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 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 provides a methodology for doing so. It is then applied to the case of New Zealand. It reveals that even if the adverse impact of penalties on vaccine objectors (at least some of whom may have rational grounds for objecting) is as small as a reduction in their quality of life of 1% per year for a period of five years and the existence of unvaccinated people is entirely responsible for covid-19 infections amongst the vaccinated, the number of additional deaths amongst the vaccinated resulting from not adopting a vaccine mandate is too few to justify a policy of mandating. However, unlike the general population, health workers come into frequent and close contact with large numbers of sick people, who are prime targets for covid-19, and therefore the vaccine mandate *may* be justified for these workers.

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1. Introduction

Vaccine mandates for the general population are proving to be extremely controversial. Opponents point to the right to choose whether to be vaccinated. Proponents point to the costs that the unvaccinated impose upon the vaccinated, in particular the increased risk to vaccinated people of death by covid-19 (because the vaccine is imperfect) and the increased load on the health system from unvaccinated people seeking treatment for covid-19 leading to some (vaccinated) people receiving an inferior level of care for non-covid conditions than they otherwise would and thereby dying earlier than they otherwise would.[1] This is yet another example of the trade-offs we face in life, individually or socially, and is therefore capable of being illuminated (and possibly resolved) by cost-benefit analysis. This paper seeks to do so.

2. Analysis

Let *N* denote the number of people in a country who object to being vaccinated against covid-19. Standard cost-benefit analysis for health issues involves discounts to 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 psychological harm and therefore to vaccine mandates, i.e., it reduces the quality of life of those objecting to being vaccinated. These objectors are on average presumably of about average age and in good health, which implies about 40 years of remaining life. For some of these people, the effects of the penalties for non-vaccination may extend to all of their remaining lives. This might occur because the objector has given up a preferred job rather than being vaccinated. Alternatively, having been vaccinated because of the penalties, the objector may experience ongoing anxiety over the possibility that the vaccine will adversely affect their health at some future point or has caused or contributed to a health condition that they did experience at any point after being vaccinated.[2] The mandating of vaccine boosters would aggravate these effects for objectors who were induced into being vaccinated. For other objectors, the effects of the penalties

[1] The costs that the unvaccinated impose upon themselves (in the form of an increased risk of death from covid-19) are not relevant here, because the unvaccinated have chosen to bear those risks.

[2] For example, see https://www.stuff.co.nz/national/health/coronavirus/126992919/farewell-and-thank-you-health-board-chief-says-goodbye-to-unvaccinated-staff.

would fade quickly. In recognition of the latter group, I (conservatively) adopt a horizon of five years for the quality of life effects of penalties on all objectors. Let *W* denote the annual discount on the quality of life of an objector arising from the penalties. The QALY loss from a mandating policy is then *N**5**W*.

Now consider the costs that the unvaccinated impose on the rest, of the types mentioned above. Let *D* be the estimated additional deaths amongst vaccinated people from the existence of unvaccinated people, if mandating is not adopted compared to being adopted. The deaths here are of people likely to have low residual life expectancies and health problems that would lower their quality of life had they not died from covid-19. Lally (2021, section 2.2) estimates 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. The QALY loss amongst vaccinated people from failure to adopt a mandating policy is then *D**5*0.8, i.e., *D**4. There will also be QALY losses amongst vaccinated people who survive the infection but suffer significant symptoms for a protracted period, but Lally (2021, pp. 17-18) finds that this contributes very little to the QALY losses from deaths.

If mandating is adopted, the *N* people alive today who object to being vaccinated will experience a QALY loss of *N**5**W* whilst the vaccinated avoid a QALY loss of *D**4. So, mandating is warranted only if *D**4 exceeds *N**5**W*.

3. Application to New Zealand

To illustrate this cost-benefit model, I consider the case of New Zealand. Penalties for failure to vaccinate in the form of loss of employment have already been introduced for some categories of workers, and there are plans to apply penalties to the general population over the age of 12.[3] Approximately 84% of the New Zealand population (of 5 million) is in the 12+ group.[4] This constitutes 4.2 million people. As of 15 November 2021, 10% of this group have not yet had a first dose (420,000) and yet have had ample opportunity so far to do so. These people can reasonably be viewed as vaccine objectors. In addition, some of those

[3] See https://covid19.govt.nz/alert-levels-and-updates/covid-19-protection/.

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

vaccinated to date are likely to have done so because of or in anticipation of penalties. So, the set of New Zealanders who object to being vaccinated (*N*) is at least 420,000.

In respect of the annual discount on the quality of life of a person subject to penalties for not being vaccinated (*W*), taking account of the fact that a person suffering from type 2 diabetes warrants a discount of about 20% per year of their remaining life (Beaudet et al, 2014, Table 3), a value for *W* of at least 1% is plausible.

It follows that mandating would only be warranted if *D**4 exceeds 420,000*5*0.01, i.e., *D* exceeds 5,200. This means 5,200 additional deaths amongst vaccinated people (from covid-19 or from other conditions arising from unvaccinated people overloading the health system with covid-19 symptoms), if mandating is not adopted compared to it being adopted. In respect of the health system being overloaded by unvaccinated people with covid-19 symptoms, any society willing to impose significant penalties upon the unvaccinated would presumably be willing to apply a much lower level of hospital care to them should they experience covid-19 symptoms, which would significantly mitigate the health system overload. Overload can also be further mitigated by expanding the capacity of the health system. This suggests that the principal adverse effect of the unvaccinated upon the vaccinated would be the additional deaths amongst the vaccinated arising from being infected with covid-19 because the existence of unvaccinated people (who are likely to increase the spread of the virus). So, vaccine mandating would be warranted only if failure to do so leads to a pool of unvaccinated people who thereby induce at least 5,200 additional deaths from covid-19 amongst the vaccinated.

I now consider whether at least 5,200 additional such deaths amongst the vaccinated could occur. The worst case scenario for the 90% of the over 12s who vaccinate without mandating (4.2m*0.9 = 3.8m) is that they are all infected as a result of the existence of the unvaccinated people who might be induced into vaccinating. In the absence of an effective vaccine, the proportion dying is the Infection Fatality Rate (IFR). Recent surveys suggest figures of 0.3 – 0.4% for Europe and the Americas (Ioannidis, 2021, page 10), and 0.70% for Europe and 0.58% for the Americas (Meyerowitz-Katz and Merone, 2021, Figure 2). The midpoint is about 0.5%, which implies 3.8m*0.005 = 19,000 dead. However, this IFR relates to the entire population rather than only those over 12, and the latter IFR would be higher because the IFR is monotonically increasing with age. Correction for this raises the IFR for the over

12s to about 0.60%.[5] This implies 3.8m*0.006 = 23,000. The vaccines reduce the risk of death by 85% to 88% on average over the first six months but rapidly wanes beyond that point (Nordstrom et al, 2021, Table 2 and Table 5). If a booster is used at that point, the average reduction in the death rate would then be at least 85%. This implies 23,000*(1 – 0.85) = 3,400 deaths amongst the vaccinated.

This is the worst case. It is inconceivable that all of the 3.8m vaccinated would be infected. Amongst those infected, it is inconceivable that all would be infected as a result of the pool of unvaccinated people, i.e., some of the vaccinated would be infected even if there were no unvaccinated people because the vaccine does not eliminate the risk of its recipients transmitting the virus and therefore vaccinated people could be infected by other vaccinated people. In fact, all of the vaccinated might become infected even if the unvaccinated pool did not exist, through the virus transmitting through the vaccinated. Amongst those vaccinated who were infected as a result of the unvaccinated pool, some would be infected as a result of the vaccine objectors who will not succumb to the penalties, and a mandating policy cannot eliminate this group. Taking account of all three of these points, the additional covid-19 deaths amongst the vaccinated in the absence of vaccine mandating would be significantly less than 3,400.

All of this suggests that failure to adopt a mandating policy will *not* lead to at least 5,200 additional deaths from covid-19 amongst the vaccinated. Furthermore the threshold figure of 5,200 presumes that the quality of life impact on the objectors is only 1% per year for five years. If it were 2% per year, the threshold for covid-19 deaths amongst the vaccinated doubles to 10,400. If the unvaccinated pool has little effect on the rate of infection amongst the vaccinated (because they are primarily infected by transmission amongst the vaccinated), the number of additional covid-19 deaths amongst the vaccinated arising from failure to adopt a mandating policy will be close to zero, which further undercuts the merits of a mandating policy.

[5] Steyn et al (2021, page 14) cites age-related IFR data from Verity et al (2020, Table 1) and matches it to the New Zealand population proportions by age groups, which implies an IFR of 0.95%. The same data can be used to estimate the IFR for the 12+ group, at 1.13%. Both figures are unreliable because they are based upon IFR data from March 2020 from only one paper (Verity et al, 2020) rather than from recent surveys of the literature (as with Ioannidis, 2021 and Meyerowitz-Katz and Merone, 2021). However, the increase of 19% (0.95% to 1.13%) can be applied to the preferred IFR estimate for the entire population of 0.5%, to yield 0.6% for the 12+ group.

4. The Case of Health Workers

The set of workers for whom failure to vaccinate leads to loss of their job includes health workers, of which there are currently about 213,000 in New Zealand (Ministry of Health, 2020, page 1). The cost-benefit analysis for them differs from that of the general population because they come into frequent and close contact with large numbers of sick people, who are the prime targets of covid-19. If the proportion of health workers who are vaccine resistant is the same as for the general adult population (10%), this would imply 21,000 people. However, health workers are likely to have a very low proportion of objectors, because they are accustomed to being directed by their employers on patient safety related matters. Suppose the proportion is instead 2%, which implies 4,000 people. Since loss of their jobs would impose a substantial loss upon them, I presume that virtually all of them would comply with a mandate.

In the previous section, the most extreme case without mandating was all 3.8m vaccinated adults being infected by members of the 420,000 pool of unvaccinated adults, leading to 3,400 deaths amongst the vaccinated. The QALY losses resulting from this (3,400*5*0.8 = 13,600) are less than those from the 420,000 objectors being subject to penalties (420,000*5*0.01 = 21,000) and therefore mandating is rejected for the general population. However, without mandating, suppose a small subset of these 420,000 unvaccinated adults (the 4,000 health workers referred to above) would be responsible for a disproportionate fraction of these 3,400 deaths because these 4,000 workers are collectively in frequent and close contact with most of the 3,400 susceptible people. In particular, suppose in the absence of mandating that they would be responsible for half of these deaths (1,700 people). In this case the QALY losses resulting from these deaths (1,700*5*0.8 = 6,800) would be more than those from these 4,000 being penalised (4,000*5*0.01 = 200) and therefore mandating would be warranted for these 4,000 people. In fact, if these 4,000 health workers were responsible for half of the 3,400 deaths, their QALY losses per person per year for five years could be as large as 0.34 (rather than the 0.01 figure used up until this point) before mandating was no longer optimal.

This analysis does not imply that vaccination should be mandated for health workers, because the 3,400 vaccinated people who might die might do so even if there were no unvaccinated people, i.e., they could all be infected through transmission of the virus amongst vaccinated

people. However, unlike the case for mandating vaccines for the adult population in general (which is not supported by a cost-benefit analysis), it is *possible* that mandating vaccination for health workers is supported by a cost-benefit analysis as shown in this section.

5. The Rationality of Vaccine Opposition

The analysis so far does not assess whether covid-19 vaccine opposition is 'rational' (however defined), but assessment of this question may still be of interest. In particular, if at least some resistance to covid-19 vaccines is 'rational', the case for recognising the adverse impact of vaccine mandates upon the objectors (as has been done in this paper) is strengthened. Accordingly, this section investigates this question.

Consider the case of a 80+ year old person. For this group, Verity et al (2020, Table 1) gives an Infection Fatality Rate (IFR) of 7.8%, i.e., a probability of death if infected of 7.8%. As indicated in footnote 5, application of this Verity et al (2020, Table 1) data to New Zealand yields an overall population-wide IFR of 0.95%, which is about double that suggested in recent surveys. So, I halve the figure of 7.8% to yield an IFR of 4% for an 80+ year old. Death rates from covid-19 also depend upon the health status of the individual, with the risk of death (if infected) being higher for those with various pre-existing conditions. Bayes Theorem says 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*, 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 suffering from a relevant pre-existing condition. So, P(*A*) = .04. Most covid-19 deaths involve people suffering from serious pre-existing conditions. For example, In respect of those dying in New York City up to 13 May 2020, in those cases where the existing medical condition of the patient was known (no underlying condition or at least one underlying condition), 98% had at least one underlying condition (the set of conditions includes diabetes, cancer, heart disease, lung disease, and

hypertension).[6] This means $P(B|A)$ = 0.98. In respect of P(B), this is the probability of an 80+ year old having any of the relevant pre-existing conditions. I assume 0.50. Substituting these parameters into equation (1) yields

$$P(A|B) = \frac{0.98 * 0.04}{0.5} = .078$$

So, a randomly selected 80+ year old would have a probability of dying from covid-19 if infected of 4%, rising to 7.8% if they suffered from any of the relevant pre-existing conditions. This is without vaccination. The vaccines reduce the risk of death by 85% to 88% on average over the first six months but rapidly wane beyond that point (Nordstrom et al, 2021, Table 2 and Table 5). So, if vaccinated with boosters, the probability of death falls from 7.8% to 7.8%*0.15 = 1.2%. This is a very substantial reduction in risk.

I now consider the case of a 20 year old who is not suffering from any relevant pre-existing condition. So, A still means death whilst B now means not suffering from any such conditions. For a 20 year old, Verity et al (2020, Table 1) gives P(A) = .019%, which is halved to 0.01% as above. Also, $P(B|A)$ = 1 – 0.98 = 0.02. In respect of P(B), this is the probability of all of the relevant pre-existing conditions being absent in a 20 year old. I presume these conditions are rare in 20 year olds and therefore adopt a probability of them being absent of 0.90. Substituting these parameters into equation (1) yields

$$P(A|B) = \frac{0.02 * 0.01\%}{0.9} = 0.0002\%$$

So, a randomly selected 20 year old would have a probability of dying from covid-19 if infected of 0.01%, falling to 0.0002% if they did not suffer from any of the relevant pre-existing conditions, i.e., 1/500,000. This is without vaccination. The vaccines reduce the risk of death by 85% to 88% on average over the first six months but rapidly wane beyond that point (Nordstrom et al, 2021, Table 2 and Table 5). So, if vaccinated with boosters, the probability of death falls from 1/500,000 to 1/3.3 million. The absolute reduction in risk is very small.

[6] See https://www.worldometers.info/coronavirus/coronavirus-age-sex-demographics/.

All vaccines have some side-effects, which could include death. A rational person will weigh these risks against the benefits of the vaccine (reduced risk of death from covid-19 if infected). For an 80+ year old with relevant pre-existing conditions, the balance seems to strongly favour being vaccinated. For a 20 year old without any such conditions, the balance no longer strongly favours vaccination. So, a person in this position *might* rationally reject the vaccine. This would require them ignoring the benefit to their fellow citizens from them being vaccinated, i.e., the reduction in the risk of highly susceptible people become infected as a result of the existence of unvaccinated people, and subsequently dying. However, rationality does not require selflessness. In addition, this hypothetical 20 year old might reasonably believe that all vaccinated people will eventually become infected through transmission amongst vaccinated people and therefore there is no social benefit from them being vaccinated.

6. Conclusions

Vaccine mandates for the general population are proving to be extremely controversial. Opponents point to the right to choose whether to be vaccinated. Proponents point to the costs that the unvaccinated impose upon the vaccinated, most particularly the increased risk to vaccinated people of death by covid-19 (because the vaccine is imperfect). This is yet another example of the trade-offs we face in life, individually or socially, and is therefore capable of being illuminated (and possibly resolved) by cost-benefit analysis. This paper has sought to do so and the conclusions are as follows.

Firstly, at least some opposition to covid-19 vaccines may be rational. Secondly, if the adverse impact of mandating amongst those objecting to vaccination is as small as a reduction in their quality of life of 1% per year for a period of five years, mandating would only be justified if failure to do so leads to a pool of unvaccinated people whose existence induces at least 5,200 additional deaths from covid-19 amongst the vaccinated. Thirdly, this figure of 5,200 is implausibly high even if the unvaccinated are entirely responsible for infections amongst the vaccinated. This implies that mandating is not warranted. Fourthly, if the adverse impact of mandating on the vaccine objectors is larger than a reduction in their quality of life of 1% per year for a period of five years, then mandating would be even less justified. Fifthly, if the unvaccinated pool has little effect on the rate of infection amongst the

vaccinated (because they are primarily infected by transmission amongst the vaccinated), the number of additional covid-19 deaths amongst the vaccinated arising from failure to adopt a mandating policy will be close to zero, which further undercuts the merits of a mandating policy. Lastly, unlike the general population, health workers come into frequent and close contact with large numbers of sick people, who are prime targets for covid-19, and therefore vaccine mandating *may* be justified for these workers.

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