NSW Productivity Commission

Boosting the NSW Influenza Vaccination Rate

The economic benefits of increasing influenza vaccination among healthy populations in New South Wales

October 2023

Acknowledgement of Country

We acknowledge that Aboriginal and Torres Strait Islander peoples are the First Peoples and Traditional Custodians of Australia, and the oldest continuing culture in human history.

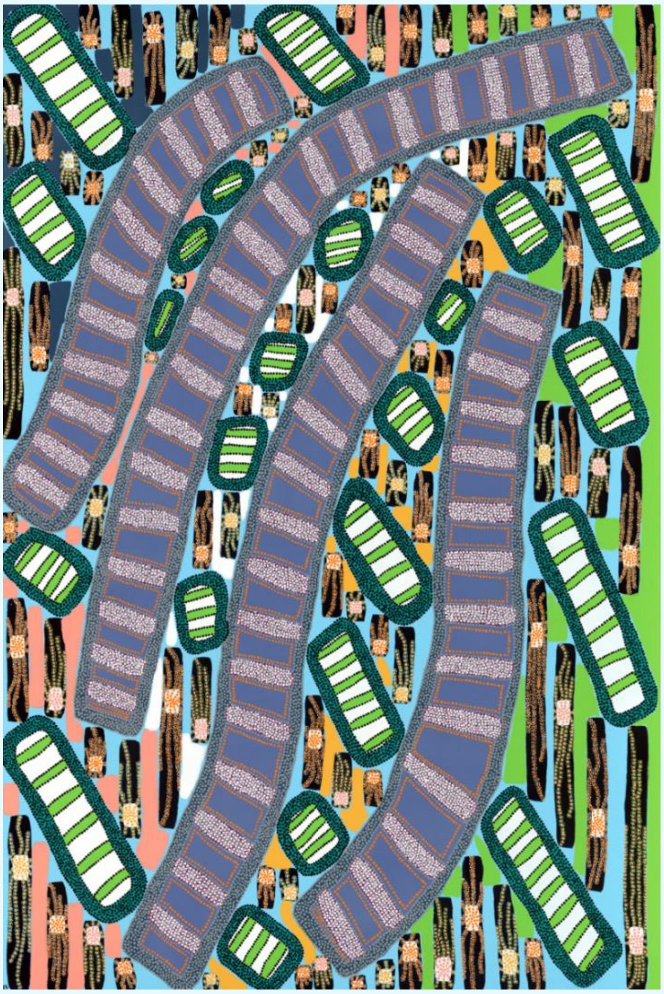
We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

We celebrate the deep and enduring connection of Aboriginal and Torres Strait Islander peoples to Country and acknowledge their continuing custodianship of the land, seas and sky.

We acknowledge the ongoing stewardship of Aboriginal and Torres Strait Islander peoples, and the important contribution they make to our communities and economies.

We reflect on the continuing impact of government policies and practices, and recognise our responsibility to work together with and for Aboriginal and Torres Strait Islander peoples, families and communities, towards improved economic, social and cultural outcomes.

Artwork:
Regeneration by Josie Rose



Productivity Commissioner's foreword

For many, influenza — or 'the flu' — is not just a runny nose. Each year in New South Wales, people get seriously ill or even lose their lives to it. People getting sick also puts strain on our hospitals and workplaces, and creates significant health and economic costs for the NSW community, including NSW families and businesses.

Luckily, we have a safe and effective vaccine that can help. Australia's current immunisation strategy focuses on vaccinating the most vulnerable groups in our community: young children, pregnant women, the elderly, and people with compromised immune systems. For these groups, immunisation is critical and there is room to improve vaccine uptake.

This paper looks at ways we could build on the great work that is already being done to promote influenza vaccination.

We might be able to provide extra protection to our most vulnerable people by encouraging more young and healthy people to get vaccinated. Even young and healthy people face risks from the flu – and they are more likely to catch and spread it than others. If more healthy young people get vaccinated, they will not only protect themselves but reduce the chance of spreading it to others. As the paper illustrates, this could have major health and economic benefits for our community.

There are many reasons why people don't get the jab, and boosting uptake is not as simple as making it free. Cost does play a role but sometimes the biggest barrier is the inconvenience of organising a vaccination or not understanding the benefits. This paper shows ways Australian governments could address some of these barriers, like supporting more schools and workplaces to offer the vaccine. It also highlights areas where further work could strengthen the evidence base.

The national vaccination landscape is evolving quickly. Pharmacies are now being funded to provide flu jabs, and an Australian Centre for Disease Control is being established. As we emerge from yet another severe influenza season this year, this paper highlights another promising opportunity to fight the flu and boost wellbeing and productivity in New South Wales.

Peter Achterstraat AM
NSW Productivity Commissioner

About the NSW Productivity Commission

The NSW Productivity Commission ('the Commission') was established by the NSW Government in 2018 under the leadership of the state's inaugural Commissioner for Productivity, Peter Achterstraat AM.

The Commission is tasked with identifying opportunities to boost productivity growth in both the private and public sectors across the state to continuously improve the regulatory policy framework and other levers the Government can pull. Productivity growth is essential to ensure a sustained growth in living standards for the people of New South Wales, by fully utilising our knowledge and capabilities, technology and research, and physical assets.

The Commission's priorities include:

- productivity and innovation
- fit-for-purpose regulation
- efficient and competitive NSW industries
- climate resilient and adaptive economic development.

Since its inception, the Commission has undertaken several reviews on productivity matters and published the landmark *Productivity Commission White Paper 2021: Rebooting the economy.*

Disclaimer

The views expressed in this paper are those of the NSW Productivity Commission alone, and do not necessarily represent the views of NSW Treasury or the NSW Government.

Regarding the recommendations in this paper, NSW Productivity Commission recommendations only become NSW Government policy if they are explicitly adopted or actioned by the NSW Government. The NSW Government may adopt or implement recommendations wholly, in part, or in a modified form.

Abbreviations

Term	Definition
DALY	Disability-adjusted life year
GP	General practitioner
ILI	Influenza-like-illness
LAIV	Live attenuated influenza vaccine
NCIRS	National Centre for Immunisation Research and Surveillance
NIP	National Immunisation Program
NVP	National Vaccination Program
RCTs	Randomised control trials
VSL	Value of a statistical life

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Executive Summary

Influenza costs NSW families, business and Australian governments

New South Wales had a severe influenza (flu) season in 2022, with more than 116,000 flu cases reported across the state, compared to an annual average of around 45,000 cases over the previous decade. Case numbers in 2023 to date suggest we are tracking toward a third relatively severe flu season in the past five years. This suggests that the time is right to consider how New South Wales can do more to avoid the heavy health and economic burden of influenza.

We estimate that New South Wales loses around $500 million each year from influenza. This is comprised of up to 8 million lost work hours, up to 4,000 lost healthy life years, more than 7,000 flu-related hospitalisations and almost 100,000 flu-related GP consultations each year. These costs vary year-to-year as they depend on the severity of the flu season. Fortunately, we have an effective vaccine that can reduce the cost of influenza to NSW society – but it is essential that we use it effectively.

Vaccinating more healthy populations under-65 can help to protect the most vulnerable and boost the economy

Existing public health strategies focus on vaccinating the vulnerable: the elderly, young children, pregnant women, and the immunocompromised. This strategy is important and more can be done to protect these groups who are most at risk, prevent flu transmission in the community, and boost the economy.

To better prevent transmission and protect the vulnerable, we could **also** target vaccination efforts towards healthy and young populations. Under 65s are ideal targets, especially children who are more likely to catch and transmit the flu when infected, compared to older people. Increasing vaccination rates among the young and healthy can help protect the elderly and vulnerable. And there is precedent. In recent decades, the United Kingdom (UK) and Canada have expanded their influenza immunisation programs beyond at-risk cohorts to include young populations. These programs reduced influenza-like illness among children and provided indirect protection for older adults and the broader population.

This approach complements the existing strategy for influenza vaccination

Current immunisation strategies identify priority and focus populations that may have an increased burden of vaccine preventable disease and have high-risk exposures. These include residents of aged care facilities, people medically at higher risk of severe disease, and healthcare workers, among others. This approach is vital as it helps to protect the most vulnerable in our community.

This paper examines the potential benefits and costs of building on the existing strategy by immunising enough young and healthy people to reach ‘herd immunity’. Our approach considers:

1. whether further indirect protection could be provided to vulnerable populations by realising herd protection effects of vaccination.
2. the broader economic benefits of vaccinating under 65s. For example, if carers did not have to take as much time off work to look after children with the flu.

New South Wales could save around 500 lives - and at least $500 million in flu-related costs - by vaccinating more under-65s each year

So, how many people in New South Wales need to be vaccinated to give us the best chance to achieve herd immunity? The best available evidence suggests we should target a 55 per cent coverage rate among the under 65 population. This equates to approximately 2 million additional vaccinations against influenza in New South Wales each year. This represents around a 30-percentage point increase in the under-65 vaccination rate.

We present some illustrative estimates to show the potential benefit New South Wales could get from more vaccinations of under-65s. Our estimates consider the indirect benefits the whole community would receive if we vaccinated enough under-65s to achieve a herd protection effect.

Delivering two million additional vaccinations to the under 65 population in New South Wales could **save around 500 lives** and provide **at least $500 million (and up to $1.3 billion)** worth of gross benefits to the state each year. This comprises: a reduction in lost work hours, avoided GP consultations and hospitalisations, and increased healthy life years (Figure 1). Each extra person under 65 vaccinated could deliver $250 to $640 worth of gross economic benefits per year to the state.

Figure 1 | Illustrative benefits of flu vaccination in New South Wales

Work hours saved: up to 8 million, worth $401 million

Hospitalisations avoided: more than 7,000, worth $54 million

GP consultations avoided: almost 100,000, worth $7 million

Healthy life years saved: 2,000-4,000, worth $443-903 million

Up to $1.3 billion worth of gross benefits to New South Wales, which substantially outweighs the $81 million cost of mass vaccination

Note: The lower bound gross estimated benefit of $500 million comprises the estimated value of hospitalisations avoided ($54 million), GP consultations avoided ($7 million), and 2,000 healthy life years saved, which indirectly captures work hours lost to the flu ($443 million). By contrast, the higher bound gross estimated benefit of $1.3 billion comprises the estimated value of work hours saved ($401 million) and 4,000 healthy life years saved ($903 million).

While promising, these estimates are based on high quality overseas studies, and actual NSW results could vary based on factors like uptake among different groups. The general principle of increasing vaccination among healthy populations, however, is consistent with advice from Australia's leading immunisation experts, the National Centre for Immunisation Research and Surveillance (NCIRS), who recommend that **everyone** 6 months and older should get an annual influenza jab.

Schools and workplaces are effective mass vaccination settings for under-65s

Increasing vaccine uptake is challenging, and unlikely to be as simple as making the vaccine free for everyone. Some of the key barriers to vaccination, especially for under-65s, are inconvenience, and apprehension about the necessity of the vaccine, as well as its financial cost. These barriers could be addressed by mass vaccination programs in schools and workplaces. In the UK, most school-aged children can receive a free influenza vaccine at school each year, benefiting the broader UK population through reduced deaths and hospitalisations. As part of this program, parents were provided with accessible and accurate information to help address any potential apprehension about the vaccine. Workplace vaccination programs can similarly benefit the whole population by limiting the spread of influenza in the broader community.

Mass vaccination could also be cost-effective. We estimate the cost of mass vaccinating 2 million more under-65s is around $81 million, around half the estimated $156 million cost of vaccinating the same number of people in GP settings. Therefore, vaccinating 2 million more under-65s would cost around $40 per person. This means that each extra person vaccinated under 65 could deliver a **net** benefit to the state worth at least $210 (and up to $600).

Australian governments could facilitate greater uptake of the vaccine in healthy populations

Vaccination rates remain low and more needs to be done to combat influenza to reduce its heavy health and economic costs. Australian governments and the community could consider initiatives that have worked in other jurisdictions across Australia and overseas to promote uptake of the vaccine. This includes allowing more of the population to be eligible for a free annual flu vaccine under the National Immunisation Program (NIP). There is strong precedent for this from overseas: the flu vaccine has been free in Ontario, Canada, since 2000 through the Universal Influenza Immunisation Program.

Australian governments could also consider a school-based influenza vaccination program, such as the UK's National Vaccination Program, which was expanded in 2012 to include healthy children aged 2-17 years through pre-school and school-based immunisation. In addition, governments could provide additional support for organisations to implement workplace-based vaccination programs, such as resources for employers to promote and deliver these programs, with guidance on how to best procure immunisers.

Issues like funding arrangements, priority cohorts and infectious disease modelling require further consideration

This paper outlines the case for increasing vaccine uptake among healthy populations in New South Wales and canvasses opportunities for Australian governments to consider. Pursuing these opportunities would require further work and national consideration of a strategic approach to influenza vaccination. As responsibility for the NIP is shared between the Commonwealth and State governments, potential cooperative actions and any funding arrangements would need to be explored further with the Commonwealth and other jurisdictions. Consideration could also be given to strategies to further increase uptake among priority cohorts and other population groups such as First Nations people and culturally and linguistically diverse people. These considerations are beyond the scope of this paper.

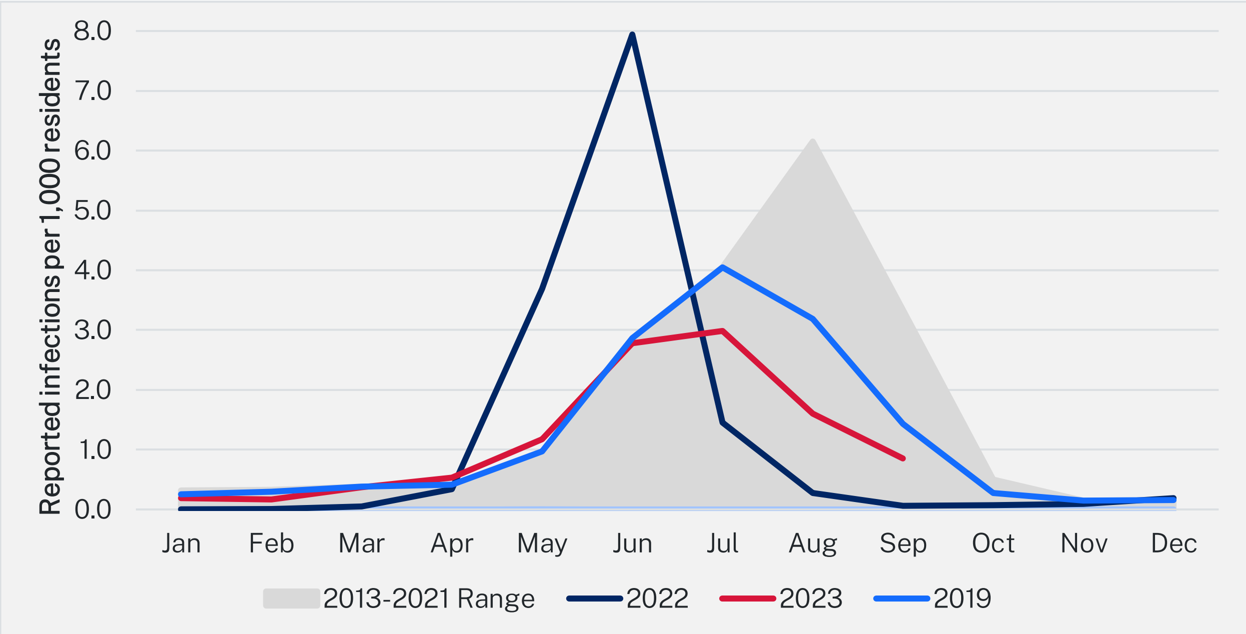
Further work could be done to strengthen the evidence about vaccinating healthy populations. The estimates we present highlight that a new approach to NSW flu vaccination could have significant benefits. But our estimates are only illustrative. More work could be done to strengthen the evidence base, including by developing a more precise target vaccination rate that accounts for contact patterns across different age groups, or constructing a local infectious disease model using NSW or Australian data. Such extensions could inform collaboration between Australian governments on strategic planning in this space, and national exploration of new strategies on influenza control.

1 Influenza costs NSW families, business, and Australian governments

Influenza has infected at least 85,000 people in New South Wales in 2023 to date, with the number of infections expected to increase further. The typical Australian flu season peaks between June and September. This follows severe influenza seasons in 2022 and 2019 (Figure 2).[1] These illnesses bring a heavy health and economic cost. We estimate that influenza costs New South Wales at least $500 million each year, and possibly up to $1.3 billion, comprising:

- Up to 8 million lost work hours (worth up to $401 million)
- More than 2,000 lost healthy life years[2] (worth between $443 million and $903 million)
- 7,200 hospitalisations related to the flu (at a cost of $54 million)
- 99,900 additional GP consultations (at a cost of more than $7 million).

Figure 2 | Reported influenza infections in New South Wales per 1,000 residents, January 2013 – September 2023[3]



Source: Australian Bureau of Statistics (ABS), NSW Health, 2023

Luckily, we have the tools to reduce the health and economic burden of influenza — an effective vaccine – but we need to use it more to achieve the maximum benefits for the community.

[1] The 2020 and 2021 influenza seasons were unusual, because COVID-19 travel restrictions, among other public health measures, essentially prevented the entry of influenza in those years. Note that reported infections in 2022 in the chart may also reflect increased propensity to test in people with respiratory symptoms during the COVID-19 pandemic.

[2] This measure combines the impact of the years of healthy life lost due to living with illness (non-fatal burden) and the years of life lost due to dying prematurely (fatal burden). We assume that this measure includes work hours lost in our estimates (captured in the non-fatal burden).

[3] This data captures infections reported/notified to NSW Health by laboratories, hospitals, medical practitioners, schools and childcare centres, and therefore may underestimate total infections. Influenza strains captured in this data are categorised as Influenza A, Influenza B and Influenza-Not-specified. Data

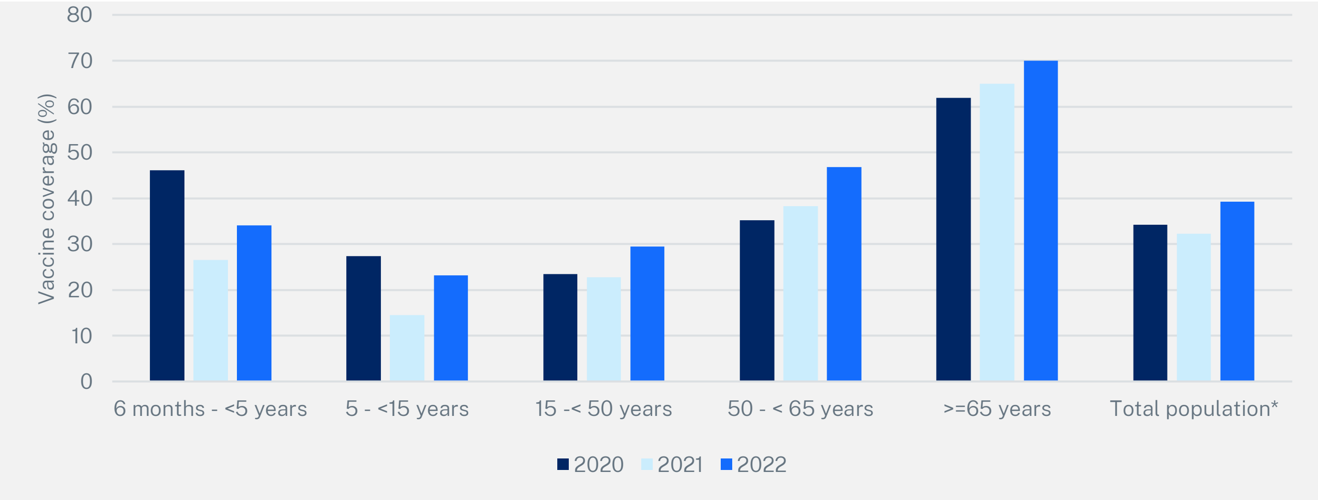
Existing public health strategies focus on vaccinating the vulnerable, such as people at risk of severe influenza: the elderly, young children, pregnant women, Aboriginal and Torres Strait Islander people and the immunocompromised. Accordingly, most influenza vaccinations are given to those aged under five or over 65 years of age (see Figure 3). Improving vaccine uptake among these groups remains an important focus, given that these groups are more likely to be hospitalised and seriously ill with the flu.

There is a strong argument, however, to give greater emphasis to vaccinating less susceptible members of the public to prevent transmission and protect the vulnerable. Specifically, it could be desirable to target a 50-60 per cent vaccination rate among the **under 65 population** each year (White, 2021; Boulier et al., 2007). This argument is broadly aligned with recent efforts by the NSW Health Chief Health Officer to encourage kids and teenagers to get vaccinated against the flu, due to rising flu infections and hospitalisations among these groups (NSW Health, 2023). Currently, only around 25 per cent of under-65s get their annual flu jab in Australia.[4]

These figures suggest New South Wales needs an additional 2 million needles in arms each year (see Appendix A for details). Although the task may seem large, so is the potential payoff. As a rule of thumb, every two additional vaccines can save one workday, and every 4,000 additional vaccines can prevent a death from influenza-pneumonia related illness (White, 2021). Further epidemiological work could refine these estimates, and we outline some potential extensions in Section 2.5.

Vaccinating more of the prime-aged population turns out to be one of the most effective ways to protect the community, especially the sick, elderly, and otherwise vulnerable. This is because younger cohorts are more likely to transmit the disease when infected and the vaccine can be more effective among these groups, compared to older cohorts (Worby et al, 2015; Boulier et al., 2007; Osterholm et al., 2012).

Figure 3 | Influenza vaccination coverage in Australia, 2020-2022



Note: Calculated as the weighted average of age-specific influenza vaccination rates published by NCIRS.

Source: NCIRS, 2023, NSW Productivity Commission

excludes persons whose age or gender was unknown, or who were not NSW residents. The shaded region captures the maximum number of reported influenza cases for each month over the 2013-2021 period.

[4] Calculated as the weighted average of age-specific influenza vaccination rates published by NCIRS for 2020-22. Note that these coverage rates may be affected by the COVID-19 pandemic.

1.1 Influenza can be a serious illness, with large health and economic costs

The health burden of influenza is high, though severity varies from year-to-year

Each year, the flu virus changes and different strains can circulate in the population. This means that the influenza season can be very different from one year to the next. Generally, the Australian influenza season peaks between June and September and between 5-20 per cent of the Australian population are infected annually (NCIRS, 2021).[5]

Influenza is a major cause of illness, hospitalisation and death. According to the most recently available data that estimates **actual** flu burden (rather than reported burden) from 2005, influenza is associated with more than 3,000 deaths and 13,500 hospitalisations each year in Australia in people aged 50 and above (Newall & Scuffham, 2008).[6] Adults aged 65 and over and children under 5 years of age have the highest rates of influenza-related hospitalisations. Among children, influenza causes more hospitalisations and deaths than any other vaccine preventable- disease in Australia (Carlson et al., 2022).

Every flu season, workers, businesses and students are adversely affected

Influenza also has adverse economic impacts due to absenteeism and reduced capacity and productivity at work, which can create significant costs for businesses. Workplace interactions represent around a quarter of all weekly interactions – and influenza transmission in the workplace accounts for one-in-six of all transmissions on average, and potentially up to one-in-three (Edwards et al., 2016).[7] On average, 3 to 6 workdays are lost for each influenza diagnosis (Keech & Beardsworth, 2008).

Similarly, influenza infection in school children leads to higher rates of student and parent absenteeism. This is partly because children are major spreaders of influenza in households and the community (Lee & Shah, 2012). A United States (US) study found that influenza contributed substantially to school absenteeism, with one school day missed per illness, on average, and over 40 per cent of students missing more than two days (McLean et al., 2017). Another study in Europe found that parents of children under 3 years of age missed an average of 3 workdays to care for their sick child per infection per year (Heikkinen et al., 2004).

Vaccination can be instrumental in decreasing this burden

The effectiveness of the flu vaccine — the extent to which it protects against influenza — varies based on a few factors. One is how well-matched it is to the seasonal flu strain in circulation. There are several strains of flu, and vaccine regulators have to predict which will be in circulation in the year ahead. They do not always forecast correctly, and this can reduce the vaccine's efficacy. The vaccine's effectiveness also varies according to the age and health of the person being vaccinated.

That said, the influenza vaccine is an effective tool at our disposal. Studies have shown it can reduce the likelihood of getting the flu by about 50-60 per cent in vaccinated, healthy adults under 65, though this figure varies each year (NCIRS, 2023). The flu vaccine can also reduce the severity of illness in people that are infected, reduce the risk of flu-associated ICU admissions, and serve as a

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[5] During this period, there are a high number of notifications and hospitalisations occurring for influenza. However, influenza peak times vary each year and hospitalisations lag from initial infection times.

[6] Note that this data refers to national influenza-related deaths and hospitalisations. This paper estimates state-level figures for New South Wales.

[7] 'Interactions' are defined as physical contact or a conversation in the physical presence of another person.

preventative tool for people with certain chronic health conditions like heart disease (Ferdinands et al., 2021; Thompson et al., 2018; Udell et al., 2013).

1.2 Influenza vaccination rates are low, especially for under 65s

Despite the well-documented benefits of immunisation, influenza vaccination rates are relatively low compared to immunisation coverage for other vaccine-preventable diseases. For example, more than 90 per cent of children in New South Wales are 'fully immunised' against a range of vaccine-preventable diseases such as diphtheria, polio and hepatitis B.[8] However, achieving immunity against these diseases is less burdensome compared to influenza, as annual vaccinations are needed for ongoing protection.

Influenza vaccination rates are especially low among school-aged children and the working age population. The National Immunisation Program subsidises vaccinations for at-risk groups, including people aged over 65, pregnant people and those with underlying health conditions. Accordingly, over the last three years, influenza vaccination coverage among people over 65 was approximately 65 per cent. In contrast, average influenza vaccination coverage for people aged under 65 was around 25 per cent (NCIRS, 2023).[9]

Vaccine uptake is limited by complacency, convenience and vaccine hesitancy

Despite strong endorsement by public health agencies, flu vaccine hesitancy still exists because many people believe the risk of getting sick is low, and doubt the vaccine is effective (Welch et al., 2023). This is probably because the level of protection the vaccine provides varies each year, as flu strains change and the vaccine changes to keep up with them (Osterholm et al., 2011). Changing flu strains – and the need to be vaccinated every year – also mean the cost of maintaining immunity is relatively high, compared to other vaccine-preventable diseases. Generally, lack of easy access, cost, and travel time, make it less convenient to get the flu jab, and limit uptake (Schmid et al., 2017).

Personal experience also seems to play a key role in vaccine uptake. Some studies suggest that unvaccinated individuals who get sick are more likely to get a flu vaccine the following year. In contrast, vaccinated people who get the flu anyway could be less likely to be vaccinated the following season (Jin & Koch., 2018). While the effects were relatively small, another US study found that disease outbreaks may be a powerful motivator for vaccination (Oster, 2017).

The COVID-19 pandemic has also affected how people engage with vaccinations. While more of us now likely have a more nuanced understanding of vaccine efficacy, research commissioned by the Australian Department of Health and Aged Care suggests that COVID-19 has acted as a barrier to flu vaccine uptake for some people. This is largely due to perceptions that the flu vaccine is less necessary during COVID-19 and the challenges of juggling the timing of COVID-19 and flu vaccines, among other reasons (Wolstenholme & Smith., 2022).[10]

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[8] This represents the proportion of children that are 'fully immunised' at age one, two and five, according to the National Immunisation Program Schedule as at March 2023.

[9] Note that data is not available before 2020 and these coverage rates may be affected by the COVID-19 pandemic. They also may be affected by changes to the NIP in 2020, when funding was introduced to vaccinate all children under 5 (and > 6 months).

[10] Combined COVID-19 and influenza vaccines are under development by some vaccine manufacturers, which could help to address difficulties juggling vaccination timing going forward.

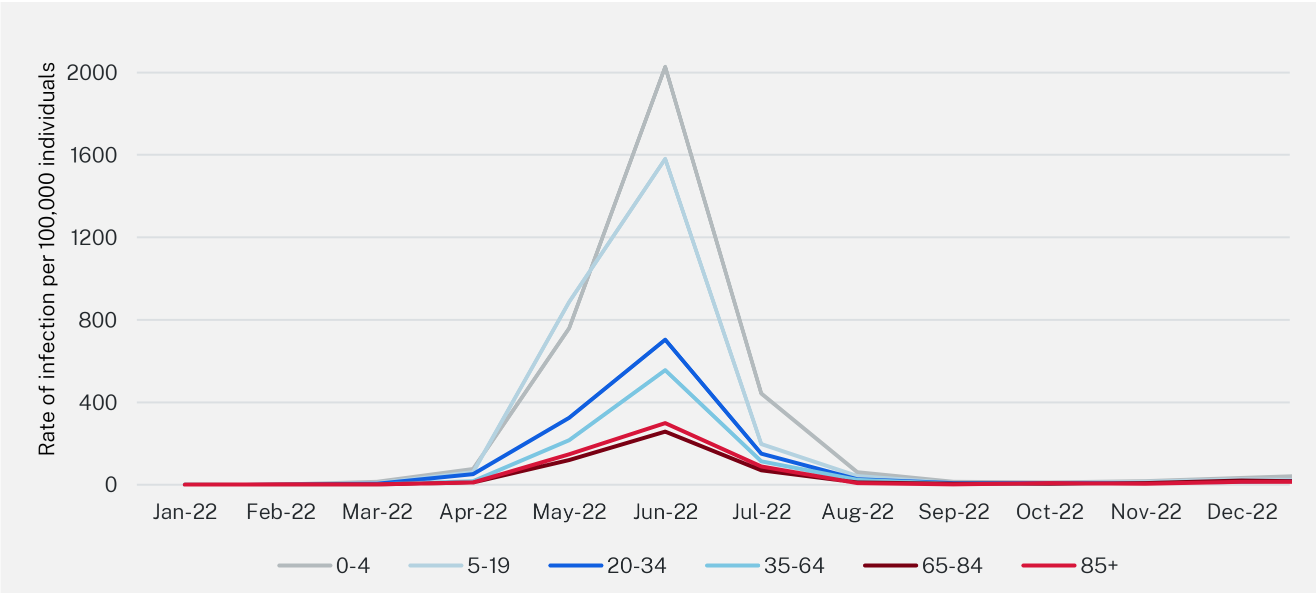
2 The case for vaccinating healthy populations against influenza

2.1 Vaccinating healthy populations can help to protect the most vulnerable and boost the economy

The current approach of targeting at-risk populations is important and there is room to improve vaccine uptake among these cohorts. However, this approach has limitations when it comes to minimising influenza transmission in the community, and indirectly protecting the vulnerable. Elderly people tend to have fewer social interactions and so are less likely to spread the disease. This is reflected in the international experience. In the US, there has been no decline in influenza-related mortality among the elderly in the past few decades, despite vaccine coverage increasing from 5 to 65 per cent in this age group (Chowell et al., 2008). A similar pattern has been observed in Italy (Rizzo et al., 2006).[11]

In contrast, overseas immunisation programs that target healthy groups (in addition to vulnerable cohorts) have proven effective in protecting both the broader population and vulnerable cohorts. These groups include school-aged children who play a bigger role in spreading the flu (Figure 4). In this section we discuss the potential benefits of targeting vaccination efforts at under-65s in New South Wales.

Figure 4 | Reported influenza infections in New South Wales per 100,000 population, by age group, Jan – Dec 2022[12]



Note: Data excludes persons whose age or gender was unknown, or who were not NSW residents.

Source: NSW Health, 2023.

[11] Note that enhanced-immunogenicity influenza vaccines for older adults have been introduced and widely used in recent years (since 2018 in Australia) and may not be reflected in these studies.

[12] Given that this data captures infections reported by laboratories, hospitals, medical practitioners, schools and childcare centres, notifications among children may be over-represented compared to adult notifications.

Under-65s are ideal targets for influenza vaccination

An effective vaccination strategy would **also** target healthy populations. In particular, New South Wales could prioritise those likely to have a strong immune response – and those most likely to transmit the flu when infected. As discussed above, the latest NCIRS research has found that influenza vaccination reduces the likelihood of getting the flu by about 50-60 per cent in vaccinated, healthy adults under 65 (NCIRS, 2023). Healthy populations, especially children, are major spreaders of influenza in households and the community (Lee & Shah, 2012). This is because children are in frequent contact with each other and their family members and are also more susceptible to flu infection than adults (Stevenson et al., 2009). Reported infection rates among children are consistently higher than any other age group, although this partly reflects their higher likelihood of being tested (Figure 4).

Higher vaccination rates among younger people will also protect the elderly and vulnerable

A Canadian study found that an 11 percentage point increase in vaccination among the prime aged population during flu seasons with a well-matched vaccine – from 22 per cent to 33 per cent – nearly halved flu-related hospital admissions in over 65s. This occurred despite no change in their own vaccine coverage (Ward, 2014). Similarly, a US study found that the main reason the vaccine saved the lives of older people was because younger people took it (White, 2021). In the UK, GP consultation rates for influenza-like-illness (ILI) in people aged 50-70 were lower in areas that piloted vaccinating school-aged children, despite no change in their own vaccination rate (Kassianos et al., 2021).

A strategy that targets vaccination by those less at risk, to reach herd immunity and protect the vulnerable, would therefore need to appeal to a sense of social responsibility. As we will discuss later, the broader public benefits also provide a strong incentive for Australian governments to encourage vaccination among healthy populations.

Even a small increase in the NSW influenza vaccination rate for under-65s could deliver significant benefits

A 1 percentage point increase in the vaccination rate of under-65s, or around 80,000 additional immunisations, could save around 16 lives in New South Wales each year.[13] Given estimates of flu-related deaths in New South Wales are between 500-1,000 per annum, this suggests substantial inroads can be made just by making better use of the tools at our disposal. Similarly, a 1 percentage point increase in the vaccination of people under 65 could reduce absenteeism and save the NSW economy 281,000 in lost work hours, worth $13.4 million each year.[14]

Therefore, a 30-percentage point increase in the vaccination rate that increases the overall coverage among under-65s to around 55 per cent could help to save almost 500 lives and $401 million worth of work hours in a typical flu season. We explore the potential impacts of this further in the following section.

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[13] We estimate this effect for New South Wales by taking White's (2021) result that an additional 1,000 vaccinations in a population of 100,000 would reduce influenza-related deaths by 0.246, in expectation.

[14] We estimate this effect for New South Wales by taking White's (2021) result that an additional 1,000 vaccinations in a population of 100,000 would reduce work hours lost to illness by 4,167 hours. We apply this to the state's under-65 population of 6.7 million people (ABS, 2022). Valued at the Australian mean wage of $47.60 per hour, this equates to a total economic saving of approximately $13.4 million for each percentage point increase in the vaccination rate.

These estimates are illustrative and could be built in further work, but also have some important advantages

The estimates presented above and in the following section aim to show the potential magnitude of benefits we could realise with more vaccinations of under-65s. It is worth noting that the underlying evidence comes from careful observational studies, relying on variation in natural settings rather than largescale randomised control trials (RCTs). Importantly, however, observational studies can confer advantages in some cases – such as understanding the population level impacts of vaccination or other medical treatments, like deworming (see Miguel & Kremer, 2004). This is because they allow us to identify the **indirect** or **spillover** effects of vaccination. That is, the protection that one vaccinated person provides to the rest of their community, which can be difficult to achieve in standard RCTs (see Appendix E: for further explanation).

On the other hand, our estimates group under-65s into one cohort, and apply findings from studies overseas. We suggest further work is done in this space, to refine our estimates and validate how they might translate to a NSW-specific context (see Section 2.5 and Appendix E:).

2.2 New South Wales could aim to vaccinate 2 million more under-65s

Herd immunity occurs when the rate of new infections starts declining

Vaccinating people generates direct and indirect benefits. People who get vaccinated develop a level of protection against infection and illness, which is considered a direct benefit. Vaccination can also reduce infection risk to the broader community, since there are fewer unwell people that can transmit the flu in the population (an indirect benefit of vaccination).

Herd immunity occurs when those who are not immune are **indirectly** protected because the spread of disease is minimal. Models of flu transmission suggest that if we achieve a certain vaccination rate, a seasonal flu epidemic fails to emerge and this is the point at which we reach 'herd immunity'.

New South Wales could reach herd immunity by vaccinating 55 per cent of under-65s

So, what proportion of people in New South Wales need to be vaccinated for the rate of new infections to decline? The best available evidence suggests that we should target a 50-60 per cent vaccination coverage rate for influenza (Fine et al., 2011; White, 2021; Boulier et al, 2007).[15]

For the purposes of illustrating the potential benefits from increased vaccination of under-65s, we assume that New South Wales could target a vaccination rate of about 55 per cent (see Appendix A). This rate represents a sweet spot: it could provide nearly the same benefit as vaccinating everyone, but at a fraction of the cost.[16]

This is illustrated in Figure 5, at the point where the red 'total benefit' line flattens out. Past this point, models suggest that any additional benefits from further increasing the vaccination rate quickly fall to zero, as the rate is already high enough to ensure minimal flu circulating in the community.[17] In practice, there are many factors that will affect **if** and when we reach herd immunity,

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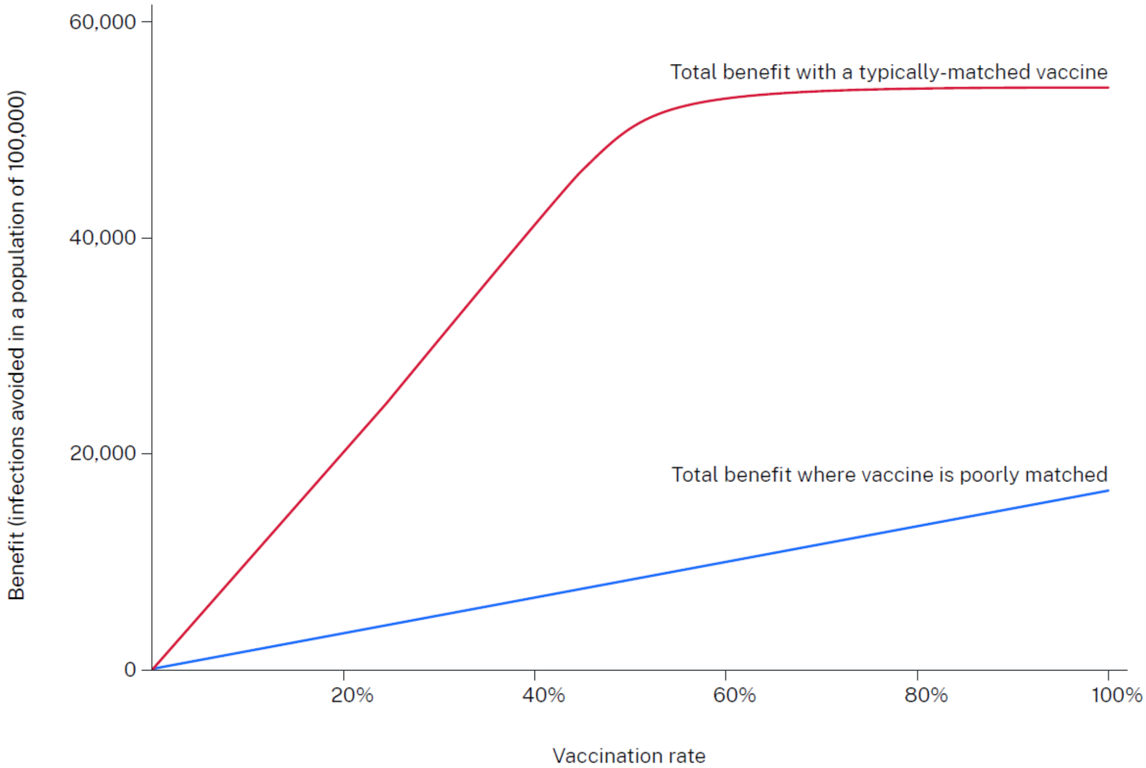
[15] See Appendix A for details. We assume influenza has a reproduction rate of 1.4 and that vaccine efficacy ranges between 50 and 60 per cent. Note that further work could be done to refine this aspirational target (see Appendix E for more details).

[16] If we make the additional assumption that the marginal social cost of vaccination is constant within this range, the 55 per cent target also represents the point at which social welfare is maximised.

[17] Ward (2014) found that a program in Ontario that increased vaccination rates among non-elderly adults by around 10 percentage points resulted in a near elimination of influenza infection – suggesting that Ontario reached this 'threshold' level of vaccination (i.e., herd immunity).

such as which age groups actually get vaccinated and how well-matched the vaccine is to the strains in circulation.

Figure 5 | Illustration of the potential benefits of vaccination, varied by vaccination rates across the population



Source: White, 2021; Boulier et al., 2007.

Reaching a 55 per cent target would be challenging, since only about 25 per cent of people aged under 65 in New South Wales typically get vaccinated for influenza.[18] This means that reaching 55 per cent would require around a 30 percentage point increase in vaccination of under-65s in New South Wales, or an additional 2 million people vaccinated.[19]

As mentioned above, further work could consider how the target rate could be refined by allowing for other key transmission factors like contact patterns for different age groups (see Section 2.5.).

2.3 2 million extra jabs could provide major economic benefits, and save up to 500 lives in New South Wales each year

In this section we provide two illustrative estimates of the potential benefits of vaccinating under-65s in New South Wales, given the limitations in the reporting of flu-related costs. These estimates

[18] Using national NCIRS data on influenza vaccination in 2022, we estimated the weighted average vaccination rate (accounting for the relative size of age-based cohorts of the population) for under-65s in Australia was 27 per cent, noting that 2022 vaccination figures were likely affected by COVID-19 and immunisation incentives. For the purposes of this paper, we round this figure to 25 per cent and use this as a proxy for NSW vaccination coverage rates.

[19] Note that NSW Health recommends that children under 9 who have never received an influenza vaccination should receive 2 doses initially (and 1 does each year thereafter).

present a range of potential benefits, which also help to reflect the variability of flu seasons each year.

We first present conservative estimates in this section that illustrate indicative yearly costs of the flu to New South Wales. We call these 'bottom-up' estimates because we are estimating the components that build up to the total costs of the flu. These estimates are based on reported cases, influenza-related GP visits, hospitalisations, and deaths. That said, the cost of influenza and benefits of vaccination are likely to vary, due to the changing severity of the flu season each year. As reported cases are probably much lower than actual cases, these estimates present a conservative, lower bound on the effects of increasing the influenza vaccination rate.

To further address the under-reporting issue, we go on to present more ambitious benefits. We call these 'top-down' estimates because these are based on rules of thumb from the literature about benefits that can be realised with extra jabs. Namely, that each additional two vaccinations save one workday, and every additional 4,000 vaccinations saves a life. Appendix B provides further details on the bottom-up and top-down calculations. Section 2.5 and Appendix E outline how our estimates could be refined with further epidemiological work.

These benefits are worth at least $500 million, or $250 per person vaccinated

Our bottom-up estimates show that New South Wales could save more than $500 million in yearly flu costs with 2 million more vaccinations of under-65s (Table 1).[20] This represents our attempt to quantify the current burden of influenza to New South Wales. These benefits include reduced hospitalisations, avoided GP consultations, healthy life years saved (which indirectly captures fewer lost work hours to the flu). Vaccination saves healthy life years by preventing flu deaths and reducing the flu's impact on people's quality of life.

These bottom-up estimates represent a conservative approach, since we use reported influenza infections, and official figures are likely to underestimate the actual number of influenza cases each year (see Appendix C).[21] We test the sensitivity of this result in Appendix C using other annual infection estimates. These conservative bottom-up estimates, alongside larger top-down estimates, allow us to present a range of potential benefits that reflect the variability of flu seasons each year.

In practice, the benefits of reaching a broad target coverage rate will vary depending on many factors. For example, if the overall target rate is reached but vaccine coverage remains low for age-groups that are particularly important for community transmission — like school-aged children — herd immunity benefits could be less than presented here. Even if the indirect benefits of herd immunity are not achieved, the influenza vaccine offers direct protection to those who do take it, and it is recommended for anyone over the age of 6 months old.

[20] Ward (2014) finds that when vaccination reaches 'herd immunity' rates, flu-related costs are virtually eliminated when the vaccine is well-matched to the circulating flu strain. We apply this assumption to our bottom-up estimates – which estimate the total annual cost of the flu to New South Wales.

[21] To estimate healthy life years lost from influenza, we use average rate of influenza infections reported per 100,000 population in New South Wales between 2010 to 2019 (i.e., pre-COVID), and apply this to the 2022 NSW population. This assumes around 34,000 flu infections each year and $443 million in healthy life years cost. In contrast, reported influenza cases in 2022 was 116,000 and the value of healthy life years lost is $1.5 billion.

Table 1 | Overview of illustrative annual benefits estimates, with bottom-up approach

Bottom-up estimates – conservative estimates of annual influenza costs in New South Wales		
	Impact of vaccination	Benefit to New South Wales
Work hours saved for carers[22]	**93,500**	**$4 million**
Breakdown	93,500 work hours saved = 14,800 working days lost x 6.3 hours per day 14,800 working days = 3 working days lost per young child with influenza, on average x 4,600 reported flu infections for children 4 and under in New South Wales, each year on average between 2010-19	$4.4 million = 93,500 work hours x $47.60 mean wage.
Hospitalisations avoided	**7,200**	**$54 million**
Breakdown	7,200 hospitalisations = 88 flu-related hospitalisations per 100,000 population x 8.1 million people in New South Wales in 2022.[23]	$53.8 million = 7,200 hospitalisations x $7,500 cost per flu-related hospitalisation.
GP consultations avoided	**99,900**	**$7 million**
Breakdown	99,950 GP consultations for flu in New South Wales = 909,600 national ILI GP consultations x 35% of all ILI consultations are for the flu x 31% of total Australian population is in New South Wales. 909,500 ILI GP consultations nationally = 4.5 influenza-like-illness (**ILI**) GP consultations per 1,000 consultations x 201.9 million GP consultations in Australia in 2022-23.	$7.0 million = 99,950 GP consultations x $70 cost per flu-related GP consultation.
Lost healthy life years avoided	**2,000**	**$443 million**
Breakdown	2, 000 healthy life years = 0.06 disability-adjusted life year (DALY) burden per reported case x 34,000 flu cases each year, on average.[24] 34,000 reported annual flu cases = 417 reported flu infections per 100,000 population in New South Wales, on average, between 2010-2019 x (8.1 million NSW population / 100,000).	$432.9 million = 2,000 healthy life years saved x $227,000 value of a statistical life year.

[22] This represents the work hours that are lost by parents of young children who are caring for their sick child, noting this is likely to underestimate work hours for other carers (e.g., of older adults, people with disability). To be conservative, we assume that work hours lost for people with the flu are implicitly captured in the estimate of lost healthy life years, as DALY includes the time lost due to ill health.

[23] The estimated number of flu-related hospitalisations and GP consultations avoided are large relative to the 34,000 average annual flu cases estimated (as part of calculations of lost healthy life years avoided). This is because the estimated value of healthy life years lost relies on **reported** flu infections, which likely underestimates actual infections. In contrast, estimates of hospitalisations and GP consultations do not rely on reported infections, and are less likely to underestimate the actual burden of infection. The ratio of estimated hospitalisations to GP consultations is about 0.07 – which is consistent with findings from literature (Newall, 2008).

[24] This is less than the number of healthy life years saved under the 'top-down' estimate below. This is because the 'bottom-up' approach relies on reported flu infections, which underestimate actual infections.

Bottom-up estimates – conservative estimates of annual influenza costs in New South Wales		
	Impact of vaccination	Benefit to New South Wales
Total benefits		$508 million

Sources: 6.3 hours per day is calculated as the weighted average of daily hours worked (accounting for full-time and part-time work) published from ABS Labour Force Survey; Workdays lost per young child with influenza is from Heikkinen et al., (2004). Flu-related hospitalisations per 100,000 population from Newall (2018); 8.1m people in New South Wales from ABS (2022). ILI GP consultations from Australian Government Department of Health (2022); GP consultations in Australia from IBIS World; Percentage of all ILI consultations for the flu from Dolk et al., (2021). Influenza DALY burden from AIHW (2019); average yearly influenza cases in New South Wales from NSW Health. $47.60 mean hourly wage from ABS (2022). We assume $70 cost per influenza-related GP consultation to be consistent with the MBS schedule which notes the Medicare rebate for 20-40 minute standard consultations are between $40-$75. We choose the upper end of the range to capture the likelihood that some patients will also make a co-payment. Estimates of $7,500 cost per hospitalisation adjusts figures from Newall (2008) to 2023 dollars. Value of a statistical life year from Australian Government Office of Impact Analysis (2022).
Notes: Hospitalisations assume the cost of episodes for admitted acute patients, not emergency department presentations which cost around $700-800, on average. There could also be other avoided costs not captured above, such as the cost of medication for illness.

...and could be as large as $1.3 billion, or $640 per person vaccinated, under less conservative assumptions

We consider another way to illustrate the benefits of vaccination, given that our bottom-up estimates are conservative. To do so, we use some rules of thumb from the literature – that two vaccines are required to save one 8-hour workday, and 4,000 vaccines are required to save a life – and apply them to New South Wales (White 2021).

The estimated benefits from this approach are not limited by the number of reported flu infections and may provide a more comprehensive view of the cost of influenza to New South Wales. Although this is partly offset by the absence of estimates for avoided GP visits and hospitalisations for this approach. These rules of thumb come from a US-based study, which mean our estimates are best seen as illustrative.

The estimated benefits from the 'top-down' approach are larger. We find that reaching herd immunity could deliver up to $1.3 billion worth of benefits (Table 2). This is mostly driven by a higher estimate for avoided mortality. Given this is potentially sensitive to how we value of a year of life, we present a range of estimates in our sensitivity analysis (see Appendix C).

Table 2 | Overview of estimated annual benefits, with top-down assumptions

Top-down estimates – estimate of the impact of vaccinating 2 million more people		
	Impact of vaccination	Benefit to New South Wales
Work hours saved	8.4 million	$401 million
Breakdown	8.4 million work hours = 1.1 million workdays x 8 hours per day 1.1 million workdays = 2 million extra vaccines / 1.92 vaccines required to save 1 workday	$400.8 million = 8.4 million work hours x $47.60 mean wage
Lives saved	500 lives	$903 million[25]

[25] This may over-represent the monetary value of lives saved. Firstly, the value of a statistical life (VSL) used is not age-adjusted – as is recommended in most health economics literature. This is important because most flu deaths are concentrated among over-65s and the standard estimates suggest that the VSL declines with age (Aldy and Viscusi, 2008). However, the Australian Government Office of Impact Analysis recommends using constant VSL values that are independent of age. Secondly, given that mortality is concentrated among older

Top-down estimates – estimate of the impact of vaccinating 2 million more people		
	Impact of vaccination	Benefit to New South Wales
Breakdown	497 lives saved = 2 million extra vaccines / 4,065 vaccines required to save 1 life	$903.4 million = 497 lives x 8 years of life lost from death by the flu, on average x $227,000 value of a statistical life year.
Total benefits		$1.3 billion

Sources: $47.60 mean hourly wage from ABS (2022). Median age of death (82) from Australian Department of Health (2022). Expectation of life at age 82 from ABS (2022). Value of a statistical life year from Australian Government Office of Impact Analysis (2022).
Notes: To be consistent with the approach used in White (2021), work hours saved in the top-down estimates represent time lost for full-time workers due to influenza and 8 work hours per day is assumed. In contrast, 6.3 hours per workday is assumed for the bottom-up estimates to account for part-time work. The estimated lives saved are equivalent to approximately 4,000 years of life saved (497 lives x 8 years of life lost from death by the flu, on average).

2.4 These benefits significantly outweigh the $80 million in costs of vaccinating 2 million additional people

Each additional jab in mass vaccination settings would cost around $40 per person

Mass vaccination can be an effective approach to boosting influenza vaccination. It helps reduce the administrative cost of vaccination and likely makes it more convenient (Prosser et al., 2008; Nowalk et al., 2013). We estimate the cost of vaccinating 2 million more people in mass vaccination settings would be about $81 million, (comprising $53 million in vaccine purchase, labour, and administration costs, and $28 million in lost work hours to attend vaccination (Table 3).

This is highly cost effective: delivering these vaccines in GP settings could cost about twice as much, likely due to the relatively high wages of GPs compared with nurse immunisers, as well as the fact that the time taken for immunisation is likely longer in a GP setting (Prosser et al, 2008). Efforts to broaden the workforce that is eligible to deliver vaccinations may offer more lower-cost alternatives to GP vaccination.[26]

Given that each additional jab delivers benefits of at least $250 and cost around $40, the benefit-cost ratio of increasing vaccination in these settings would be around 6. This return is consistent with other similar flu immunisation programs overseas (Ward, 2014).

Table 3 | Summary of costs of vaccinating 2 million more people under 65 in New South Wales

	Cost of mass vaccination	Cost of vaccination in GP settings
Administering vaccine	$53 million	$128 million
Breakdown	$52.6 million = $26 cost per vaccine x 2 million additional vaccinations	$27.54 million = $63 cost per vaccine x 2 million additional vaccinations
Work hours lost to vaccination	$28 million	
Breakdown	$28.1 million = 591,100 work hours lost to vaccination x $47.60 mean wage	

people who may already be suffering from other illnesses and co-morbidities, the 8-year assumption of life lost may be too high.

[26] For example, from January 2024, community pharmacies will be funded to administer vaccines through the National Immunisation Program (i.e., eligible patients will no longer face an administration fee). Separately, some jurisdictions during the pandemic (such as the UK) allowed unregistered healthcare support workers to deliver COVID-19 vaccinations.

	Cost of mass vaccination	Cost of vaccination in GP settings
	591,100 work hours lost to vaccination = 30 minutes lost to vaccination x 1,182,200 people that are additionally vaccinated in New South Wales and working. 1,182,200 additional vaccinations of working people = 2 million vaccinations x 89% of under-65s are working age x 66% labour force participation rate.	
Total costs	$80.7 million	$155.5 million

Source: Cost per vaccination converts estimates from White (2021) into 2023 AUD figures. We take the mean wage of $47.60 from ABS (2022); and the working age population and labour force participation rates from ABS (2023).
Notes: There may also be other costs of vaccination not captured in the above such as the costs of promoting uptake of the vaccine. Note these estimates apply US-based cost estimates to New South Wales in the absence of more relevant Australian-based data available.

2.5 There is an opportunity to do further work in this space

Further work could be done to inform new national strategies on influenza control

Each year, Australian governments face the challenges that come with the influenza season, including the complex challenge of trying to increase vaccine uptake. While some State governments have made the vaccine temporarily free for all to boost uptake, the extent to which this has increased vaccine uptake remains unclear. Our illustrative estimates highlight a potential opportunity to further boost influenza vaccination.

Further work is needed, ideally at a national level. This is because influenza presents a national health challenge where Commonwealth and State governments share both the burden and responsibility. Further work could provide useful extensions to our estimates (examples provided below and in Appendix E:).

- **A more precise aspirational target vaccination coverage rate could be developed.** This could account for contact patterns and transmission dynamics across different age groups, among other factors.
- **A more sophisticated national economic model could be constructed based on local infectious disease modelling.** This could include local data about our population structure, social mixing patterns across ages, transmission parameters, vaccine effectiveness and background vaccination uptake levels. Economic estimates could then reflect this greater granularity by showing how the benefit-cost ratio varies based on uptake across cohorts.[27] Our estimates could also be improved by using NSW-specific vaccine cost data.
- **Further analysis could be undertaken on potential policy options to increase vaccine coverage among healthy populations and vulnerable cohorts.** We have canvassed some options in Sections 3 and 4, but more detailed analysis could be undertaken and initiatives identified to increase uptake across different cohorts. For example, it would be useful to have more insight into how the impact of funding incentives might vary across age groups. This could draw on updated information and data about peoples' attitudes towards vaccination.

This work could assist Australian governments with strategic planning and with exploring new strategies on influenza control. The establishment of the Australian Centre for Disease Control in 2024 presents an opportunity to pursue some of this work.

[27] It could also build on existing work, such as *Mathematical modelling to inform national seasonal influenza vaccination policy,* commissioned by the Australian Government Department of Health in 2019.

3 How and where could influenza vaccine uptake be improved?

Currently, most Australian adults receive vaccinations in medical settings - fewer than 30 per cent of vaccinated adults reportedly receive the jab at a pharmacy or the workplace (Trent et al., 2021). An additional challenge is that many unvaccinated people do not have regular contact with a healthcare provider, suggesting that non-medical settings can play an important role in increasing influenza vaccination rates (Lee et al., 2009).

Mass vaccination in non-medical settings can help to address some of these key barriers. Mass vaccination opportunities are particularly important for under-65s, who might otherwise forego annual vaccination due to inconvenience, cost and complacency. We outline two models of mass vaccination of under-65s below, including a school-based and workplace-based program, that have proven effective overseas.

While this paper focuses on potential ways to increase influenza vaccine uptake among healthy populations in schools and workplaces, there also remains room to boost uptake among vulnerable cohorts.

3.1 School-based vaccination can boost uptake for children

Despite big potential benefits, school-aged children have among the lowest vaccination rates

Targeting vaccination among school-aged children could deliver a significant payoff. This is because they play the leading role in spreading influenza virus yet have among the lowest influenza vaccination rates of all age groups (Worby et al., 2015; NCIRS, 2022). School-aged children are also more susceptible to influenza than is commonly understood (Baguelin et al., 2015). Flu infection in school children leads to higher rates of absenteeism among students and parents, additional medical costs and higher risk of more severe disease outcomes, such as pneumonia. Available data has also found that vaccinating school-aged- children is an efficient and cost-effective way to reduce the influenza disease burden in the broader community (Li & Leader, 2006; Salo et., al., 2006; Basta et. al., 2009).

Government-subsidised school-based vaccination has proven effective overseas

Unlike other vaccinations, such as for meningococcal, that form part of government immunisation programs, in New South Wales the onus is on parents to vaccinate their children against influenza by taking them to a clinic. This likely contributes to low rates of vaccination.

Overseas, publicly funded school-based vaccination programs have been effective in increasing coverage among school-aged children and reducing influenza-related illness in a cost-effective way. Schools have the advantage of vaccinating large numbers of school-aged children compared with clinic-based delivery (Cawley et al 2010). School-based programs provide accessible vaccination to regional, rural, and low-income households and reduce the demand on parental resources (Daley et Al., 2007; Lind et. Al., 2015). A survey of paediatricians in the US supported school-based programs to achieve target vaccination rates for children and alleviate pressure from office-based doctors (Keanne, Hudon & King, 2012).

In the UK, the National Vaccination Program (NVP) was extended in 2013 to target healthy children and adolescents aged 2-17 years of age through nasal vaccination. This had significant positive impacts for the broader population as well as for children. The program has resulted in substantial reductions in flu-related GP consultations, emergency department presentations and hospitalisations for children and older adults. See **Box 1**.

School vaccinations can be effective because they overcome three key barriers to vaccination: financial cost, parental attitudes towards the vaccine, and the inconvenience of vaccination (Effler et al 2010; Humiston et al., 2014; Pannaraj et al., 2014; Szilagyi et al., 2016; Yoo et al., 2019). These barriers are discussed further below.

School based mass vaccinations can remove the financial costs of getting a child vaccinated

Influenza vaccination rates have increased substantially when vaccines have been made free, both in Australia and overseas (Ward 2014; Howard et al 2021). This suggests that cost is an important factor in parents' decision to get their kids a flu jab. In 2018, the Australian National Immunisation Program was expanded in some jurisdictions, providing free flu shots to children under 5 years of age.[28] Jurisdictions that extended the NIP saw a 30-70 percentage point increase in vaccine uptake in the eligible group.[29] In New South Wales, the coverage rate of influenza vaccination in children under 5 years of age increased by 44 percentage points (Howard et al., 2021).

Schools provide a way to get vaccine information to parents

Parental uncertainty and misperceptions around the risk of influenza infection and vaccine safety can prevent parents from vaccinating their child (Daley et al., 2007; Flood et al., 2010; Santibanez & Kennedy, 2016). Parents may be unaware or misinformed about the benefits of immunisation in young children, resulting in apprehension about vaccines' necessity, efficacy and safety (Carlson et al., 2022; Daley et al., 2007). Survey evidence from the US indicates that many parents do not consider the flu vaccine to be necessary for healthy children, with two in five parents considering their child 'unlikely to get very sick from the flu' (Baty et al., 2013; Flood et al., 2010; Santibanez & Kennedy, 2016). Many parents are also sceptical of the protection vaccination provides children. Additionally, parental concerns about vaccine safety and the risk of adverse side effects may also inhibit uptake among children (Chow et al 2017; Frawley et al 2019).

School based mass vaccination programs can help address parents' uncertainty about vaccines. Educating parents on the risk of influenza and the benefits of vaccination is positively associated with uptake among children (Chow et al., 2017; Effler et al., 2010; Kassianos et al., 2020). A key part of the school-based vaccination program in the UK was providing accessible and accurate vaccine information to parents. Further research found that engaging with parents via school communication channels was essential to securing parental consent and vaccine uptake within the UK program (Kassianos et al., 2020). Information can be distributed from the classroom and present an opportunity to be a trusted source of influenza vaccine information to parents. This information can be translated into other languages based on the student demographic to increase accessibility and uptake.

Vaccinating in schools is convenient

The inconvenience of organising vaccination for children can also inhibit vaccine uptake. Parents who do not have easy access to a GP or pharmacy may forgo vaccination, despite understanding the necessity of doing so (Price et al., 2022). Survey evidence suggests that lack of available and convenient appointments, extended wait times, and vaccine shortages makes flu vaccination a low priority for busy parents – and can result in limited uptake of influenza vaccination. A US study found that almost a quarter of parents considered inconvenient appointment times a significant barrier to vaccinate. Two thirds of parents reported at least one medical-setting barrier (inconvenience, unavailable appointments, vaccine shortages) as a discouraging factor to vaccinate, highlighting the value of mass vaccination of children in non-medical settings (Alison et al., 2010).

[28] Since 2020, the NIP has provided free influenza vaccinations to under-5s. Before this, vaccines for this cohort were jurisdictionally funded.

[29] Comparing the average yearly vaccination rate between 2014-17 and 2018.

Box 1 – School-based vaccination program in the UK

Each year, school-aged children in the UK are eligible to receive a free nasal vaccine for influenza at school

In 2012, the Joint Committee on Vaccination and Immunisation (JCVI) recommended that the UK's National Vaccination Programme (NVP) for influenza be extended to include healthy children aged 2 to 17 years, using a nasal vaccine. This involved a school-based immunisation program for children aged 5-17 and pre-school immunisation (children aged 2-4) through GPs. The recommendation was informed by transmission modelling which indicated that this approach could directly reduce infections in the general population and indirectly protect high-risk groups (Kassianos et al., 2020; JCVI 2012).

Rollout

The full roll-out of the childhood influenza NVP aimed to vaccinate 9 million children during October to December each year (in line with the UK flu season). The roll-out of the program began in 2013-14 and covered children aged 2-3 years through GP practices and primary school-aged children (4-11 years) in school-based pilot programs across England and Scotland (Kassianos et al., 2020).[30] Due to the scale of the program, it was phased in over several years and expanded over time to include children in all age groups.

As of 2023, all children aged 2-3 years and all primary school-aged children have access to subsidised influenza vaccinations through the NVP via GP and school-based programs. Eligibility of secondary school children has varied across influenza seasons due to COVID-19. During the 2021-22 season, all children aged 2-16 years were eligible for subsidised vaccinations under the NVP. However, as of 2023, children in years 7-9 will be offered a subsidised vaccine later in the influenza season, with any remaining vaccines offered to children in years 10-11 (UKHSA, 2022).

Uptake

Uptake of the vaccine among school-aged children has been good to excellent since the introduction of the program. On average, between 30 per cent and 80 per cent of school-aged children were vaccinated each year between 2013 to 2021 (Kassianos et al., 2020). There has been much higher uptake in schools compared to GP/pharmacy settings (Howell-Jones et al 2023).[31] Uptake was also influenced by other factors such as severity of influenza season, vaccine supply constraints, parental attitudes, socioeconomic factors, vaccine efficacy and COVID-19 (student absences, labour shortages and lockdowns) (Kassianos et al., 2020).

Outcomes

Since the program's introduction, the childhood influenza NVP has positively impacted influenza-related-outcomes at age-specific and population levels. In the 2014-15 season, immunisation of children aged 5-10 years resulted in the following outcomes for their age group, compared to non-pilot areas:

- 94 per cent reduction in GP ILI consultations
- 74 per cent reduction in emergency department respiratory attendances
- 93 per cent reduction in confirmed influenza hospitalisations.

Vaccinating school-aged children also provided substantial indirect protection in other age groups. GP ILI consultations for individuals aged 50-70 years were significantly lower in pilot

[30] Age cohorts for immunisation vary between devolved administration and each phase of the roll-out.

[31] This is based on the best available data that compares vaccination in GP/pharmacy settings with vaccination in schools from the 2015-16 influenza season.

areas compared to non-pilot areas (3.4 per 100,000 vs 17.4 per 100,000 consultations), as were infections (8 per cent positive vs 30 per cent positive). Similar results were also seen at the general population level (aged over 17) with a 59 per cent reduction in GP consultations (Pebody et al 2015).

3.2 Workplace vaccination programs can help to protect the broader population

The convenience of workplace vaccination programs can motivate uptake among staff and can deliver benefits to the broader population

Working individuals that do not belong to an at-risk group often require a visit to a GP or pharmacy and incur an out-of-pocket cost to receive a flu vaccination. Offering vaccination in the workplace could improve coverage as it ensures the vaccine is convenient and accessible to workers who might otherwise not seek out the vaccine.

Workplace-based vaccination programs can be highly convenient for staff, given that most adults spend a lot of time at work. This means an employer's decision to deliver a workplace-based influenza vaccination program has the potential to substantially increase overall vaccination rates and provide broader benefits to the community. A Belgian study simulated the impact of an employer-funded influenza vaccination program at the workplace over a seven-year period. The simulation assumed that 20 per cent of the general Belgian population received their influenza vaccine but that coverage among Belgian workplaces was much higher, at 90 per cent. The model results suggested that employer-based programs could avert an additional 355,000 flu cases (or 78 per cent of all symptomatic cases), with almost 60 per cent of these avoided cases in the unemployed population. This implies that workplace vaccination programs can make large contributions to preventing the spread of influenza in the general population (Verelst, 2021).[32]

Workplace vaccination programs can be cost-effective for organisations

The benefits of workplace vaccination programs to businesses are well-documented (Prosser et al., 2008; Rothberg & Rose, 2005; Mori et al., 2022). These programs reduce absenteeism and presenteeism - where workers return to work before they are fully recovered and work inefficiently as a result. Workplace vaccination programs also contribute to positive employee perceptions of being supported by their organisation.

Workplace vaccination saves businesses money by reducing absenteeism and presenteeism, especially if employees do work that puts them at a high risk of infection. A US study found that such programs saved organisations up to $1,000 per vaccinated employee across all ages and major occupational groups (Lee et al., 2009).[33] While the return on investment for employers is generally positive, it likely varies between seasons, depending on the flu strain circulating and the vaccine match (Bridges et al., 2000; Verelst, 2021).

So, how can employers maximise the effectiveness of workplace vaccination initiatives?

[32] The study assumed vaccination coverage in the employed population was 90 per cent each season and assumed that all vaccination of the employed population is administered at the workplace and funded by their employer.

[33] This study found influenza vaccination to be cost saving (range of $15 to $995) for the employer for serologic attack rate scenarios of 20 per cent or higher (i.e., pandemics). However, they did not account for asymptomatic cases and a reduced transmission of influenza when symptomatic employees stay home. Savings for organisations varied by attack rate, reproduction rate, vaccine type and industry (median wages varied by industry).

Effective initiatives address convenience and confidence-related barriers among staff, such as by providing on-site vaccination, vaccination at no cost to employees, and education programs that explained the importance and benefits of vaccination (Landwehr et al., 2021; Ofstead et al., 2013). The following section offers potential initiatives and levers that Australian governments could consider to support workplaces to implement effective vaccination programs.

4 What can Australian governments do to facilitate vaccination in healthy populations?

Increasing vaccine uptake is challenging and vaccination rates remain low. It is clear from the onset of the flu season each year that more needs to be done to combat influenza so that we can avoid its heavy health and economic costs. This includes directly addressing the barriers to vaccination (as outlined in Section 3) such as inconvenience, financial cost, confidence in the vaccine, and parental concerns.

In this section, we outline initiatives and levers that Australian governments and the community could consider to improve uptake of the influenza vaccine. This includes initiatives that have been implemented in other jurisdictions across Australia and overseas, such as mass vaccination programs in non-medical settings which target healthy populations.

Further consideration about how these initiatives may be implemented and funded is required, which is beyond the scope of this paper. This may include exploring potential cooperative actions and funding between the Commonwealth and other jurisdictions given shared responsibility for the NIP.

4.1 Allow more of the population to be eligible for a free annual flu vaccine

Influenza vaccinations could be made free to the broader population

To address cost and convenience barriers to uptake, Australian governments could consider broadening eligibility for free influenza vaccines so that anyone can access free flu vaccines through a universal influenza vaccination program. Further work would be needed to consider potential funding arrangements between Commonwealth and State governments if eligibility for free vaccines is to be broadened, given shared responsibility for the NIP.[34]

Currently, people in New South Wales (who are not eligible for a free influenza vaccine) face around $20-25 in out-of-pocket costs for a jab at their local pharmacy (Chemist Warehouse, 2023; Priceline, 2023). In contrast (and as noted in Section 3), we estimate that each additional person under-65 that is vaccinated could deliver around $210 worth of net benefits to the state.

Free universal influenza vaccination programs have precedent in Australia. In Western Australia, all residents aged over 6 months were eligible for a free flu jab throughout May and June of 2023. In 2022, most states across Australia offered residents a free flu vaccination between June to July. Vaccination coverage across Australia was around 40 per cent in 2022, compared with 32 per cent in 2021 (NCIRS, 2023). In Ontario, Canada, the vaccine has been free to all since 2000 through the Universal Influenza Immunisation Program (UIIP) (see Box 2).

Reaching optimal levels of vaccine coverage may not be as simple as making the vaccine free. Indeed, the vaccine has been free for vulnerable cohorts, for years and vaccination rates still remain lower than would be ideal among some groups. Complementary initiatives are needed to address non-financial barriers to uptake, and further is needed to better understand these barriers, and how they may differ for different groups (see also Section 2.5).

[34] Funding considerations for future initiatives are beyond the scope of this paper. See Appendix D for a summary of current influenza vaccination funding arrangements.

In broadening eligibility for free influenza vaccination, Australian governments could consider strategies to further increase vaccine uptake among priority cohorts. These include First Nations people and culturally and linguistically diverse people. This may require consideration of strategies that promote vaccine uptake while acknowledging the unique cultural values and vaccine beliefs among different populations.

BOX 2 – Universal Influenza Immunisation Program in Ontario

Ontario, Canada, provides a free influenza vaccine for all citizens aged 6 months and older

Since 2000, Ontario, Canada, has delivered a Universal Influenza Immunisation Program which provides a free influenza vaccine for all citizens aged 6 months and over. In addition to traditional settings, the vaccine is administered in schools, workplaces, pharmacies, community centres and shopping malls.

Vaccine uptake

Since its introduction, the program has increased vaccine coverage for all age groups and there has been consistently higher coverage among those with chronic underlying condition (Glezen, 2009). Vaccine uptake increased by 24 percentage points in Ontario between 1997 and 2005 for those aged 12 and above, compared with a 15 percentage point increase in other Canadian provinces (Kwong et al., 2005).

Influenza-associated deaths and health service use

After the introduction of UIIP, flu-related deaths and hospitalisations and clinic visits were significantly lower in Ontario. In particular, greater reductions were observed among hospitalisations for older people aged 65-84. Flu-related deaths for the overall population declined 74 per cent in Ontario (from 15 deaths per 100,000 population to 4 deaths) compared to 57 per cent in other provinces (from 16 deaths per 100,000 population to 7 deaths) (Kwong et al., 2007).

The program increased vaccination rates for under-65s by around 10 percentage points and resulted in a near elimination of influenza infection – a 92 per cent reduction when the vaccine was well-matched. It also found that during the epidemic period hospital admissions almost halved and there was a 14 per cent decrease in work absenteeism. Overall, the program is estimated to deliver $171 million worth of savings (in an average vaccine match season), compared to annual program costs of $33 million – which represents a benefit-cost ratio of about 7 (Ward, 2014).

4.2 Set-up a school-based influenza vaccination program

The subsidy for influenza vaccinations could be extended to cover school-aged children

New South Wales could consider expanding eligibility for free vaccinations for school-aged children, who are ideal candidates for vaccination, through a school-based program similar to the UK's approach.

School-aged children in the UK are eligible to receive a free influenza vaccine at school each year administered nasally. In 2012, the UK expanded its National Vaccination Program to include healthy children aged 2-17 years through pre-school and school-based immunisation. Since its introduction, the program has improved flu-related outcomes across the population. It reduced GP consultations, emergency department attendances and hospitalisations among children aged 5-10, and reduced infections and GP consultations in people aged 50-70 (Kassianos et al., 2021). Australia has also seen some efforts to expand access to free influenza vaccinations. Since 2020, WA primary-school-aged children have had access to free influenza vaccinations at their local GP (Department of Health, WA, 2021).

Australian governments could explore ways to bring nasal spray flu vaccines to Australia for kids

While a nasal spray vaccine for influenza is used for school-aged children across the US, Canada, Europe and the UK, it is not yet available in Australia. The nasal spray is a live attenuated influenza vaccine (LAIV) that is administered intranasally for people aged 2-49 years. The nasal spray vaccine was first licensed in 2003 in the US and later expanded into markets across Canada, Europe and the UK. LAIV contains live forms of the influenza virus that have been weakened to stimulate the body's immune system and produce protective antibodies.

Stakeholder engagement indicates that a nasal vaccine is an important requirement for a school-based vaccination program because:

- The vaccine can be safely given at the same time as other routine childhood vaccinations and avoids the need for multiple injection sites on the body (both arms and legs, for example) during school-based mass vaccinations.
- Vaccines administered intranasally may be more widely accepted by parents and school-aged children compared to injected influenza vaccines (Public Health England, 2016).

In addition, the LAIV intranasal vaccine has been shown in some studies to have higher efficacy compared with inactivated intramuscular vaccines (i.e., needle-based influenza vaccine) in children aged 6-17 years, as well as younger children (Fleming et al., 2006; Vesikari et al., 2006; Bracco et al., 2009; Tam et al., 2007; Belshe et al., 1998). [35] It can also be administered quickly. In the UK, nasal vaccines administered in pilot areas took two minutes per child. One area estimated that each nurse was able to vaccinate around 50 children per 2.5-hour session (Kassianos et al., 2021).

While some progress has been made in the last decade, at the time of writing, no nasal spray flu vaccine was available in Australia. FluMist is a nasal spray LAIV that is currently distributed by AstraZeneca overseas. FluMist was registered in Australia with the Therapeutic Goods Administration in 2016 with specific conditions of registration. However, neither FluMist nor any other nasal spray vaccines are currently available for sale in Australia.[36]

In discussions with the NSW Productivity Commission, AstraZeneca noted that while a Southern Hemisphere version of the FluMist vaccine has not yet been manufactured, its 'ambition is to make FluMist available to as many people as possible including in the Southern Hemisphere'. In late 2021, AstraZeneca established a dedicated global vaccines and immune therapies unit to drive vaccination efforts, including efforts related to broader nasal spray distribution.

Australian governments could explore ways to support the development of a viable and preferably competitive market for nasal spray LAIVs in the Southern Hemisphere.

Australian governments could facilitate parent-focused initiatives to promote uptake among children

Australian governments can draw lessons about how to boost vaccine uptake among school-aged children from the UK campaign. One lesson was that effective engagement with parents is crucial to secure uptake, especially education about the importance of vaccination. As part of the program, an

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[35] Efficacy of influenza vaccines is varied across influenza seasons and jurisdictions. For example, the nasal spray vaccine was removed from the US market during the 2016-2018 seasons due to efficacy issues. Some studies have shown that the vaccine effectiveness of nasal influenza vaccines may not necessarily be higher than needle-based vaccines (Chung et al., 2019).

[36] This report discusses FluMist because it was registered in Australia with the Therapeutic Goods Administration.

invitation letter with vaccine information was distributed to parents and translated in multiple languages in many sites. School teams also provided parents with responses to frequently asked questions and a contact line for queries (Kassianos et al., 2021).

Australian governments could also consider initiatives to help ensure immunisers, such as medical practitioners, pharmacists and nurses, are equipped to address vaccine hesitancy among parents and others. COVID-19 vaccination efforts demonstrated the importance of nurses working in partnership with individuals and communities to promote confidence in the vaccine (Burden et al., 2021). Governments could play an enabling role in supporting nurses, pharmacists and other immunisers with this task (Lip et al., 2023). This could include developing resources (such as communication aids) for immunisers, to inform discussions about vaccinations with parents. It could also include training to equip immunisers with knowledge and skills to navigate different attitudes and beliefs about vaccination practice.

There may also be value in Australian governments supporting ‘nudges’ to remind parents and clinicians about influenza vaccination. Past experience suggests that parents who receive a recommendation from their paediatrician or specialist are much more likely to immunise their child (Tuckerman et al., 2018). Text message reminders sent by health care professionals to parents or children have been shown to increase vaccine uptake among some at-risk groups. In South Australia, a parent-level ‘nudge’- a text message delivered in a hospital setting – resulted in higher influenza vaccine uptake compared with clinician nudges alone (Tuckerman et al., 2023).[37]

4.3 Promote more workplace-based vaccination initiatives

There is a clear incentive for organisations to provide their staff with access to annual influenza vaccinations given the return on investment in the form of better staff attendance. However, Australian governments could provide additional support to these efforts. This could include tips for providing a successful workplace vaccination program, suggestions on how best to procure immunisers for the workplace, and a checklist for employers delivering such a program. For example, the Victorian Department of Health provides a workplace influenza vaccination kit that aims to support organisations to deliver workplace vaccination programs. The kit includes sample email text and promotional materials to promote vaccination programs, influenza facts for staff, and tips on convincing colleagues to get vaccinated (Victorian Department of Health, 2023).

Australian governments already subsidise vaccinations for staff in some sectors – and this could be expanded

As savings for organisations vary based on the influenza season, businesses may not want to commit to workplace vaccination programs. Therefore, there may be an opportunity for Australian governments to subsidise workplace vaccinations in selected settings. For example, all NSW Health staff are provided with a free annual influenza vaccination in NSW Health facilities. A similar approach could be taken in other high-transmission workplaces and/or workplaces with more at-risk populations. This could include early childhood services and schools, for example, given that children are more likely to transmit the disease when infected and young children are more prone to illness as their immunity develops (Worby et al., 2015). It could also include workplaces where staff work with children and the elderly, such as people who work in youth and children’s services, aged care facilities, correctional staff, teachers and student teachers on placement in schools.

[37] Parents were sent an SMS that recommended the influenza vaccine for children and encouraged parents to ask about the vaccine at their upcoming hospital appointment.

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Appendix A: Estimating the optimal flu vaccination rate

This appendix presents our approach to estimating the optimal flu vaccination rate for New South Wales to reach herd immunity. Section 2.5 proposes some further work that could be done to inform a more nuanced estimate of the target vaccination rate for New South Wales/Australia.

We estimate that the vaccination rate among under 65s required to reach herd immunity in New South Wales is **55 per cent.** This is broadly consistent with both (1) the basic formula for herd immunity (Fine et al., 2011) and (2) modelling of the theoretical marginal social benefit curves for influenza vaccination (White 2021; Boulier et al., 2007). These approaches estimate optimal vaccination rates of around 50-60 per cent in a well-matched season and are outlined below.

Basic formula for herd immunity – Fine et al., 2011

Fine et al., (2011) outlines a standard formula (where V_c is the required vaccine coverage) for herd immunity with a fully-effective vaccine:

$$V_c \approx 1 - \frac{1}{R_0}$$

Where R_0 is the basic reproduction rate; that is, the number of new infections an infected person creates. Ward (2014) assumes that influenza has a $R_0 = 1.4$, which implies:

$$V_c = 1 - \frac{1}{1.4} \approx 0.29$$

If vaccine effectiveness is imperfect, then higher vaccination coverage is required to achieve herd immunity (Fine et al., 2011):

$$V_c = \frac{1}{V_e} \times \left(1 - \frac{1}{R_0}\right)$$

White (2021) reports that influenza vaccine efficacy rates vary between 50-60 per cent for the prime age population in a good year.

Assuming a **55 per cent vaccine effectiveness**, the required vaccine coverage rate for the prime-age population is **53 per cent**:

$$V_c = \frac{1}{0.55} \times \left(1 - \frac{1}{1.4}\right) \approx 1.82 \times 0.29 = \mathbf{0.53}$$

Assuming **60 per cent vaccine effectiveness**, the required coverage rate for the prime-age population is approximately **50 per cent**:

$$V_c = \frac{1}{0.6} \times \left(1 - \frac{1}{1.4}\right) \approx 1.67 \times 0.29 = \mathbf{0.48}$$

Modelling marginal benefits of vaccination – White 2021

White (2021) presents a model derived from Boulier et al. (2007) that describes the theoretical marginal social benefit curves for the case of influenza vaccination which depend on vaccine efficacy. Several studies find values of vaccine efficacy among the prime-age population in the range of 50-60 per cent in a well-matched season (Demicheli et al., 2014; Grohskopf et al., 2014).

Assuming vaccine efficacy of 50 per cent, White estimates that the vaccine threshold beyond which there would be limited marginal benefits of vaccination is approximately **60 per cent.**

Appendix B: Estimating the costs and benefits of influenza vaccination for New South Wales

This appendix presents the approach to estimating:

- The number of additional vaccinations to reach herd immunity in New South Wales
- Total benefits of vaccination in New South Wales
- Total costs of vaccination in New South Wales.

Additional vaccinations required in New South Wales

National NCIRS data on influenza vaccination in 2022 was used as a proxy for current rates of influenza vaccination in New South Wales. The weighted average vaccination coverage rate for people aged under 65 was calculated to be ~27 per cent. For the purposes of this paper and to be conservative, we round this down to 25 per cent (Table 4).

Table 4 | Average influenza vaccination rates in Australia in 2022 (NCIRS, 2023)

	%	Notes / Source
Reported vaccination rates, 2022		
Average influenza vaccination rate in Australia	41	Average 2022 coverage rates reported by NCIRS
Average vaccination rate under 65s in Australia	33	As above, only for under 65s
Weighted average vaccination rates, 2022		
Weighted average influenza vaccination rate in Australia	39	Calculated; weights represent age groups as % of total NSW population (ABS, 2022)
Weighted average vaccination rate under 65s in Australia	**27**	As above, only for under 65s

Assuming influenza coverage among those aged under 65 increases from 25 per cent to 55 per cent (see Appendix A for details about the target vaccination rate), we calculate that approximately 2 million additional vaccinations are needed in New South Wales (Table 5).

Table 5 | Estimates of current and target vaccinated population under 65 in New South Wales

	No. of people	Notes / Source
Estimate of vaccinated population under 65 in New South Wales, assuming 25% vaccination rate		
NSW population aged under 65 years	6,740,500	ABS, 2022
Estimated vaccinated NSW population under 65	1,685,100	Calculated
Estimate of target vaccinated population under 65 in New South Wales, assuming 55% target rate		
Target vaccinated NSW population under 65	3,707,300	Calculated
Additional vaccinations required for people under 65	**2,022,100**	Calculated

Benefits of influenza vaccination

We construct different estimates of the benefits of influenza vaccination, including:

- bottom-up calculations of the total yearly costs of influenza in New South Wales on average, assuming that vaccination delivers herd immunity that eliminates the costs of influenza.
- top-down calculations of a 30-percentage point increase in the vaccination rate applying White's (2021) findings.

Bottom-up estimates

We estimate the total costs of influenza in New South Wales and then assume that increasing the vaccination up to the point of herd immunity (i.e., 2 million extra people) will eliminate the costs of influenza. Table 6 presents an overview of these calculations.

Table 6 | Overview of bottom-up calculations

Approach	Applied to New South Wales
GP consultations	
The 5-year average GP influenza-like-illness (ILI) consultation rate was 4.5 per 1,000 consultations (Australian Department of Health, 2022)	**National ILI-related GP consultations:** Applying this Australian Department of Health finding, we estimate that around 908,550 of the 201.9 million annual GP consultations in Australia (IBIS World, 2023) are for ILI i.e., 201.9 million x (4.5 / 1,000) = 908,550. **National flu-related GP consultations:** Assuming around 35 per cent of these ILI GP consults are actually related to influenza, and not other ILI like presentations such as pneumonia or RSV, we estimate there are 317,993 annual flu-related GP consultations nationally (Dolk et al., 2021) i.e., 908,550 consultations x 0.35 = 317,993. **NSW flu-related GP consultations:** Scaling these figures to the NSW population (given New South Wales made up 31.4% of the total population in 2022), we estimate around 100,000 GP consultations for the flu in the state each year i.e., 318,000 x 0.314 = 99,850. **Total cost avoided**: $7 million, assuming $70 cost per influenza-related GP consultation i.e., $70 x 99,850 = $6,989,475. We assume $70 to be consistent with the MBS schedule which notes the Medicare rebate for 20-40 minute standard consultations are between $40-$75. We choose the upper end of the range in order to capture the likelihood that some patients will also make a co-payment.
Work hours lost for carers	
On average, parents with children under 3 years of age missed an average of 3.2 workdays to care for their sick child per infection per year (Heikkinen et al., 2004)[38]	**Lost workdays:** We estimate 14,839 lost workdays each year i.e., 3.2 workdays lost per infected child x 4,637 reported flu infections among children aged 0-4 each year between 2010 and 2019 (pre-COVID) = 14,839 lost workdays. **Lost work hours:** We estimate this is equivalent 93,490 work hours lost i.e., 14,839 lost work days x 6.3-hour workday = 93,489.98. **Total cost avoided:** Using the mean hourly wage in New South Wales of $47.57, we estimate these lost work hours cost New South Wales $$4,447,417 in an average flu season (applying the approach to monetising lost work hours from White, 2021; Ward, 2014).
Hospitalisations[39]	

[38] Flu infections in New South Wales are not reported for children under 3 years, but they are reported for children between 0 and 4 years. We use reported flu cases among 0-4 year olds to estimate work hours lost among carers.

[39] The estimated number of flu-related hospitalisations and GP consultations avoided are large relative to the 34,000 average annual flu cases estimated (as part of calculations of lost healthy life years avoided). This is because the estimated value of healthy life years lost relies on *reported* flu infections, which likely underestimate actual infections. We use reported cases because we are applying the DALY burden per *reported* case. In contrast, estimates of hospitalisations and GP consultations do not rely on reported infections and are less likely to underestimate the actual burden of infection. It should be noted that the ratio of estimated hospitalisations to GP consultations is about 0.07 – which is consistent with findings from literature (Newall, 2008).

Approach	Applied to New South Wales
87.8 influenza-attributable respiratory hospitalisations per 100,000 population (Newall, 2018)	**Flu-related hospitalisations:** Applying this to the NSW population in 2022, we estimate that there are around 7,200 flu-related hospitalisations in New South Wales each year i.e., 8.1 million people in New South Wales (ABS, 2022) x (87.8 / 100,000) = 7,169 hospitalisations. **Total cost avoided:** Assuming that each flu-related hospitalisation costs $7,510 (converting estimates of flu-related hospitalisation costs from Newall, 2008 to 2023 dollars), this costs the NSW economy around $54 million on average each year i.e., $7,510 x 7,169 hospitalisations = $53,843,034.
Healthy life years lost	
Average DALY burden per influenza-reported case is 0.06 (AIHW, 2019)	**DALY burden per reported case:** The most recent available data on the burden of influenza in 2015 indicated that the DALY burden in Australia was 5,764 years (AIHW, 2019). Given there were around 100,600 reported flu cases in Australia in 2015, we estimate a DALY burden per reported case of 0.06 or 3 weeks of healthy life lost i.e., 100,600 cases / 5,764 DALY burden = 0.057 DALY burden per case. **Total DALY burden p.a.:** During the 10 years between 2010 and 2019, there were 417 reported flu infections per 100,000 population in New South Wales, on average. We apply this rate to the 2022 NSW population to estimate 34,050 reported flu cases per year i.e., 417 x (8.1 million / 100,000).[40] This would result in an estimated 1,951 healthy life years lost i.e., 34,050 flu cases x 0.057 DALY burden per reported case. **Total cost avoided:** $442.88 million, assuming $227,000 VSL (OBPR, 2022) i.e., $227,000 x 1,951 healthy life years = $442,880,648

Top-down estimates

Top-down calculations of the benefits of vaccinating under-65s (up to 55 per cent target coverage rate) in New South Wales is outlined in Table 7 below. These apply ratios from White (2021) to the NSW population.

Table 7 | Overview of top-down calculations applying White (2021)

White (2021)	Applied to New South Wales
Work hours saved	
An additional 1.92 vaccinations are required to save one 8-hour work day	**Workdays saved:** 2,022,153 additional vaccinations / 1.92 vaccinations = 1,053,205 workdays saved. **Work hours saved**: 1,053,205 workdays x 8 hours = 8,425,638 work hours. **Total cost avoided**: This equates to $400,816,444.97 million each year (assuming a mean hourly wage of $47.60) i.e., $47.57 x 8.4 million work hours saved.
Lives saved	
An additional 4,065 vaccines are required to save 1 life	**Lives saved:** 2,022,153 additional vaccinations / 4,065 vaccinations = 497 lives saved. **Monetising lives saved**: This equates to $ 903,377,576 million each year i.e., 497 lives saved x 8 years of life lost from death by the flu, on average (median age of death, 82, from Australian Department of Health, 2022 and expectation of life at age 82 from ABS, 2022) x $227,000 value of a statistical life year (OBPR, 2022).

[40] The estimate of 34,000 annual cases in New South Wales represents a lower bound as it relies on the number of reported flu cases (this results in an estimated benefit of $443 million in healthy life years saved). We use *reported* cases because we are applying the DALY burden per *reported* case. In Appendix C, we conduct sensitivity analysis and estimate healthy life years lost using other assumptions about the number of influenza infections each year. Assuming more annual infections (between 100,000 to 116,000 cases each year), the estimated benefit of healthy life years saved is between $1.3 to $1.5 billion.

Costs of influenza vaccination

We conduct two estimates of vaccination: mass vaccination and GP vaccination (Table 8).

Table 8 | Overview of cost calculations

Approach	Applied to New South Wales
Costs of mass vaccination	
Cost per vaccination in a mass vaccination setting is $15 in USD (White, 2021).	**Cost per vaccination in AUD:** Converting 2016 USD figures into 2023 AUD figures, we estimate that the cost per vaccination in mass vaccination settings is around $26 per vaccination. **Total cost of administering vaccinations**: $52.6 million i.e., $26 x 2.022 million people = $52,575,978.
Costs of vaccination in GP settings	
Cost per vaccination in a GP setting is $37 in USD (White, 2021).	**Cost per vaccination in AUD**: Converting 2016 USD figures into 2023 AUD figures, we estimate that the cost per vaccination in GP settings is around $63 per vaccination. **Total cost of administering vaccinations**: $127.4 million i.e., $63 x 2.022 million people = $127,395,639.
Working hours lost for vaccination	
Around 30 minutes of work time is lost due to vaccination (Verelst et al. 2021).	**Working age people to be vaccinated:** 89 per cent of under-65s in New South Wales are aged between 15-64 i.e., are of working age. This means there are around 1.79 million working-age people in New South Wales that need to be vaccinated i.e., 2.022 million x 88.58% = 1,791,251. **Working people vaccinated:** We estimate that 66 per cent of people aged 15-64 in New South Wales are working (based on the participation rate) i.e., 1.79 million x 66% = 1,182,225 people are working. **Work hours lost to vaccination:** If each of these 1.2m people lose 30 minutes of work time, this results in 591,112 work hours lost i.e., 1,182,225 people x 30 minutes = 591,112. **Total cost:** This is equivalent to $28 million, assuming $47.60 mean hourly wage i.e., 591,112 x $47.60 = $28,119,866.

Appendix C: Sensitivity analysis

This appendix outlines sensitivity analysis conducted on the estimated costs and benefits of influenza vaccination in New South Wales. This includes the following:

- Changing current and target vaccination coverage rates
- Using an alternative approach to estimating DALY burden of influenza
- Using alternative assumptions to estimate the value of lives saved
- Using median wages instead of mean wages.

Changing target and current vaccination coverage rates

We assume a 55 per cent vaccination coverage rate is required to reach herd immunity in New South Wales throughout the paper. Varying this assumption changes the number of additional people that need to be vaccinated in New South Wales to reach herd immunity, and therefore changes our estimates of the net benefit of vaccination. Below we present estimates under alternative assumptions that we should target a 50 per cent vaccination rate (implicitly assuming a more effective vaccine) and a 60 per cent vaccination rate (i.e., a relatively less effective vaccine), using our bottom-up approach.

We apply varying coverage rates to the cost of vaccination, rather than the benefits. We test the sensitivity of the benefits estimates through other approaches outlined overleaf.

Table 9 | Sensitivity analysis – changing target vaccination rates

Target vaccination coverage of under-65s	**50 per cent**	**55 per cent (base case)**	**60 per cent**
Assumption	*Assumes 1.7 million additional vaccinations or a 25 ppt increase in vaccination rate*	*Assumes 2 million additional vaccinations or a 30 ppt increase in vaccination rate*	*Assumes 2.4 million additional vaccinations or a 35 ppt increase in vaccination*
Total cost of mass vaccination	$67 million	$81 million	$94 million
Net benefit	$441 million ($261 per vaccine)	$427 million ($211 per vaccine)	$414 million ($175 per vaccine)

We assume vaccination coverage is currently 25 per cent among under-65s in the paper. Varying this assumption changes estimates of the net benefit of vaccination. We present estimates under alternative assumptions below, using our bottom-up approach.

Table 10 | Sensitivity analysis – changing current vaccination coverage rates

Current vaccine coverage	**20 per cent**	**25 per cent (base case)**	**30 per cent**
Assumption	*Assumes 1.3 million currently vaccinated (and 2.4 million additional vaccinations needed)*	*Assumes 1.7 million currently vaccinated (and 2 million additional vaccinations needed)*	*Assumes 2 million currently vaccinated (and 1.7 million additional vaccinations needed)*
Total cost of mass vaccination	$94 million	$81 million	$67 million
Net benefit	$414 million ($175 per vaccine)	$427 million ($211 per vaccine)	$441 million ($262 per vaccine)

An alternative approach to estimating DALY burden

We based our estimate of healthy life years saved from vaccination on average reported infections in New South Wales per 100,000 residents from 2010 to 2019, scaled to the 2022 NSW resident population. This reflects a lower bound, as it is based on reported influenza infections (likely underestimating actual infections). Here we test the sensitivity of this result to using different annual infection numbers. Firstly, we assume 100,000 annual cases, which takes the estimated number of flu-related GP consultations in New South Wales as a proxy for infection figures. Secondly, we use a different time period to estimate the average number of cases. We use 2022 infection figures (116,000 cases), which represents a particularly severe flu season.

Table 11 | Sensitivity analysis – number of estimated influenza infections p.a.

Number of estimated infections in New South Wales p.a.	34,000 cases (base case)	100,000 cases	116,000 cases
Assumption	*Takes the average reported flu infections per 100,000 population between 2010 to 2019 and scales it to 2022 estimated NSW population*	*Takes the estimated number of flu-related GP consultations each year in New South Wales as a proxy for the number of annual flu cases*	*Takes the number of reported flu cases in New South Wales in 2022*
Benefit of healthy life years saved (bottom up)	$443 million	$1.3 billion	$1.5 billion
Total benefit	$508 million	$1.4 billion	$1.6 billion

Alternative assumptions to estimate the value of lives saved

We estimate the value of the 500 estimated lives saved by using the value of a statistical life (VSL) and assume 8 years of life are saved when preventing a flu-related death in our top-down approach to estimates. This may over-represent the monetary value of lives saved. Firstly, the VSL used is not age-adjusted – as is recommended in most health economics literature. This is important because most flu deaths are concentrated among over-65s and the literature indicates that VSL declines in older age (Aldy and Viscusi, 2008). Secondly, given that mortality is concentrated among older people who may already be suffering from other illnesses and co-morbidities, the assumption of 8 additional life years could be too high. Below, we estimate the value of lives saved by adjusting the VSL and making an adjustment for comorbidities.

Table 12 | Sensitivity analysis – alternative assumptions to the value of lives saved

Approach to value of lives saved	Base case	Age-adjusted VSL	Adjusting for comorbidities	Adjusting VSL and for comorbidities
Assumption	*The VSL used is not age-adjusted and the value of lives saved does not adjust for comorbidities.*	*The VSL used is age adjusted. We assume the VSL for the years of life saved when preventing a flu-related death (among older adults) is $90,000 i.e., about 40% of the standard VSL.*[41]	*We assume 4 years of life are saved (instead of 8 years) when preventing a flu-related death, as a proxy to account for comorbidities.*	*We use an age-adjusted VSL and assume 4 years of life are saved when preventing a flu-related death.*
Value of lives saved	$903 million	$358 million	$452 million	$179 million

[41] Aldy and Viscusi (2008) find that VSL rises and falls over the life cycle, peaking at $375,000 at age 45 and declining to about $150,000 in a person's 60s. We take 40 per cent of the standard VSL ($150,000 / $375,000 = 40 per cent) as a proxy to adjust the VSL for age in our sensitivity analysis.

Approach to value of lives saved	Base case	Age-adjusted VSL	Adjusting for comorbidities	Adjusting VSL and for comorbidities
Assumption	*The VSL used is not age-adjusted and the value of lives saved does not adjust for comorbidities.*	*The VSL used is age adjusted. We assume the VSL for the years of life saved when preventing a flu-related death (among older adults) is $90,000 i.e., about 40% of the standard VSL.*[41]	*We assume 4 years of life are saved (instead of 8 years) when preventing a flu-related death, as a proxy to account for comorbidities.*	*We use an age-adjusted VSL and assume 4 years of life are saved when preventing a flu-related death.*
Total benefit	$1.3 billion	$759 million	$853 million	$580 million

Median wages instead of mean wages

We based our estimate of the value of work hours lost to illness on mean hourly wages. Here we test the sensitivity of this result by using median wages.

Table 13 | Sensitivity analysis – wages

Wages	$47.60 per hour (base case)	$37 per hour
Assumption	*Mean wages*	*Median wages*
Total benefits (bottom-up)	$508 million	$507 million
Total benefits (top-down)	$1.3 billion	$1.2 billion
Total costs (mass vaccination)	$81 million	$74 million

Appendix D: Current funding mechanisms for influenza vaccination

National Immunisation Program (NIP)

The National Immunisation Program (NIP) aims to increase national immunisation coverage to help reduce diseases that can be prevented by vaccination. The program provides a series of free vaccines to eligible people at specific times throughout life, ranging from birth to adulthood. It provides routine vaccinations free to those who hold or are eligible for a Medicare card. Examples of vaccinations that are free for certain groups through the NIP include: influenza immunisation for young children, HPV, diptheria and pertussis for adolescents, pertussis for pregnant women, and shingles and pneumococcal for older adults 70 years and over (DoAH, 2023).

The NIP is a collaborative program between the Australian Government and State and Territory Governments. The Australian Government is responsible for the national immunisation policy and the purchase and procurement of vaccines funded under the program. State and Territory Governments are responsible for the coordination and oversight of immunisation service delivery and distribution of vaccines (DoAH, 2023).

Recent expansions of the NIP across Australia

Recently, some states have expanded eligibility for free immunisation against the flu. In 2022, most states across Australia made vaccination against the flu free for residents given the severe influenza season. In 2020, the WA Government provided primary-school-aged children with access to free influenza vaccinations through GPs and pharmacies. In 2023, South Australia extended their Annual Funded Influenza Program to include people who are homeless. This covers adults and children currently living in improvised dwellings, tents or sleeping rough, supported accommodation for the homeless, boarding houses, other temporary dwellings, or severely crowded dwellings (SA Health, 2023).

Appendix E: Possible extensions

This paper presents some illustrative estimates to show the potential size of the benefit that we could get from more vaccinations of under-65s in New South Wales. These are broad estimates with some limitations which are outlined below. We would welcome further epidemiological modelling to complement the results presented in this paper.

- **Epidemiological modelling on the indirect benefits** of influenza vaccination would be very useful, particularly to inform more targeted strategies.
- Our report refers to evidence of the indirect benefits of influenza vaccination using high-quality observational studies. This is because there are inherent challenges with measuring the size of indirect benefits of vaccination using other recognised methods, like RCTs. This is because RCTs that randomise vaccination across individuals cannot capture externality/indirect benefits.
    - To illustrate, suppose that an RCT assigned one half of an office to receive an influenza vaccine and the other half a placebo. If the vaccine was effective and had positive spillovers, all participants in the trial could be protected by the herd immunity effect and there would be no measurable difference in outcomes for the treatment and control groups.
    - Cluster RCTs can capture externality benefits, like in Loeb et al. (2010), but it is difficult to show the impact on severe, infrequent outcomes like mortality. That said, there are many studies that show that flu vaccination in one group provides indirect protection in other groups (Friedman et al., 2019).
- In contrast, high quality observational studies on the population wide effects of influenza vaccination – such as Ward (2014) and White (2021) – rely on 'quasi-random' variation, such as year-to-year variations in the quality of the vaccine 'match', to uncover actual population level effects, inclusive of indirect effects or spillovers.
- **Applying outcomes from overseas studies**. This report applies some findings from overseas-based studies to estimate the potential benefits of influenza vaccination in New South Wales (White, 2021; Ward, 2014). There are differences between the context of those studies (US and Canada-based studies) and the NSW setting that this report focuses on, which may limit the applicability of some estimates presented in this paper. For example, the Australian healthcare system and immunisation program set up is different to that of the US. This report uses these studies in the absence of more relevant, Australian-based evidence and data available.
- **Stratifying vaccination targets by age-group.** The target vaccination rate presented in this paper groups under-65s into one target cohort for vaccination. The way that this target rate was derived does not account for key factors such as population movements, heterogeneity of different populations and the impact of age-group-specific influences on mixing patterns and dynamics. This means that even if the target rate is achieved, there may be suboptimal coverage depending on the specific groups that take up the vaccine, which would affect the size of benefits that could be realised with vaccination. Ideally, the target rate would be stratified by age group and other population groups (primary school-age students, adolescents, young adults, adults with families, working and non-working people), and would account for other parameters like transmission, vaccine effectiveness for prevention, and background vaccination uptake levels.

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