurrence of vaccine-associated myocarditis. [76]

h. CV TAG recognises that some people aged 30 to 49 years who are not currently eligible for a second booster dose may wish to be able to access it with the aim of minimising their risk of infection from COVID-19. An individual's personal decision to have a second booster dose may be influenced by concern that an infection might result in time off work and/or be associated with prolonged symptoms. However, the available data in this age group suggest that the impact of a second booster dose on infection, transmission and maintenance of healthcare capacity is likely to be limited.

i. There are limited data to date on the safety profile of a second Pfizer booster, particularly among younger people. However, from the limited data available, the safety profile of the second booster appears similar to the safety profile of the first booster, giving no indication that there would be a difference in safety after the second booster dose.

j. Although there is limited evidence on safety and effectiveness of other vaccines (e.g. Nuvaxovid (Novavax) and Vaxzevria (AstraZeneca)) as a second booster, their safety and effectiveness profile is unlikely to be importantly different to that from the first booster.

84. **CV TAG recommendations:**

a. CV TAG does not support making a second booster dose available to healthy adults aged less than 50 years as it is unclear whether the benefits outweigh the risks in this population.

b. Improving coverage of the first booster, needs to be the **top priority** of the National Immunisation Programme among all eligible adults, especially Māori and Pacific populations.

c. The age eligibility criteria for second boosters among Māori and Pacific Peoples should be lowered to 40 years because of a higher risk of adverse outcomes from COVID-19.

d. In accordance with previously issued advice, a second booster dose is recommended for:

   i. People aged 65 years and over

   ii. Māori and Pacific Peoples aged 50 years and over (see c. above)

   iii. Residents of aged care facilities

   iv. Residents of disability care facilities aged 16 years and over

   v. Severely immunocompromised people (people aged 12 years and older) who were eligible for and received a three-dose primary course, with the first booster as a fourth dose (noting this is a fifth dose for this group).

   vi. People aged 16 years or older who have:

      1. A medical condition that increases the risk of severe breakthrough COVID-19 illness (see **Table 1** in memo in the **Appendix** for expanded groups).

      2. Disabled people with significant or complex health needs, or multiple comorbidities which increases the risk of poor outcomes from COVID-19.

e. A second booster is recommended for younger people (including those who are pregnant) who fall within the eligibility criteria *i-vi* above.

f. Expanded groups in Table 1 (see **Table 1** in the **Appendix)**, should be revised to include those with severe mental illness and/or addiction.

g. Any extension of eligibility will require clear communication to the public on the difference between those that are 'recommended' and those that are 'eligible' for a second booster dose and choose to receive it after considering their personal situation.

h. In line with previous recommendation made by CV TAG, the second booster dose should be offered from six months after a first booster dose, or after last infection, with some flexibility within the "Book my Vaccine" system.

i. Pfizer remains the preferred second booster vaccine for use in Aotearoa New Zealand.
j. If Pfizer is not considered suitable for that individual, other COVID-19 vaccines currently approved in New Zealand and in use within the National Immunisation programme (i.e. Nuvaxovid) can be used as an alternative second booster dose. All recommendations are subject to the conditions in which they have been approved by Medsafe, and therefore younger age groups may only receive a second booster of a vaccine for which the primary course has already been approved.
k. CV TAG will continue to monitor all relevant information and will update their recommendations as further evidence becomes available.

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References

1. Ministry of Health. *COVID-19 Mortality in Aotearoa New Zealand: Inequities in Risk*. 2022; Available from: https://www.health.govt.nz/publication/covid-19-mortality-aotearoa-new-zealand-inequities-risk.
2. Waitangi Tribunal. *Hauora: Report on Stage One of the Health Services and Outcomes Kaupapa Inquiry*. 2019; Available from: https://forms.justice.govt.nz/search/Documents/WT/wt_DOC_152801817/Hauora%20W.pdf.
3. Centers for Disease Control and Prevention (CDC). *Underlying Medical Conditions Associated with Higher Risk for Severe COVID-19: Information for Healthcare Professionals*. 2022; Available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/underlyingconditions.html.
4. Te Whatu Ora, *(Unpublished report) NRHCC Hospitalisaion Brief Report - Novel Corona Virus (COVID-19)*. 2022.
5. Al-Aly, Z. *Long-term neurological sequelae of SARS-CoV-2 infection*. Nature Medicine 2022 2022/10/03; Available from: https://doi.org/10.1038/s41591-022-02018-4.
6. Centers for Disease Control and Prevention (CDC). *Post-COVID Conditions: Overview*. 2021 9 July 2021 [cited 2022 31 March]; Available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/post-covid-conditions.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhcp%2Fclinical-care%2Flate-sequelae.html.
7. Tahana, J. *Fears equity disaster on the horizon as threat of long Covid among Māori emerges*. 2022; Available from: https://www.rnz.co.nz/news/te-manu-korihi/469058/fears-equity-disaster-on-the-horizon-as-threat-of-long-covid-among-maori-emerges.
8. UK Health Security Agency. *The effectiveness of vaccination against long COVID. A rapid evidence briefing*. 2022 [cited 31 Mar 2022; Available from: https://ukhsa.koha-ptfs.co.uk/cgi-bin/koha/opac-retrieve-file.pl?id=fe4f10cd3cd509fe045ad4f72ae0dfff.
9. Mahase, E., *Covid-19: Vaccinated people are less likely to get long covid, review finds.* BMJ, 2022. **376**: p. o407.
10. Ministry of Health. *National and DHB immunisation data*. 2022; Available from: https://www.health.govt.nz/our-work/preventative-health-wellness/immunisation/immunisation-coverage/national-and-dhb-immunisation-data.
11. Ministry of Health. *Flu vaccine data*. 5 Oct 2022; Available from: https://www.health.govt.nz/your-health/conditions-and-treatments/diseases-and-illnesses/influenza/flu-influenza-vaccines/flu-vaccine-data.
12. Horizon Research Limited, *(Unpublished report) Attitudes and behaviours towards vaccination and the COVID-19 second booster vaccine August 2022 Report*. 2022.
13. Horizon Research Limited, *(Unpublished report) Equitable access to COVID-19 healthcare July 2022 Report*. 2022.

14. Waitangi Tribunal. *Haumaru: The Covid-19 Priority Report*. 2021; Available from: https://waitangitribunal.govt.nz/assets/Documents/Publications/Covid-Priority-W.pdf.
15. Medsafe. *Adverse events following immunisation with COVID-19 vaccines: Safety Report #44 – 30 June 2022*. 2022; Available from: https://www.medsafe.govt.nz/COVID-19/safety-report-44.asp.
16. Te Whatu Ora, *(Unpublished data) Vaccine Safety Surveilleance and Research.* 2022.
17. Priddy, F.H., et al., *Immunogenicity of BNT162b2 COVID-19 vaccine in New Zealand adults.* Vaccine, 2022. **40**(34): p. 5050-5059.
18. Ministry of Health. *Clinical criteria in support of second booster eligibility*. 2022; Available from: https://www.health.govt.nz/covid-19-novel-coronavirus/covid-19-vaccines/clinical-criteria-support-second-booster-eligibility.
19. Gurney, J., J. Stanley, and D. Sarfati. *The inequity of morbidity: Disparities in the prevalence of morbidity between ethnic groups in New Zealand*. Journal of Comorbidity 2020; 2235042X20971168]. Available from: https://journals.sagepub.com/doi/abs/10.1177/2235042X20971168.
20. Swets, M.C., et al. *SARS-CoV-2 co-infection with influenza viruses, respiratory syncytial virus, or adenoviruses*. The Lancet 2022 2022/03/25/; Available from: https://www.sciencedirect.com/science/article/pii/S014067362200383X.
21. Steyn, N., Binny, R. N., Hannah, K., Hendy, S. C., James, A., Lustig, A., Ridings, K., Plank, M. J., Sporle, A. *Māori and Pacific people in New Zealand have a higher risk of hospitalisation for COVID-19*. New Zealand Medical Journal 2021 9 July 2021 [cited 134 1538]; Available from: https://pubmed.ncbi.nlm.nih.gov/34239143/.
22. Steyn, N., et al., *Estimated inequities in COVID-19 infection fatality rates by ethnicity for Aotearoa New Zealand.* New Zealand Medical Journal, 2020. **133**(1521): p. 28-39.
23. McLeod, M., et al., *COVID-19: we must not forget about Indigenous health and equity.* Australian and New Zealand Journal of Public Health, 2020. **44**(4): p. 253-256.
24. Johnson, A., P. Howden-Chapman, and S. Eaqub. *A stocktake of New Zealand's housing: February 2018*. [Report] 2018; Available from: https://apo.org.au/node/132781.
25. Ferdinands, J.M., et al., *Waning 2-Dose and 3-Dose Effectiveness of mRNA Vaccines Against COVID-19–Associated Emergency Department and Urgent Care Encounters and Hospitalizations Among Adults During Periods of Delta and Omicron Variant Predominance — VISION Network, 10 States, August 2021–January 2022.* MMWR. Morbidity and Mortality Weekly Report, 2022. **71**(7): p. 255-263.
26. Collier, D.A., et al., *Age-related immune response heterogeneity to SARS-CoV-2 vaccine BNT162b2.* Nature, 2021.
27. Kontopoulou, K., et al., *Immunogenicity after the first dose of the BNT162b2 mRNA Covid-19 vaccine: real-world evidence from Greek healthcare workers.* Journal of Medical Microbiology, 2021. **70**(8).
28. Meyer, M., et al., *Humoral immune response after COVID-19 infection or BNT162b2 vaccine among older adults: evolution over time and protective thresholds*. 2021, Cold Spring Harbor Laboratory.

29. Tober-Lau, P., et al., *Long-term immunogenicity of BNT162b2 vaccination in the elderly and in younger health care workers*. 2021, Cold Spring Harbor Laboratory.
30. Benotmane, I., et al., *Weak anti-SARS-CoV-2 antibody response after the first injection of an mRNA COVID-19 vaccine in kidney transplant recipients.* Kidney Int, 2021.
31. Monin-Aldama, L., et al. *Interim results of the safety and immune-efficacy of 1 versus 2 doses of COVID-19 vaccine BNT162b2 for cancer patients in the context of the UK vaccine priority guidelines*. 17 March 2021; Available from: https://www.medrxiv.org/content/10.1101/2021.03.17.21253131v1.
32. Goupil, R., et al. *Short-term antibody response and tolerability of one dose of BNT162b2 vaccine in patients receiving hemodialysis*. 1 April 2021; Available from: https://www.medrxiv.org/content/10.1101/2021.03.30.21254652v1.
33. Kennedy, N.A., et al., *Anti-SARS-CoV-2 antibody responses are attenuated in patients with IBD treated with infliximab.* Gut, 2021. **70**(5): p. 865-875.
34. Deepak, P., et al., *Glucocorticoids and B Cell Depleting Agents Substantially Impair Immunogenicity of mRNA Vaccines to SARS-CoV-2.* medRxiv, 2021.
35. Palich, R., et al., *Weak immunogenicity after a single dose of SARS-CoV-2 mRNA vaccine in treated cancer patients.* Ann Oncol, 2021.
36. Jerome, B., et al., *Impaired immunogenicity of BNT162b2 anti SARS-CoV-2 vaccine in patients treated for solid tumors.* Ann Oncol, 2021.
37. Weigert, A., et al., *Longitudinal analysis of antibody responses to the Pfizer BNT162b2 vaccine in Patients Undergoing Maintenance Hemodialysis*. 2021, Cold Spring Harbor Laboratory.
38. Tzarfati, K.H., et al., *BNT162b2 COVID-19 Vaccine is significantly less effective in patients with hematologic malignancies.* Am J Hematol doi: 10.1002/ajh.26284, 2021.
39. Prendecki, M., et al., *Comparison of humoral and cellular responses in kidney transplant recipients receiving BNT162b2 and ChAdOx1 SARS-CoV-2 vaccines*. 14th July 2021, Cold Spring Harbor Laboratory.
40. Clarke, C.L., et al., *Comparison of immunogenicity between BNT162b2 and ChAdOx1 SARS-CoV-2 vaccines in a large haemodialysis population*. 14th July 2021, Cold Spring Harbor Laboratory.
41. Whitaker, H., et al. *Pfizer-BioNTech and Oxford AstraZeneca COVID-19 vaccine effectiveness and immune response among individuals in clinical risk groups* 9th July 2021; Available from: https://khub.net/documents/135939561/430986542/RCGP+VE+riskgroups+paper.pdf/a6b54cd9-419d-9b63-e2bf-5dc796f5a91f.
42. Espi, M., et al., *The ROMANOV study found impaired humoral and cellular immune responses to SARSCov-2 mRNA vaccine in virus unexposed patients receiving maintenance hemodialysis.* Kidney International, 2021.
43. Hadjadj, J., et al., *Immunogenicity of BNT162b2 vaccine Against the Alpha and Delta Variants in Immunocompromised Patients*. 9th August 2021, Cold Spring Harbor Laboratory.

44. Del Bello, A., et al., *Efficiency of a boost with a third dose of anti–SARS-CoV-2 messenger RNA–based vaccines in solid organ transplant recipients.* American Journal of Transplantation, 2021.
45. Labriola, L., et al., *Immunogenicity of BNT162b2 SARS-CoV-2 Vaccine in a Multicenter Cohort of Nursing Home Residents Receiving Maintenance Hemodialysis.* American Journal of Kidney Diseases, 2021.
46. Cotugno, N., et al., *HUMORAL AND CELLULAR IMMUNOGENICITY and SAFETY UP TO 4 MONTHS AFTER VACCINATION WITH BNT162B2 mRNA COVID-19 VACCINE IN HEART AND LUNG TRANSPLANTED YOUNG ADULTS*. 2021, Cold Spring Harbor Laboratory.
47. Wei, J., et al., *Antibody responses to SARS-CoV-2 vaccines in 45,965 adults from the general population of the United Kingdom.* Nature Microbiology, 2021.
48. Regev-Yochay, G., et al. *4th Dose COVID mRNA Vaccines' Immunogenicity & Efficacy Against Omicron VOC*. medRxiv 2022; 2022.02.15.22270948]. Available from: http://medrxiv.org/content/early/2022/02/15/2022.02.15.22270948.abstract.
49. Yechezkel, M., et al., *Safety of the fourth COVID-19 BNT162b2 mRNA (second booster) vaccine.* medRxiv, 2022: p. 2022.06.07.22276117.
50. Munro, A.P.S., et al., *Safety, immunogenicity, and reactogenicity of BNT162b2 and mRNA-1273 COVID-19 vaccines given as fourth-dose boosters following two doses of ChAdOx1 nCoV-19 or BNT162b2 and a third dose of BNT162b2 (COV-BOOST): a multicentre, blinded, phase 2, randomised trial.* Lancet Infect Dis, 2022.
51. Medicines and Healthcare products Regulatory Agency. *Coronavirus Vaccines Summary of Yellow Card reporting*. 01 June 2022; Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1080316/Coronavirus_vaccine_-_summary_of_Yellow_Card_reporting_DLP_25.05.2022.pdf.
52. Nicola Klein and Tom Shimabukuro. *Safety update of 1st booster mRNA COVID-19 vaccination*. 20 April 2022; Available from: https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2022-04-20/03-COVID-Klein-Shimabukuro-508.pdf.
53. Bar-On, Y.M., et al. *Protection by 4th dose of BNT162b2 against Omicron in Israel.* medRxiv 2022; 2022.02.01.22270232]. Available from: http://medrxiv.org/content/early/2022/02/01/2022.02.01.22270232.abstract.
54. Su, J.R. *Myopericarditis following COVID-19 vaccination: Updates from the Vaccine Adverse Event Reporting System (VAERS)*. August 30, 2021; Available from: https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-08-30/03-COVID-Su-508.pdf.
55. Mevorach, D., et al., *Myocarditis after BNT162b2 mRNA Vaccine against Covid-19 in Israel.* New England Journal of Medicine, 2021.
56. Bar-On, Y.M., et al. *Protection by a Fourth Dose of BNT162b2 against Omicron in Israel.* N Engl J Med 2022 May 5 [cited 386 18]; 2022/04/06:[1712-1720]. Available from: https://www.nejm.org/doi/full/10.1056/NEJMoa2201570.

57. Magen, O., et al. *Fourth Dose of BNT162b2 mRNA Covid-19 Vaccine in a Nationwide Setting*. N Engl J Med 2022 Apr 28 [cited 386 17]; 2022/04/14:[1603-1614]. Available from: https://www.nejm.org/doi/full/10.1056/NEJMoa2201688.
58. Gazit, S., et al. *Relative Effectiveness of Four Doses Compared to Three Dose of the BNT162b2 Vaccine in Israel*. medRxiv 2022; 2022.03.24.22272835]. Available from: http://medrxiv.org/content/early/2022/03/24/2022.03.24.22272835.abstract.
59. Grewal, R., et al. *Effectiveness of a Fourth Dose of COVID-19 Vaccine among Long-Term Care Residents in Ontario, Canada: Test-Negative Design Study*. 1 June 2022; Available from: https://www.medrxiv.org/content/10.1101/2022.04.15.22273846v2.full.pdf.
60. Brosh-Nissimov, T., et al. *Hospitalized patients with severe COVID-19 during the Omicron wave in Israel - benefits of a fourth vaccine dose*. medRxiv 2022; 2022.04.24.22274237]. Available from: http://medrxiv.org/content/early/2022/04/27/2022.04.24.22274237.abstract.
61. Gazit, S., et al., *Short term, relative effectiveness of four doses versus three doses of BNT162b2 vaccine in people aged 60 years and older in Israel: retrospective, test negative, case-control study*. BMJ, 2022. **377**: p. e071113.
62. Mallapaty, S. *Fourth dose of COVID vaccine offers only slight boost against Omicron infection*. Nature 2022 23 February [cited 2022 25 February]; Available from: https://www.nature.com/articles/d41586-022-00486-9.
63. Statistics NZ. *Growth in life expectancy slows*. 2021 21/06/2022]; Available from: https://www.stats.govt.nz/news/growth-in-life-expectancy-slows.
64. World Health Organisation (WHO). *Questions and Answers: COVID-19 vaccines and pregnancy*. 15 Feb 2022; Available from: https://www.who.int/publications/i/item/WHO-2019-nCoV-FAQ-Pregnancy-Vaccines-2022.1.
65. UK Health Security Agency. *COVID-19 vaccine surveillance report, Week 7*. 17 February 2022; Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055620/Vaccine_surveillance_report_-_week_7.pdf.
66. UK Health Security Agency. *COVID-19 vaccine surveillance report: Week 12*. 2022; Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063023/Vaccine-surveillance-report-week-12.pdf.
67. Romero-Ibarguengoitia, M.E., et al., *Analysis of Immunization, Adverse Events, and Efficacy of a Fourth Dose of BNT162b2 Vaccine in Health Workers in Mexico, a Pilot Study*. Vaccines, 2022. **10**(7): p. 1139.
68. World Health Organisation (WHO). *Interim statement on the use of additional booster doses of Emergency Use Listed mRNA vaccines against COVID-19*. 2022; Available from: https://www.who.int/news/item/17-05-2022-interim-statement-on-the-use-of-additional-booster-doses-of-emergency-use-listed-mrna-vaccines-against-covid-19.

69. (ATAGI), A.T.A.G.o.I. *ATAGI updated recommendations for a winter dose of COVID-19 vaccine*. 7 July 2021; Available from: https://www.health.gov.au/news/atagi-updated-recommendations-for-a-winter-dose-of-covid-19-vaccine.
70. CBC news. *Ontario expands access to 4th COVID-19 vaccine doses to all adults*. July 14 2022; Available from: https://www.cbc.ca/news/canada/toronto/ontario-covid-update-rapid-tests-moore-1.6519060.
71. CBC News. *N.B. lowers 4th dose eligibility as COVID claims 4 more lives, hospitalizations nearly double*. 12 July 2022; Available from: https://www.cbc.ca/news/canada/new-brunswick/covd-19-new-brunswick-new-wave-hospital-patients-outbreaks-1.6517809.
72. Star, A. *B.C. rolling out fourth COVID-19 vaccine dose in the fall*. 7 July 2022; Available from: https://www.aldergrovestar.com/news/b-c-rolling-out-fourth-covid-19-vaccine-dose-in-the-fall/.
73. Ministry of Health, *COVID-19 Vaccine Uptake (%) by Prioritised Ethnicity, Age and Region*. 2022.
74. Reynolds, C.J., et al., *Immune boosting by B.1.1.529 (Omicron) depends on previous SARS-CoV-2 exposure*. Science, 2022. **377**(6603): p. eabq1841.
75. Zhao, X., et al., *Effects of a Prolonged Booster Interval on Neutralization of Omicron Variant*. New England Journal of Medicine, 2022. **386**(9): p. 894-896.
76. Le Vu, S., et al., *Risk of Myocarditis after Covid-19 mRNA Vaccination: Impact of Booster Dose and Dosing Interval*. medRxiv, 2022: p. 2022.07.31.22278064.