Tab 1

A COST-BENEFIT ANALYSIS OF COVID-19 VACCINE MANDATES

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Abstract

Covid-19 vaccine mandates for the general population must trade off the rights of those who (rationally) object to being vaccinated against the costs that the unvaccinated impose upon the vaccinated, most particularly the increased risk to vaccinated people of death by covid-19. This paper applies this principle to the covid-19 vaccine mandates applied to the adult population of New Zealand in 2021. It concludes that opposition to covid-19 vaccines was rational for young, healthy people, and the costs of the vaccine mandates (primarily in the form of reducing the quality of life of those objecting to them) were at least 32 times the benefits of mandating (primarily in the form of reduced deaths from covid-19 arising from inducing more people to vaccinate). Even in respect of health workers, who come into frequent and close contact with large numbers of people at high risk from covid-19, the costs of mandates for these workers still exceeded the benefits, and therefore even they were not justified. Consequently, they were also unjustified for education workers, who were even less likely to come into close and frequent contact during their work hours with people at high risk from covid-19.

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1. Introduction

In 2021, with the arrival of covid-19 vaccines, governments in many countries imposed penalties for non-vaccination, including loss of employment and limitations upon activities. Such "vaccine mandates" were extremely controversial. Opponents pointed to the right to choose whether to be vaccinated, and to concerns over the safety of the vaccine. Proponents pointed to the costs that the unvaccinated imposed upon the vaccinated, in particular the increased risk of covid-19 to vaccinated people (because the vaccines did not completely eliminate the risk of death but they did reduce the risk of infecting another person).

Assessing competing claims of this type involves issues of both ethics and economics. In respect of ethics, the crucial requirement is that of proportionality: "the burdens (and/or harms) involved in an intervention should be outweighed by the public health benefits achieved" (Jamrozik, 2022, page 2). Optimal vaccination policy has also been the subject of considerable economic analysis, even pre-covid (see Gersovitz, 2011, and Klein et al, 2007, for summaries). This typically involves determining ex-ante both the socially optimal level of vaccination and the optimal choice for individuals, and therefore assessing whether the two match. In general, the socially optimal level of vaccination exceeds the optimal level judged by each individual, because individuals are presumed to ignore the benefits to others in them being vaccinated (the reduced risk of infecting others if infected, magnified by the reduced risk of becoming infected, which are "positive externalities") whilst the socially optimal level appropriately reflects these positive externalities. Boulier et al (2007, Figure 3 and Figure 4) provides dramatic illustrations of the disparity in these public and private benefits. Accordingly, this literature concludes that government intervention is warranted in some situations, typically in the form of subsidising vaccination or taxing those who fail to do so. Vaccination is typically assumed not to entail any risk of adverse side-effects, such as with Boulier et al (2007). A rare contrary example is Bauch and Earn (2004), but this assumes that all individuals face the same vaccine risks and benefits, and therefore that opposition to vaccination by some individuals is misinformed ("vaccine scares" arising from factors such as "media coverage").

Economic analysis of covid vaccination policy has naturally been less extensive. Boppart et al (2022) considered whether it would be desirable to vaccinate all adults, and concluded that it was. This is unsurprising because the authors do not recognise that there are any adverse side-effects from vaccines. The authors do not consider the question of mandates. Ferranna et al

(2023) considered the costs and benefits of mandating vaccination for US federal government workers, and concluded that this was desirable. The conclusion is unsurprising because the authors again do not recognise any risk of adverse side-effects. However the authors did acknowledge that the coercive measures provoked resentment, and this subtracted an unknown amount from the benefits (ibid, section 5). Avriette (2024) conducted a similar analysis for US Defense Department employees, and reached the same conclusion. Vaccine risks are recognised but the only resulting costs that are recognised are those to the employer in the form of medical costs and lost days of work (ibid, page 15). Bardosh et al (2024) considered the costs and benefits of mandating vaccine boosters for North American university students in 2022, and concluded that it was not warranted because the target group was extremely low risk and the vaccine had only modest and transient effectiveness against transmission of the omicron variant that was dominant at that time. Since the health risks of the mandate to the vaccinated outweighed the health benefits to the population, the authors did not need to quantify non-health related effects arising from coercion, but they did record their substantial negative effects (ibid, page 34).

None of these papers considered the merits of vaccine mandates for the entire adult population of a country, which raises the following issues. Firstly, while the short-term vaccine risks may have been equal across individuals and very small, the covid risks (and hence the vaccination benefits) for very young healthy people were also very small and grew dramatically with age and co-morbidities, with the result that the individual vaccination risks may have outweighed the individual benefits for a large fraction of the population subject to the mandates, and it would be rational for such people to oppose being vaccinated. The fact that the vaccine was newly developed, and therefore its medium and long-term risks were unknown, provided a further rationale for vaccine opposition, but one less amenable to quantification.[1] The purpose of vaccination, and therefore coercion, was to enhance protection for the rest of the community because vaccination reduced the risk of members of the coerced group infecting others *if* they became infected. Secondly, the benefits of mandates for the entire adult population are greater than those for just university students because the latter are a very low risk group, even if they acted as transmitters to the rest of the community. Thus, in addition to the adverse health

[1] As noted by the NZ Royal Commission (2024, section 7.3.1.3): "..vaccines (like most medicines) are not entirely without risks. Where a vaccine has been used for many years, these risks are usually well understood. But covid-19 vaccines were very new at the point they were rolled out..".

consequences for those coerced into vaccination, it is necessary to quantify the other adverse effects of coercion (including the loss of employment and restrictions on the activities of those who refuse vaccination), so as to assess whether the costs of mandating exceeded its benefits.

This paper considers the costs and benefits of the mandates that were applied to the entire adult population of New Zealand in 2021. I commence by assessing whether opposition to vaccination was rational for some sectors of the community, based upon information available to them in late 2021. Upon concluding that this was the case for many people, I then conduct a social cost-benefit analysis of the vaccine mandates.

2. The Rationality of Vaccine Opposition

The risk of death from covid-19 if one is infected is strongly related to the age and health of a person. In respect of age, I conservatively invoke the Infection Fatality Rate (IFR) data used (until late 2021) by Steyn et al (2021a, page 14), which was drawn from Verity et al (2020, Table 1).[2] These rates are shown in the second column of Table 1. These range from 0.0015% (1/67,000) to 6.64% (1/15) for the 75+ group. Death rates from covid-19 are also strongly associated with various pre-existing conditions (co-morbidities). This information along with estimates of the prevalence of these pre-existing conditions in the general population permits one to deduce the IFRs for covid-19 conditional on whether an individual does or does not suffer from any of the pre-existing conditions (denoted "unhealthy" and "healthy" respectively). Doing so involves the use of Bayes Theorem, which states that the probability of event A occurring conditional upon B occurring is the probability of B occurring conditional upon A occurring multiplied by the unconditional probability of A divided by the unconditional probability of B (Mood et al, 1974, page 36), i.e.,

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \qquad (1)$$

In this case, A means death from covid-19 and B means "Healthy" or "Unhealthy". So, for the healthy group H, the probability of death is

[2] Wherever possible, I use data and parameter estimates from New Zealand government sources or from parties whose work was commissioned by the government. I do this to guard against any potential criticism that sources were chosen to yield results critical of the government's decisions. One of Steyn's co-authors (Shaun Hendy) notes that their work in late 2021 was commissioned by the government (Hendy, 2025, page 235).

$$P(D|H) = \frac{P(H|D)P(D)}{P(H)}$$

The left-hand side of this equation is the Infection Fatality Rate conditional upon being healthy (IFR_H) whilst *P*(*D*) is the probability of death from covid if infected and without conditioning on the health status of the individual (the unconditional infection fatality rate or IFR_O). So

$$IFR_H = \frac{P(H|D)IFR_O}{P(H)} \tag{2}$$

Similarly, the Infection Fatality Rate conditional upon the individual being in the unhealthy group (*U*) is as follows:

$$IFR_U = \frac{P(U|D)IFR_O}{P(U)} \tag{3}$$

Most covid-19 deaths involved people suffering from serious pre-existing conditions. In particular, in respect of England and Wales over calendar 2020, the proportion of those dying with a pre-existing condition was 73% in the 0-64 group and 84% in the 65+ group.[3] So, for the 0-64 group, $P(U|D) = 0.73$ and therefore $P(H|D) = 0.27$. The prevalence of these conditions is very low in children and grows strongly with age. For example, in respect of type 2 diabetes (the commonest type of diabetes), the prevalence rises from less than 1% for those under 34 years old to a peak of 13% for 70-74 year olds (Ministry of Health, 2007, Table 1). In respect of heart disease the rate rises from less than 1% for those under 44 years old to 30% for the 75+ group (National Health Committee, 2013, Figure 2). So, I estimate the proportion of 0-29 year olds suffering from any of these pre-existing conditions as 1%, the proportion of those in the 75+ group suffering from any of them at 50%, and for the percentage to grow linearly over the intervening age groups. The resulting rates (prevalence) are shown in the third column of Table 1. So, for 0-29 year olds, $P(U) = 0.01$ and therefore $P(H) = 0.99$.

[3] New Zealand data of this kind does not seem to be available. The commonest such conditions are dementia, diabetes, heart disease and cancer. See Table 2 of https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/preexistingconditionsofpeoplewhodiedduetocovid19englandandwales.

Substituting these values for $P(H|D)$, $P(U|D)$, $P(H)$, and $P(U)$ into equations (2) and (3) then yields the IFRs conditional on health status. For example, for the healthy 0-9 group,

$$IFR_H = \frac{0.27 * 0.0015\%}{0.99} = 0.0004\%$$

This is 1/240,000 and shown in the first row of Table 1. In addition:

$$IFR_U = \frac{0.73 * 0.0015\%}{0.01} = 0.11\%$$

This is 1/900 and is also shown in the first row of Table 1. So, the unconditional probability of a 0-9 year old dying from covid-19 if infected (and unvaccinated) is 1/67,000, rising to 1/900 if they suffer from any of the relevant pre-existing conditions and falling to 1/240,000 if they do not suffer from any of the relevant pre-existing conditions. Columns 4 and 5 of Table 1 shows these results for all age groups, for the unvaccinated. As shown in Table 1, the risk of death for a healthy 0-9 year old if infected and unvaccinated (1/240,000) is very low, but this risk rises very significantly with age and health status, to as much as 1/15 for a healthy 75+ year old and to 1/9 for an unhealthy 75+ year old.

Table 1: Risk of Death from Covid-19 if Infected and Unvaccinated

	IFR_0	Prevalence	IFR_H	IFR_U
0-9	1/67,000	0.01	1/240,000	1/900
10-19	1/12,500	0.01	1/46,000	1/170
20-29	1/3,300	0.01	1/12,000	1/50
30-39	1/1,200	0.09	1/4,000	1/150
40-49	1/500	0.17	1/1,500	1/120
50-59	1/140	0.25	1/400	1/50
60-69	1/50	0.34	1/150	1/20
70-74	1/27	0.42	1/100	1/13
75+	1/15	0.50	1/50	1/9

I now turn to the implications of the vaccine.[4] All vaccines have some adverse side-effects for some recipients, which could include death.[5] A rational person will therefore weigh these risks plus the risk of death from covid-19 if vaccinated (because the vaccine does not guarantee protection against covid-19) against the risk of death from covid-19 if unvaccinated (which will be higher than if vaccinated). Let P_S be the probability of the vaccine causing death (or its equivalent in terms of side effects), P_{IV} be the probability of being infected with covid-19 if vaccinated, P_{IU} be the probability of being infected with covid-19 if unvaccinated, IFR_V the Infection Fatality Rate if vaccinated, IFR_U the Infection Fatality Rate if unvaccinated, and R the reduction in the probability of an infected person dying from covid-19 if vaccinated (the "effectiveness" of the vaccine against death given infection). A rational person then compares the following probabilities of death:

From vaccination: $P_S + P_{IV}IFR_V = P_S + P_{IV}IFR_U(1 - R)$

From not vaccinated: $P_{IU}IFR_U$

This is equivalent to the following comparison:

From vaccination: P_S

From not vaccinated: $IFR_U[P_{IU} - P_{IV}(1 - R)]$

The last expression is the increased risk of death from covid-19 from being unvaccinated, allowing for both the risk of being infected and the risk of dying if infected. As shown there, this increased risk from not being vaccinated depends upon the values for P_{IU} and P_{IV}, which must be estimated. These depend upon the vaccination rate (they decline as the vaccination rate increases, because the vaccine could be expected to reduce transmission of the virus). I adopt a vaccination rate of 90% of the 12+ group, consistent with the situation achieved in late

[4] Since vaccine effectiveness declined significantly after six months, boosters were required to maintain their effectiveness (Nordstrom et al, 2021) and I assume this was done.

[5] As noted by the NZ Royal Commission (2024, section 7.3.1.3): "..vaccines (like most medicines) are not entirely without risks. Where a vaccine has been used for many years, these risks are usually well understood. But covid-19 vaccines were very new at the point they were rolled out..".

2021 (NZ Royal Commission, Figure 1, page 333), and therefore assume each individual accurately forecasted this vaccination rate, and acted as described above.[6]

In September 2021 Steyn et al (2021b, Table 3) estimated the number of covid-19 infections in New Zealand within one year at 972,000 if 90% vaccination of the 12+ group were achieved (which it was) and minimal other measures to contain the virus were adopted (test, trace, isolate and quarantine). With a population for New Zealand of 5 million, this implies a population-wide infection rate of 19.4%. With 84% of the population in the 12+ group, vaccinating 90% of the 12+ group implies vaccinating 76% of the entire population. i.e., 0.84*0.90 = 0.76.[7] Thus, the values for P_{IU} and P_{IV} must satisfy

$$0.76P_{IV} + 0.24P_{IU} = 0.194$$

In addition, Steyn et al (2021b, Table 1) estimated the effectiveness of the vaccine against infection at 70%. It follows that $P_{IV} = 0.3P_{IU}$. Substitution of this into the last equation and solving yields $P_{IU} = 0.41$, and therefore $P_{IV} = 0.12$. Steyn et al (2021b, Table 1) also estimated R (the reduction in the probability of an infected person dying from covid-19 if vaccinated) at 0.80.

Substituting these estimates for P_{IU}, P_{IV}, and R into the vaccination comparison above, the increased risk of death from covid-19 from being unvaccinated is 39% of the Infection Fatality Rate for an unvaccinated person, as follows:

$$IFR_U[P_{IU} - P_{IV}(1 - R)] = IFR_U[0.41 - 0.12(1 - 0.8)] = 0.39IFR_U \qquad (4)$$

Applying this coefficient of 0.39 to the IFR_U values in the last two columns of Table 1 yields the results shown in Table 2. The increased risk of death from covid-19 from being unvaccinated for a healthy 0-9 year old (1/630,000) is extremely low and rises significantly with age and adverse health, to 1/120 for a healthy 75+ year old and 1/22 for an unhealthy 75+

[6] This is a simplifying assumption. A more sophisticated approach would be to assume that all individuals act in accordance with the actual evolution in the vaccination rate and their perceptions of how other individuals will behave, which introduces complex game-theoretic considerations (such as in Chen and Toxvaerd, 2014).

[7] For the proportion of the population in the 12+ group, see https://www.statista.com/statistics/436395/age-structure-in-new-zealand/).

year old. To put these increased risks from covid-19 in context, the annual road death toll in New Zealand is about 300, which is a risk of 1/17,000, which is approximately the risk in Table 2 for a healthy person of age 30.

Table 2: Increased Risk of Death from Covid-19 due to being Unvaccinated

	Healthy	Not Healthy
0-9	1/630,000	1/2,300
10-19	1/120,000	1/440
20-29	1/31,000	1/120
30-39	1/10,000	1/380
40-49	1/4,000	1/300
50-59	1/1,000	1/130
60-69	1/380	1/50
70-74	1/250	1/34
75+	1/120	1/22

A rational person will compare this increased risk of covid-19 from being unvaccinated with the risk from the vaccine. In respect of the vaccine risks, there were two primary classes of evidence available by the end of 2021 from New Zealand government entities or sources relied upon by the New Zealand government. The first was the randomised, double-blinded, placebo-controlled studies conducted by Pfizer and the FDA in support of Pfizer's application for government approval of the vaccine.[8] The first of these studies involved 44,000 adults (aged 16+), of which half were (randomly) assigned the vaccine and half a placebo (Pollack et al, 2020). Over the two-month period following the administering of the vaccine or placebo, Covid-19 was diagnosed in considerably more cases in the placebo group than the vaccinated group (162 to 8), yielding a vaccine efficacy (reduction in risk of covid) of 95%, with a 95% confidence interval of 90% to 98% (ibid, Table 2). Furthermore, the only subsequent deaths in either group (six participants) were judged to be unrelated to Covid-19, the vaccine, or the placebo (and details were provided). So, the death rate from the vaccine implied by this sample

[8] The Pfizer vaccine was the principal vaccine administered in New Zealand (NZ Royal Commission, 2024, section 7.2.5), and the government relied upon these studies in adopting this vaccine.

pair (the difference in the death rates) is zero. However this does not provide assurance that the vaccine is safe, even within the two-month period examined here. As with the efficacy, it is essential to determine the confidence interval. At the usual 95% level, with one "death" and one "no death" added to each sample group (see Agresti and Caffo, 2000):[9]

$$(1-1) \pm 1.96\sqrt{2\left(\frac{1}{22{,}002}\right)\left(\frac{22{,}001}{22{,}002}\right)\left(\frac{1}{22{,}002}\right)} = 0 \pm \frac{1}{7{,}940}$$

At the upper limit of this confidence interval, with a vaccine risk of 1/7,940, Table 2 shows that this exceeded the increased risk of not being vaccinated for all healthy people under the age of 37.[10]

In subsequent analysis of the same participants over the longer period of six months, the FDA (2021, pages 18 and 23) reported 21 deaths in the vaccinated group and 17 in the placebo group, and judged that none of the deaths were due to vaccination. If the latter were true, the result would again be no deaths in either group and therefore the analysis and conclusion in the previous paragraph would also apply here. However, in the absence of details about the deaths, one might take the view that the use of a placebo group deals with the issue of deaths from extraneous causes, and therefore the raw difference in the two groups provides the estimated death rate from the vaccine, of 4/22,000, i.e., 1/5,500. Table 2 reveals that this exceeds the increased risk of not being vaccinated for all healthy people under the age of 40. Furthermore, the 95% confidence interval calculated as before (Agresti and Caffo, 2000) is:

$$\frac{1}{5{,}500} \pm 1.96\sqrt{\frac{\left(\frac{22}{22{,}002}\right)\left(\frac{21{,}980}{22{,}002}\right) + \left(\frac{18}{22{,}002}\right)\left(\frac{21{,}984}{22{,}002}\right)}{22{,}002}} = \frac{1}{5{,}500} \pm \frac{3.1}{5{,}500}$$

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[9] Adding one "death" and one "no death" to each sample improves the estimator, particularly in the case of no deaths in the two groups (as in this case) because otherwise the estimated standard error would be zero, which is nonsensical.

[10] The wide confidence interval on the death rate is a consequence of the insufficiently large sample size (22,000 in each group). The sample size was presumably chosen to generate a sufficiently narrow confidence interval on the efficacy, and this was achieved with a 95% confidence interval of 90% to 97% (Pollack et al, 2021, Table 2), but a sample size sufficient for this purpose was insufficient to generate a narrow confidence interval on the death rate.

At the upper limit of this confidence interval, with a vaccine risk of 1/1,341, Table 2 shows that this exceeds the increased risk of not being vaccinated for all healthy people under the age of 54.

Pollack et al (2020) also reported four cases with serious side effects, all of them in the vaccinated group. This is a rate of 1/5,500. Standard cost-benefit analysis for health issues involves discounts to Quality Adjusted Life Years (QALYs) for imperfect health status. Beaudet et al (2014, Table 3) estimates quality of life discounts for various medical events, none of which appear in Pollack's set. Using an average discount of 10% over the conditions reported by Pollack, the 1/5,500 risk of such conditions arising from the vaccine is equivalent to a risk of death of 1/55,000. Adding this to the probability of death from the vaccine (above) does not materially change the results.

A subsequent Pfizer study on 12-15 year olds involved 1,130 participants in each of the vaccine and placebo groups. There were significantly more Covid-19 cases found in the placebo group than the vaccine group (16 vs 0), implying a vaccine efficacy of 100%, and no serious adverse effects related to the vaccine were detected (Frenck et al, 2021). Adding this data to the Pollack data, to form sample pairs covering the 12+ age group does not materially change the conclusions above.

The second primary source of evidence on vaccine risks was reports after administration of the vaccine commenced. Within New Zealand, reports of this type come from Medsafe (the New Zealand Medicines and Medical Devices Safety Authority, which is a government entity), and sourced from CARM (Centre for Adverse Reactions Monitoring). These reports involve much larger numbers of subjects than Pfizer's study, but lacked the latter's statistical controls, especially the lack of a control group given only a placebo. So, many of the phenomena reported may have happened even if the vaccine had not been administered. This imparts an upward bias to the reported rate. However, they also rely upon those vaccinated and the health sector workers that they encounter to report all adverse effects, which risks significant underreporting, and Medsafe (2001) has estimated that only about 5% of adverse reactions are reported. So, there are both upward and downward biases. This severely degrades the quality of these reports.

In respect of deaths, the December 2021 report from Medsafe (2021) recorded 127 potentially suspicious deaths following the vaccine, of which one was considered to be likely due to the vaccine, 14 were still under investigation, 55 were judged unlikely to be due to the vaccine, and 57 could not be assessed due to insufficient information. Since 3.8 million people had been vaccinated up to this date (Medsafe, 2021), the one victim confirmed to that date would imply a fatality rate of 1/3,800,000.[11] However, if all of the 14 cases still under investigation and all of the 57 cases whose cause could not be assessed were also due to the vaccine, the fatality rate would be 1/53,000. Thus, relying on this CARM information alone, the most one could conclude is that the fatality rate from the vaccine was somewhere between 1/53,000 and 1/3.8m. By reference to Table 2, the upper bound of 1/53,000 implies that the vaccine was riskier than covid for healthy people under 23.[12]

Medsafe (2021) also reported the age distribution of these 127 suspicious cases, as shown in the first two columns of Table 3, with their percentages in the next column. If none of the suspicious deaths were vaccine-related, one would expect them to be similar in their age distribution to all deaths in the population of vaccinated people (shown in the fourth column of the table).[13] This is clearly not the case. Alternatively, if the suspicious deaths were all due to the vaccine, one would expect them to be similar in their age distribution to that of the vaccinated population (shown in the fifth column of the table, and reported by Medsafe, 2021). Again, this is clearly not the case. Alternatively, some proportion could be natural deaths (and therefore accord with the fourth column) and the rest due to the vaccine (and therefore accord with the fifth column). Using proportions of 80% and 20% respectively provides the best fit

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[11] As noted in the previous section, 76% of the entire population were vaccinated by December 2021, being 90% of the 12+ age group, and 76% of New Zealand's population of 5m at that time is 3.8m.

[12] One year later, the number of cases considered to be caused by the vaccine had grown to 4 whilst the cases still under investigation and unable to be assessed due to insufficient information had fallen to 17 (Medsafe, 2022). So the maximum number of deaths that could be due to the vaccine was now only 21, which is a maximum fatality rate of 1/181,000. However, this information was not available in late 2021 when individuals had to make a vaccination decision.

[13] Medsafe (2021) reports the numbers vaccinated in these age groups. The total population in these age groups is drawn from column K of Table 3 of "National Population Estimates: 30 June 2023", https://www.stats.govt.nz/information-releases/national-population-estimates-at-30-june-2023/. Dividing vaccinated numbers in each age group by total population yields vaccination rates of 90 – 94% in each group, which are very similar. So the age distribution of deaths for vaccinated people would be very similar to the age distribution of deaths for all people. The former can then be estimated by the latter, and the latter is drawn from column E of Table 6 of "Births and Deaths: Year Ended December 2021", https://www.stats.govt.nz/information-releases/births-and-deaths-year-ended-december-2021-including-abridged-period-life-table/.

to the data in column 2, which implies that 127*0.2 = 25 of the suspicious cases were vaccine induced.[14] Relative to the 3.8m people vaccinated, this is a risk of 1/152,000.

Table 3: Suspect Vaccine Deaths

Age	Suspect Cases		Deaths	Population	80/20 Mix
10-29	7	5%	2%	28%	8%
30-59	24	19%	11%	46%	18%
60-79	57	45%	35%	21%	32%
80+	39	31%	52%	5%	42%

Medsafe (2021) also compared actual deaths amongst the vaccinated within 21 days of a dose with the expected number of deaths over the same period, with the latter based upon data from 2009-2018 (the "natural death rate"), and finds that actual deaths are much lower (900 versus 1,900 for dose 1). Prima facie, this suggests that the vaccine is not causing deaths. However, the fact that the actual deaths are *below* rather than equal to the expected deaths (and markedly below) reveals that the prediction model is very poor, and therefore the vaccine could be causing a moderate number of deaths that are masked by the inadequacy of the prediction model. For example, if the vaccine had even caused 100 deaths, this would be drowned out by the difference between the actual and expected deaths (900 versus 1,900).

Medsafe (2021) also reported 1,651 "serious adverse events" following vaccination that are *suspected* to be due to the vaccine, up till 4 December 2021, none of which involved death. These include strokes, heart attacks and facial paralysis. Across the 3.8m people vaccinated up until this point, the rate is 1/2,300. As noted earlier, standard cost-benefit analysis for health issues involves discounts to Quality Adjusted Life Years (QALYs) for imperfect health status. Beaudet et al (2014, Table 3) estimates quality of life discounts for various medical events, of which heart attacks and strokes appear in the Medsafe list, with discounts of 11% and 16% respectively. Using an average discount of 10% over the conditions reported by Medsafe, the 1/2,300 risk of such conditions arising from the vaccine is equivalent to a risk of

[14] Using a Chi-Squared test (Mood et al, section 5.2), the resulting chi-squared values for the three hypotheses are 30, 306, and 11.3 respectively, with p values of 0, 0, and 0.01 respectively. So, even the third hypothesis has a low p value, but it is a much better fit to the data than the other two.

death of 1/23,000. Table 2 reveals that this risk in isolation would exceed the increased risk from covid-19 from being unvaccinated for any healthy person under the age of 29 so long as the vaccine risks for such people are the same as for the population as a whole. The net effect of underreporting and events not due to the vaccine is unknown but the scale of the underreporting is so large that it suggests the net effect is downward. If this warrants a tripling in the reported number, from 1,651 to 5,000, the resulting rate over the 3.8m people vaccinated is 1/760, which is equivalent to a risk of death of 1/7,600. Table 2 reveals that this risk would exceed the increased risk from covid-19 from being unvaccinated for any healthy person under the age of 37. Adding deaths (the one reported or the 25 or 72 suspected above) does not materially change this result.

Medsafe (2021) does not provide any information on the age and health distribution of this set of serious adverse events, but it does provide the age distribution of the entire set of reported side effects. These are distributed broadly across age groups with a median age of 39, which is similar to the general population. This reveals that side-effects are not significantly age related, and the same may then be true of "serious adverse effects".

All of these conclusions are based on Table 2, which in turn is derived from Table 1 and a vaccination rate of 90% for the 12+ group. As this rate increases, the risks of covid for the unvaccinated fall and therefore tilts their decision towards not vaccinating. For example, suppose the risk of death from the vaccine is 1/10,000. With a vaccination rate for the 12+ group of 90%, Table 2 shows that vaccination would not be optimal for healthy people under 35. If the analysis underlying equation (4) were redone with a 70% vaccination rate, Table 2 would then be redone and vaccination would not be optimal for healthy people under age 30. If the analysis were redone with a 95% vaccination rate, vaccination would not be optimal for healthy people under 40. So, as the vaccination rate rises, the set of people for whom vaccination is not optimal grows. This is 'free-riding' but it is still rational to act in this way.

The analysis conducted here relies upon the age-specific IFR's in Verity et al (2020, Table 1), which were derived from only one country (China) in early 2020, and used by Steyn et al (2021a, 2021b). Coupling these with the matching group population proportions for New Zealand (Steyn et al, 2021a, page 14) implies an overall IFR for New Zealand of 0.94%. By comparison, in a widely cited survey of empirical estimates from many countries as at January 2021, Sorensen et al (2022, Table 2) estimated the population-wide IFR for New Zealand at

0.79%. This suggests that Steyn et al's age-specific IFRs in the second column of Table 1 should be reduced by 16%. This would only slightly increase the set of people for whom it was not rational to vaccinate.

In conclusion, the information available at the end of 2021 from Pfizer and the FDA was very unsatisfactory due to the sample sizes, and that from Medsafe was also unsatisfactory due both to the lack of a placebo control group and to massive underreporting. This information suggests that the increased risk of covid-19 from being unvaccinated significantly exceeded the vaccine risks for unhealthy people at any age and also healthy people over about age 50. In addition, the increased risk of covid-19 from being unvaccinated for healthy people under about age 30 was so low that it was even less than the (low) risk from the vaccine. For healthy people in the 30-50 age range, the situation was unclear. Furthermore, the Pfizer study only reported results within a two-month period following administration of the vaccine or the placebo, the FDA study did so for only six months, and the self-reporting in Medsafe's process would be unlikely to reveal adverse results arising beyond a few months after vaccination. So, none of these data sources provided any information on medium or longer-term adverse effects. In view of all this, opposition to vaccination in 2021 by many people was entirely rational. In addition, a person might rationally have opposed vaccination if they had a history of severe adverse reactions to vaccines or a medical condition that might be aggravated by a vaccine, and exemptions for this were only rarely granted (NZ Royal Commission, 2024, section 8.5.2.2).

3. Social Cost-Benefit Analysis of the Vaccine Mandates in New Zealand

The previous section demonstrates that many people might rationally have objected to being vaccinated (arising from the risks of the vaccine), based upon information available by late 2021. I therefore undertake a social cost-benefit analysis on the merits of the vaccine mandates introduced in New Zealand in 2021. These mandates took three different forms, as detailed in the NZ Royal Commission (2025, section 8.4). The first type required certain occupational groups to be vaccinated as a condition of (continued) employment. These commenced with border workers in May – July 2021 (revoked in July 2022), followed by education, prison, and health workers in November 2021 (revoked in April, July, and September 2022 respectively), and finally Police and Defence staff in December 2021 (revoked in April 2022). The second type facilitated other employers adopting such policies (introduced in December 2021 and revoked May 2022), and many then did so, sometimes in order to minimise their legal risk (NZ

Royal Commission, 2024, page 415) and sometimes in response to demands from some of their staff (ibid, page 425). The third type involved providing proof of vaccination ("vaccine passes") in order to attend certain gatherings (such as concerts or sports events) or venues such as hairdressers and cafes (introduced in December 2021 and revoked April 2022). In addition, most New Zealand universities imposed vaccine requirements on staff and students (introduced at the beginning of 2022 and revoked a few months later), presumably prompted by the government's actions. Finally, many vaccinated people engaged in informal coercive actions, such as severing personal interactions with unvaccinated people including family members (NZ Royal Commission, 2024, section 8.5.2.3), presumably prompted or heightened by the government's actions. These actions by the government were unprecedented; prior to covid-19, vaccines had never been mandated in New Zealand for any contagious disease (BPAC, 2012, page 5).

I start with the costs of mandating. As noted earlier, standard cost-benefit analysis for health policy involves discounts to Quality Adjusted Life Years (QALYs) for imperfect health status. For example, a person suffering from type 2 diabetes without complications warrants a discount of about 20% per year of their remaining life (Beaudet et al, 2014, Table 3). The same principle applies to a vaccine mandate, i.e., it reduces the quality of life of those objecting to being vaccinated. The adverse effects of the mandating policy on those objecting were diverse. If the objector refused to vaccinate, they may have lost their job with its financial and psychological consequences, been denied entry to a university with its educational and future employment consequences, have lost valued social interactions with vaccinated people including family members ("socially marginalised"), denied various commercial services (haircuts, cafes, events, etc), and been stigmatised as an "anti-vaxxer" or a "conspiracy theorist" (Dewar et al, 2025; NZ Royal Commission, 2024, section 8.5.2.3; Bardosh et al, 2024, page 134). Alternatively, having acceded to being vaccinated because of the penalties, the objector would then have been subject to what they could reasonably believe to be the risk of vaccine side-effects that exceeded the reduction in their risk of dying from covid-19, possible anxiety over these future risks, and possible anxiety over the possibility that the vaccine caused a health condition that they experienced at some point after being vaccinated. In both cases, objectors may have experienced a strong sense of being unjustly treated, a loss of trust in government institutions and a reduced inclination to accept other types of vaccines (NZ Royal Commission, 2024, section 8.5.2.3; Dewar et al, 2024; Bardosh, 2024, page 134).

Many of these disadvantages would have remained well after the mandates were revoked (Dewar et al, 2025; NZ Royal Commission, section 8.5.2.3). Some of those who lost their jobs and reapplied for them after the mandates were removed were not successful. Others would have been sufficiently aggrieved at their treatment that they did not even seek to reapply. Those who were socially excluded may have felt sufficiently aggrieved that the disrupted relationships were never resumed. Amongst those who reluctantly acceded to the vaccine, the risks and anxiety over them would have remained. For all of these groups, the termination of the mandates within months of being imposed (due to the vaccine's limited ability to prevent transmission of the omicron variant that arrived shortly after most of the mandates were imposed) may have reinforced the sense of injustice.

For purposes of quantifying such effects, I invoke the WELLBY framework, which attempts to add quality of life factors such as mental health and the state of the environment to standard cost-benefit analysis.[15] Within this framework, and using a 0 – 10 scale of happiness, Frijters (2021, page 53) estimated normal life at 6, the loss of employment as a reduction of 0.7, and forced social distancing and lockdowns of the UK type as a loss of 0.5. Since a year of life in good health is one QALY, the loss of employment for one year would be equivalent to the loss of 0.7/6 = 0.12 QALYs and forced social distancing for one year would be equivalent to the loss of 0.5/6 = 0.08 QALYs. Consequently, a conservative estimate of the average adverse impacts described above for vaccine objectors would be the loss of 0.04 QALYs per annum for 2.5 years, i.e., an average loss of 0.1 QALYs per vaccine objector.

Turning now to the benefits from a mandating policy, these were primarily in the form of fewer deaths due to a higher vaccination rate (comprising the direct benefits in reducing the death rate amongst the additional people vaccinated and the indirect benefits in reducing their risk of infecting others, which lowers the death rate in the others). The avoided deaths here involved people likely to have low residual life expectancies and health problems that would have lowered their quality of life had they not died from covid-19. Lally (2021, section 2.2) estimated the average residual life expectancy of the covid-19 victims (had they not died from covid-19) as five years for European countries and the discount for health problems during this five-year period at 20% per year. Letting D denote the number of deaths avoided by the

[15] This framework has been adopted by the New Zealand Treasury: see https://www.treasury.govt.nz/publications/treasurys-stewardship-reports/wellbeing-reports.

mandates, the QALYs gained from adopting a mandating policy would then be D*5*0.8, i.e., $4D$. There will also be QALY gains from reducing the number of 'long covid' cases amongst the vaccinated, i.e., vaccinated people who survived the infection but suffered significant symptoms for a protracted period. Lally (2021, pp. 17-18) estimated that this contributed an additional 4% to the QALY gains. So, the QALY gains from the mandates were $4.16D$.

The vaccine mandates were applied to the 12+ age group in New Zealand, who constituted 84% of its 2021 population (of 5 million), and therefore 4.2m people.[16] Letting V denote the vaccination rate that would have been achieved without the mandates (the "voluntary vaccination rate"), the number of vaccine objectors would then be $4.2m(1 - V)$, and therefore the cost of the mandates would be $4.2m(1 - V)0.1$. The cost-to-benefit ratio from the mandates is then

$$\frac{C}{B} = \frac{4.2m(1 - V)0.1}{4.16D} \tag{5}$$

The actual vaccination rate achieved was about 90% (NZ Royal Commission, 2025, Figure 1, page 333). In addition, Steyn et al (2021b, Table 3) forecasted the deaths from covid-19 in New Zealand within one year for various vaccination rates from 70% to 95% of the 12+ group (in 5% increments), assuming minimal other measures to contain the virus being adopted (including limited TTIQ: test, trace, isolate and quarantine). So, V must be less than 90% and therefore values of V from 70% to 85% are considered. Table 4 shows the results. For example, Steyn et al (2021b, Table 3) estimated the deaths within one year as 15,542 with a vaccination rate of 70%, falling to 3,539 with a vaccination rate of 90%. If $V = 0.7$, the mandates would have raised the vaccination rate from that figure of 70% to the observed maximum rate of 90%, and therefore the number of lives saved by the mandates (D) would have been 15,542 – 3,539 = 12,003. Substitution into equation (5) yields a cost-to-benefit ratio for the mandates of

$$\frac{C}{B} = \frac{4.2m(1 - 0.7)0.1}{4.16(12{,}003)} = \frac{126{,}000}{50{,}000} = 2.5$$

The (very conservatively) estimated costs are therefore 2.5 times the benefits. These figures are shown in the first row of Table 4. As V rises from 70% to 85%, Table 4 shows that the

[16] See https://www.statista.com/statistics/436395/age-structure-in-new-zealand/.

benefits fall more rapidly than the costs, leading to higher cost-to-benefit ratios. The most important results in this table are in the last two rows, where the costs are at least 3.8 times the benefits, because the vaccination rate was already 80% when the principal mandates took effect in November 2021 (NZ Royal Commission, Figure 1, page 333) and this implies that the voluntary vaccination rate was at least 80%. In all cases in Table 4, and especially the last two rows, the costs of the mandates exceeded their benefits and therefore the mandates were not warranted. A major factor in this result was that the voluntary vaccination rate was at least 80%, leaving only 10% at most resulting from the mandates.[17]

These results assume very limited measures other than vaccination to contain the virus. More extensive such measures, such as additional testing, tracing, isolating and quarantining, would have reduced covid-19 deaths, but the difference in the estimated covid deaths is approximately the same, and therefore so too is the benefit from the vaccine mandates. In addition, the costs of mandating would be unchanged. So, mandating would still have been unjustified. For example, with stricter such measures, Steyn et al (2021b, Table 4) forecasted the deaths under 70% and 90% vaccination rates for the 12+ group at 13,271 and 1,157 respectively. So, at a voluntary vaccination rate of 70% rising to 90% with mandating, the avoided deaths amongst the vaccinated group would have been 12,114 compared to 12,003 in Table 4. So, the costs of the mandates would still be about 2.5 times the benefits.

Table 4: Cost-to-Benefit Ratios of Vaccine Mandates

V	QALY Benefits	QALY Costs	*C/B*
70%	(15,542 – 3,539)4.16 = 50,000	0.1(1 - .7)4.2m = 126,000	2.5
75%	(12,088 – 3,539)4.16 = 36,000	0.1(1 - .75)4.2m = 105,000	2.9
80%	(8,886 – 3,539)4.16 = 22,000	0.1(1 - .8)4.2m = 84,000	3.8
85%	(6,008 – 3,539)4.16 = 10,000	0.1(1 - .85)4.2m = 63,000	6.3

The analysis conducted above uses forecasts of covid deaths for various vaccination rates from Steyn et al (2021b), which relies inter alia upon the age-specific IFR's in Verity et al (2020,

[17] This increase in the vaccination rate as a result of the mandates (of up to 10%) is consistent with international evidence (Drew, 2022).

Table 1), and which were derived from only one country (China) in early 2020. Coupling these with the matching group population proportions for New Zealand (Steyn et al, 2021a, page 14) implies an overall IFR for New Zealand of 0.94%. By comparison, in a survey of empirical estimates from many countries at the more relevant time of January 2021, Sorensen et al (2022, Table 2) estimated the population-wide IFR for New Zealand at 0.79%. This suggests that Steyn et al's age-specific IFRs in the second column of Table 1 should be reduced by 16%. Doing so would reduce Steyn et al's estimated deaths in Table 3 by 16%, and do likewise to the QALY benefits whilst not affecting the QALY costs. So, mandating would have been even less justified. In particular, the cost-to-benefit ratios of the mandates in Table 4 would have all been at least three, and those in the critical last two rows would be at least 4.5.

By contrast with the forecasts of covid deaths for various vaccination rates used above, and drawn from Steyn et al (2021b), Datta et al (2024, Table 1) estimated ex-post that the vaccines saved 6,650 lives over the period January 2022-June 2023.[18] Furthermore, Datta et al estimated that a reduction in the vaccination rate of 10% would have raised deaths by 3,788 – 3,163 = 625 (ibid, Table 1). This figure can be applied to a reduction in the vaccination rate from 90% to 80%, interpolated to reductions within that band, and extrapolated to reductions moderately in excess of 10%. The results appear in Table 5, differing from Table 4 only in substitution of the Datta et al (2024, Table 1) estimates for the Steyn et al (2021b, Table 3) forecasts. For example, if the voluntary vaccination rate was $V = 80\%$, the effect of the mandates would have been to raise the rate to 90%, thereby saving 625 lives.[19] With 4.16 QALYs per life saved, the benefits would have been 2,600 QALYs. The cost is 84,000 QALYs, from Table 4. The costs are then 32 times the benefits. For Table 5 in toto, the costs of the mandates were at least 24 times that of the benefits, and at least 32 times in the more significant last two rows. So, the vaccine mandates were not only unwarranted on the basis of forecasts in late 2021 but even

[18] The latter research was funded by the Ministry of Health and Michael Plank is a common author in the two papers.

[19] By contrast with this figure of 625 deaths, Steyn et al (2021b, Table 3) forecasted the lives that would be saved by raising the vaccination rate from 80% to 90% at 8,886 – 3,539 = 5,347, as shown in the third row of Table 4 above. So, Steyn et al's forecasts were nine times that of the ex-post estimates of Datta et al (2024). One source of this error is that the forecasts were based on the prevailing delta version of covid-19 rather than the less serious omicron version that arrived within months. Another factor would have been IFR estimates that were based on the contemporaneous definition of a covid-19 death as any death within 28 days of being reported as a case. The Ministry of Health reports 7018 such deaths, whereas deaths in which covid-19 was judged to be the underlying cause are about 60% less, at only 2981: see https://www.tewhatuora.govt.nz/for-health-professionals/data-and-statistics/covid-19-data/covid-19-case-demographics#details-of-covid-19-deaths. Datta et al's (2024, Table 1) estimate of 3,163 covid deaths at the vaccination rate of 90% that was achieved accords with the Ministry's latter definition of a covid death.

more so on the basis of subsequent information. The cost-to-benefit ratios in Table 5 are so large that even reducing the QALY cost of 0.1 per vaccine objector to 0.005 would still leave costs in excess of benefits.

This analysis ignores the impact on health care available to New Zealanders as a result of dismissing health care workers who refused to vaccinate. The extra deaths of patients resulting from the loss of these staff would reduce the number of lives saved from imposing the mandates for health workers, thereby reducing the benefits of the mandates shown in Table 4 and Table 5. This reinforces the conclusion that the mandates were unjustified.

Table 5: Cost-to-Benefit Ratios of Vaccine Mandates

V	QALY Benefits	QALY Costs	C/B
70%	1250*4.16 = 5,200	0.1(1 - 0.7)4.2m = 126,000	24
75%	937*4.16 = 3,900	0.1(1 - 0.75)4.2m = 105,000	27
80%	625*4.16 = 2,600	0.1(1 - 0.8)4.2m = 84,000	32
85%	312*4.16 = 1,300	0.1(1 - 0.85)4.2m = 63,000	48

This analysis also ignores the costs of adverse vaccine events amongst those coerced into vaccinating. For example, suppose V = 0.8 and therefore the mandates coerced 420,000 vaccine objectors to vaccinate (90% rate achieved less 80% if no mandates, applied to the 4.2m in the 12+ group). Also, suppose that the risk of death (or its equivalent in non-fatal effects) from the vaccine was as much as 1/5,000, which is not inconsistent with the analysis in the previous section. Allowing an average of about 40 years of residual life expectancy per vaccine fatality (because they would be of average age and good health), the QALY loss here from the mandates would be 420,000*(1/5,000)*40 = 3,400 QALYS, which exceeds the benefits of vaccination in the third row of Table 5. However, if the vaccine fatality rate was only 1/50,000 (which is also not inconsistent with the analysis in the previous section), the QALY loss would instead be 420,000*(1/50,000)*40 = 340, which is far less than the benefits in the third row of Table 5. Since these vaccine risks seem so unclear, I do not include these costs in the analysis. Any allowance for them would reinforce the conclusion that the mandates were unwarranted.

The conclusion here that the government's decision was unjustified is unsurprising because there does not seem to have been any quantitative analysis of this matter by government (NZ Royal Commission, 2024, page 402). The Commission (ibid, page 403) states that "the decision to require vaccination involved a careful weighing up of people's right to refuse medical treatment against the benefits decision makers believed would result from making vaccination mandatory." However, the Commission immediately contradicts this by stating that "This is a judgement call." A judgement call is a non-quantitative process, and it does not constitute a careful weighting up of costs and benefits when quantitative analysis is possible, as shown here.

In summary, using estimates of the costs and benefits of the vaccine mandates, the estimated costs exceed the estimated benefits by at least 32 times and therefore the mandates were not warranted. The fact that the costs are very conservatively estimated and benefits likely to be overestimated reinforces this conclusion. A significant factor in this conclusion is that the voluntary vaccination rate was at least 80%, with the result that the mandates could not have raised the vaccination rate by any more than 10%.

4. The Case for Mandating Vaccination for Health Workers and Education Workers

The analysis in the preceding section relates to the general adult population. I now consider whether mandates were warranted for only health workers and education workers in late 2021. I start with health workers. As described in the previous section, from November 2021 – September 2022, vaccination against covid was a condition of employment for workers in the health sector. In this sector, there were about 213,000 staff in 2021 (Ministry of Health, 2020, page 1). The cost-benefit analysis for them differs from that of the general adult population because they came into frequent and close contact with large numbers of sick people, which raised their risk (if they were infected) of infecting people who were at high risk from covid-19, and also raised their risk of becoming infected. Consequently, the failure of such people to get vaccinated would have caused more deaths than would be the case for a similar sized group from the rest of the adult population.

Let W denote the voluntary vaccination rate of health workers, D the lives saved by mandating vaccination for health workers, and L the average QALY losses per health worker opposed to vaccination if mandating were imposed. Following equation (5), the cost to benefit ratio from mandating the vaccine for health workers is:

$$\frac{C}{B} = \frac{213{,}000(1 - W)L}{4.16D} \tag{6}$$

One would expect the rate of voluntary vaccination amongst health workers (W) to be much higher than the voluntary rate in the rest of the population (V) because patient safety is fundamental to the jobs of health workers and they are accustomed to being directed by their employers on patient safety-related matters. Consistent with this, Dewar et al (2024, Figure 1) concluded that the lower bound is 90%, corresponding to the rate observed at the time the mandates for health workers were announced, whilst the upper bound is the 95% rate actually achieved after the imposition of the mandates. So the mandate for health workers could only have raised the vaccination rate by 5% at most, from 90% to 95%.

Datta et al (2024, Table 1) estimated that raising the vaccination rate for the adult population from zero to the rate actually attained saved 6,650 lives over the period January 2022-June 2023, and that the last 10% of that increase saved 625 lives. For health workers, the rate actually achieved was about 95% and the lower bound on the voluntary rate was about 90% (Dewar et al, 2024, Figure 1), with corresponding figures for the rest of the adult population of about 90% and 80% respectively (NZ Royal Commission, 2024, Figure 1, page 333). Suppose the voluntary vaccination rates achieved were V = 80% (its lower bound) and W = 84%, which would be 8/9th of the rates actually achieved for both health workers and for the rest of the adult population (using the entire set of mandates). At this point, 8/9th of the 6,650 lives saved by vaccination would have been achieved, without any resort to mandates, leaving only 738 lives at most to be saved by mandates. In evaluating the merits of mandating the vaccine just for health workers, it would be most favourable to the case for such mandating to assume that all of those remaining 738 lives were saved as a result of the vaccination rate for health workers rising from 84% to their maximum achieved rate of 95%. As noted above, W is at least 90%. So, raising W from 84% to 90% would have saved 6/11th of the remaining 738 lives, leaving only 335 lives at most to be saved by the vaccine mandate for health workers.

I now consider various possible combinations of V and W, starting with V = 0.8 and W = 0.9. Mandating the vaccine for health workers, thereby raising their vaccination rate to the observed maximum of 95%, would save only 335 lives at most, as concluded above. So, D = 335. Substituting these parameter values into equation (6) along with the earlier (conservative) estimate for L of 0.1 yields:

$$\frac{C}{B} = \frac{213{,}000(1-0.9)0.1}{4.16(335)} = \frac{2{,}130}{1{,}393} = 1.5$$

The costs exceed the benefits, so mandating would not be warranted. This is shown in Table 6. Alternatively, if W (the voluntary rate for health workers) was actually 0.93 rather than 0.90, then only 2/11th of the 738 deaths referred to above (134 deaths) could at most be avoided by mandating the vaccine for health workers and therefore raising their vaccination rate to 95%. So, D = 134 and W = 0.93. Substitution of these parameter values into (6) with L = 0.1 yields a cost-to-benefit ratio of 2.7, as shown in Table 6.

Table 6: Cost-to-Benefit Ratio of Vaccine Mandates for Health Workers

	L = 0.1	L = 0.2
V = 0.8, W = 0.90	1.5	3.0
V = 0.8, W = 0.93	2.7	5.4
V = 0.85, W = 0.90	1.4	2.8
V = 0.85, W = 0.93	2.4	4.8

If V was actually 0.85 rather than 0.80, which is 85/90th of the vaccination rate actually achieved under the general mandates for the adult population sans health workers, a value for W of 0.90 (being its lower bound) would represent the same fraction of the maximum vaccination rate achieved for health workers. At this point, 85/90th of the 6,650 lives saved by vaccination would have been achieved, without any resort to mandates, leaving only 370 lives at most to be saved by mandates. Mandating the vaccine for health workers would then at most save these 370 lives, so D = 370 at most. Substituting W = 0.9, D = 370, and L = 0.1 into equation (6) yields a cost-to-benefit ratio of 1.4. Again, mandating was not warranted. Alternatively, if W was actually 0.93 rather than 0.90, then only 2/5th of the 370 deaths referred to above (being 148 deaths) could at most be eliminated by mandating the vaccine for health workers and therefore raising their vaccination rate to 95%. So, D = 148 and W = 0.93. Substituting these parameter values into (6) with $L = 0.1$ yields a cost-to-benefit ratio of 2.4, as shown in Table 6. In all cases, the mandates for health workers were unwarranted.

These results assume that vaccine mandates for just health workers explain all saving in lives beyond those saved with voluntary vaccination rates, which exaggerates the benefits of the mandates. Despite this, such mandates were still not warranted. These results also assume an average QALY loss per health worker who objected to vaccination (L) equal to the very conservative estimate of 0.1 adopted for the general adult population. The average QALY loss per health workers who objected is likely to be higher than in the general population because concerns amongst health workers on this matter are likely to be more evidence-based (Dewar et al, 2025), and hence more resistant to mandates, and loss of employment from failure to vaccinate would be more serious due to the lack of close employment substitutes. Table 6 therefore shows the results from doubling L to 0.2. This doubles the cost-to-benefit ratio, and therefore reinforces the conclusion that the mandate for health workers was not justified. A significant factor in this conclusion is that voluntary vaccination rates by health workers and the rest of the population were so high that the few lives left to be saved by mandating the vaccine for health workers could not compensate for the QALY losses suffered amongst the much larger number of health workers who objected to vaccination.

As in the previous section, this analysis ignores the impact on health care available to New Zealanders as a result of dismissing health care workers who refused to vaccinate. The extra deaths of patients resulting from the loss of these staff would reduce the number of lives saved from imposing the mandates for health workers, thereby further raising the cost-to-benefit ratios in Table 6. Again, this reinforces the conclusion that the vaccine mandate for health workers was not justified.

The set of workers for whom failure to vaccinate led to loss of their job also includes education workers. Unlike health workers, education workers do not come into frequent and close contact with large numbers of people who are at high risk from covid-19. So, since mandates were not warranted for health workers, they were also unwarranted for education workers.

As with the general mandates, it is unsurprising that the government's imposition of mandates for health and education workers was unjustified because there does not seem to have been any quantitative analysis of this matter by government (NZ Royal Commission, 2024, page 407).

Ironically, the Commission claimed that "there is a clear case for requiring vaccination for workers interacting with medically vulnerable people", but this unequivocal claim is immediately undercut by their statement that "it is not possible to assess how many cases of covid-19 may have been prevented by these requirements" (ibid, page 407). One does not necessarily need to assess how many cases (i.e., deaths) were averted by these requirements. If an upper bound on the number of deaths averted by them leads to the conclusion that the mandates were unjustified, that is sufficient, as shown above.

In summary, unlike the rest of the population, health workers come into frequent and close contact with large numbers of sick people, who are at high risk from covid-19, which raises the possibility that mandating the vaccine for these workers might have been justified. However, even here, the costs of these mandates exceeded the benefits, and therefore they were not justified. Consequently, a vaccine mandate for education workers was even less justified than for health workers, because education workers were even less likely to come into close and frequent contact during their work hours with people at high risk from covid-19.

5. Conclusions

Covid-19 vaccine mandates for the adult population of New Zealand have been extremely controversial. Opponents pointed to the right to choose whether to be vaccinated, and to concerns over the safety of the vaccine. Proponents pointed to the costs that the unvaccinated impose upon the vaccinated, most particularly the increased risk to vaccinated people of death from covid-19. This involves a trade-off between the lives saved from vaccine mandates and the harm they inflict upon those who rationally oppose vaccination. This paper has sought to do so and the conclusions are as follows.

Firstly, opposition to covid-19 vaccines seems rational for young, healthy people. Secondly, even if the adverse impact of mandating on those objecting to vaccination was as small as a reduction in their quality of life of 4% per year for a period of 2.5 years, mandating was not warranted because these costs were at least 32 times the benefits of mandating (in the form of reduced deaths from covid-19 arising from the unvaccinated people who were induced to vaccinate). Thirdly, even in respect of health workers who come into frequent and close contact with large numbers of people who are at high risk from covid-19, the costs of vaccine mandates exceeded the benefits, and therefore they were not justified. Fourthly, vaccine mandates for education workers were even less justified than for health workers, because education workers were even less likely to come into close and frequent contact during their work hours with people at high risk from covid-19. Finally, it is unsurprising that the decisions were unjustified because they do not seem to have been based upon any quantitative cost-benefit analysis.

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