Impact of Australia's No Jab, No Pay policy on vaccination uptake – a before-after study in two national birth cohorts

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Summary

Background Data on impact of financial penalties for non-vaccination are sparse. Australia has required full vaccination for government family assistance payment eligibility since 1998. In 2016, the No Jab, No Pay (NJNP) policy removed registered non-medical objection as exemption option and increased eligibility assessment to yearly. We aimed to examine NJNP impact on vaccine uptake in children.

Methods Individual-level Australian Immunisation Register data were used to assemble two-year-wide pre-/post-NJNP birth cohorts aged 1–<3 years, stratified by registered objection (yes/no) and vaccination status (zero-dose/partially vaccinated/fully vaccinated). At 5–<7 years, we measured odds ratios (ORs) and 95% confidence interval (CIs) for vaccination outcomes post-versus pre-NJNP and compared observed post-NJNP numbers with those expected if proportions pre-NJNP applied.

Findings Pre-NJNP of 562,316 children aged 1–<3 years, 92.1% were fully vaccinated, 4.9% partially vaccinated and 3.0% zero-dose; objection was registered for 1.1% overall (23.9% of zero-dose). Post-NJNP of 615,607 aged 1–<3 years, 92.7% were fully vaccinated, 4.7% partially vaccinated, 2.6% zero-dose; objection was registered for 1.5% overall (37.7% of zero-dose). By 5–<7 years of age, full vaccination was significantly higher post-than pre-NJNP in children with registered objection (zero-dose 14.6% versus 1.2% [OR 14.1; 95% CI 10.5–18.9]; partially vaccinated 41.7% versus 8.4% [OR 7.9; 95% CI 6.4–9.7]) and without objection (zero-dose 10.1% versus 4.9% [OR 2.2; 95% CI 2.0–2.4]; partially vaccinated 39.2% versus 34.5% [OR 1.2; 95% CI 1.1–1.3]). Post-NJNP we estimated 49,510 more children (3.7% with registered objection) to be fully vaccinated than expected. Odds of remaining zero-dose were 0.38 (95% CI 0.34–0.42) with versus 0.66 (0.63–0.70) without registered objection and fewer children (9,206, 1.5%) were persistently zero-dose post-than pre-NJNP (10,696, 1.9%).

Interpretation Full vaccination by age 5–<7 years increased post-NJNP irrespective of baseline vaccination/objection status. Relative increases were much higher among children with registered objection than without, but partially vaccinated children without objection largely accounted for numerical increases, suggesting increased eligibility assessment was more important than changes in exemption criteria.

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Keywords: Childhood vaccination; Childhood immunisation; No Jab No Pay; Vaccine mandates; Immunisation mandates; Immunisation coverage; Vaccination policy; Public health policy design; Financial sanctions; Vaccine hesitancy; Parent attitudes and beliefs

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Research in context

Evidence before this study

We searched Google Scholar on 12th July 2024, with the terms "impact" and "financial" and "penalties" and "child" and "vaccination", in any language from 1999 onwards. After excluding studies relating to policies that did not include financial penalties or were limited to vaccines against COVID-19 and/or to older age groups (adolescents and adults), we identified three studies from the United States, two studies from Europe and four studies from Australia.

Added value of this study

Our study is the first to analyse a national policy using individual level data on immunisation status and registered (non-medical) objection. A long-standing comprehensive national immunisation register allowed us to compare the vaccination status of completely unvaccinated (zero dose) with partially vaccinated children and with those who did and did not have a registered objection. Our design using two large birth cohorts of identical width over a four-year period gave adequate power to examine receipt of all recommended and individual vaccines. The substantial size of payments foregone in Australia (maximum AUD $26,000 [€15,600] annually per child for lower income families by 2019), with around half of all families estimated to be eligible for some payment, added to capacity to detect an effect. Previous evaluations of the impact of the No Jab No Pay (NJNP) Australian legislation introduced in 2015 varied in their methods and conclusions. We found that by all measures and in all subgroups examined, immunisation uptake increased in the post-compared with the pre-NJNP cohort over the four-year follow-up period. In children without registered objection, relative increases in full vaccination were lower (ORs 1.2–2.2) than those with registered objection (ORs 5.1–14.1) but they made up more than 95% of the estimated additional 49,510 children (8.0% of total post-NJNP cohort) fully vaccinated after four years follow-up. Based on this we concluded that additional eligibility assessments made a much greater contribution to increases in fully vaccinated children than removal of non-medical objection exemptions.

Implications of all the available evidence

Financial sanctions for non-vaccination were effective in a high-income country where their application has strong bipartisan public support, and where data on vaccination status is recorded at individual level by a high functioning immunisation information system. Countries considering the merits of financial sanctions should take account of the countervailing issues of limited impact on vaccine-refusing families, and potential to exacerbate inequity among socioeconomically disadvantaged families who are more likely to receive and need financial assistance.

Introduction

Parental refusal of childhood vaccines has been linked to measles and pertussis outbreaks in the United States,[1] where there is a long history of mandatory vaccination requirements at school entry.[2] Mandatory vaccination also has a long history in Europe,[3] but has attracted more attention following strengthening of mandates in France, Germany and Italy following measles outbreaks in 2017–18.[4] Evidence on the effectiveness of mandates is limited,[5,6] and primarily relates to school entry mandates in the United States.[5,7] Financial mandates are uncommon globally[8] and evidence of their effectiveness is limited and mixed.[5,9,10] Early studies of payment or withholding of payment dependent on vaccination status among small numbers of children in different US States differed in their findings. A study in the US Midwest found that financial payments significantly added to the effectiveness of other measures,[11] while randomised studies of financial penalties for incomplete vaccination among low income families found no impact on uptake in Maryland[12] but significant impact in Georgia,[13] and their focus on low-income families was criticised on ethical grounds.[14] To our knowledge, only Australia has adopted a policy at national level requiring documented receipt of all recommended vaccines for eligibility for government family assistance payments, although countries in Europe have variably enforced fines[3,4] and financial penalties continue to apply in some states in the US.[15]

In Australia, linking eligibility for some government family assistance payments to full vaccination began in 1998.[16] By 2019, the maximum estimated monetary value of these payments had increased to AUD $26,000 (€15,600) annually per child for lower income families[10] with around half of all families estimated to be receiving some payment.[17] In November 2015, the Social Services Legislation Amendment (No Jab, No Pay) Act,[18] hereafter abbreviated as NJNP, removed registered non-medical (i.e. religious, moral or philosophical) exemption from the full vaccination requirement for payment eligibility, narrowed allowable medical exemptions and made eligibility assessments, previously at 1, 2 and 5 years only, annual up to 20 years of age.[19] Frequency of eligibility assessment increased to fortnightly from July 2018.[17] Although evidence from many settings has found that access barriers are more important contributors to incomplete childhood vaccination than active vaccine refusal,[20–22] vaccine mandates using financial mechanisms, as exemplified by NJNP, have attracted international interest.[3,4,23] As in the United States,[14] the application of financial mandates has been criticised in Australia for disproportionate impact on low-income families and other less advantaged groups, such as migrants and refugees.[24,25]

Previous evaluations of NJNP impact using Australian Immunisation Register (AIR) data have differed in methodology and findings. An ecological before-after analysis of vaccine coverage data among children aged less than five years found no statistically significant impact.[23] In contrast, a longitudinal study of changes in coverage at one, two and five years found significant increases, but limited to more disadvantaged areas,[26] and a before-after study using individual-level AIR data for children aged five to less than seven years found a significant increase in uptake of the third dose of diphtheria-tetanus-pertussis (DTP)-containing vaccine, but a slight decrease in first doses of measles-mumps-rubella (MMR) vaccine.[17] None of these studies analysed individual level data on registered (non-medical) objection—the first two used data on proportions of children with registered objection living in Australian Bureau of Statistics defined geographic areas containing populations between 30,000 and 130,000 people and the third did not assess by registered objection status.

Based on our previous work[19] and data from the Longitudinal Study of Australian Children[27] we hypothesised that the majority of children who had no vaccines recorded on the AIR by 12 months of age had parents who objected to vaccination, even if this objection was not registered. We used a before-after design and individual-level AIR data to compare vaccine uptake by five to less than seven years of age in two-year-wide pre- and post-NJNP birth cohorts aged one to less than 3 years at baseline, with our analysis stratified by individual-level registration of non-medical objection and vaccination status at baseline.

Methods

Data source

Since 1996, vaccination data have been captured in a national immunisation register (Australian Childhood Immunisation Register [ACIR]) built from demographic and vaccination data of children aged under seven years registered with Medicare (Australia's universal health care system). On 1 January 2016, the register expanded to include records of vaccines received up to 20 years of age, and on 30 September 2016 became the all-age AIR. A person remains active on the AIR until Medicare is notified that they have died or permanently left Australia, after which an 'end date' is applied to their AIR record, with such records not included in subsequent analyses. Childhood vaccination data in the AIR have a high level of completeness and accuracy.[28] The study was exempted from ethics approval by The Sydney Children's Hospitals Network Human Research Ethics Committee as analysis was limited to de-identified administrative data under the approval of the Australian Government Department of Health and Aged Care.

Study design

Two study cohorts were assembled, comprising children aged one to less than 3 years at baseline (31 March 2008 for the pre-NJNP cohort and 31 March 2015 for the post-NJNP cohort). We used the date of NJNP announcement rather than NJNP implementation for data censoring of the post-NJNP cohort as the policy received considerable media attention, which may have prompted catch-up vaccination before the implementation date. At baseline children were allocated to six sub-cohorts based on their registered (non-medical) objection (RO) status (yes/no) and vaccination status. Using AIR data, vaccination status was classified as "zero-dose" (no vaccine doses recorded), "partially vaccinated" (some vaccine doses recorded but not fully vaccinated), and "fully vaccinated" (record of all policy-required doses). To maximise comparability, given that eligibility was assessed annually until mid-2018, fully vaccinated status at baseline was assessed using year-wide age-based coverage algorithms, with the same algorithms used for both pre- and post-NJNP cohorts. For children one but less than two years of age, fully vaccinated was defined as three doses of DTP, polio, *Haemophilus influenzae* type b (Hib) and hepatitis B containing vaccines (usually given together over the study period as a hexavalent combination vaccine) and three doses of pneumococcal conjugate vaccine, and if two but less than three years of age, as three doses of DTP, polio and hepatitis B, four doses of Hib and one dose of MMR vaccine. Vaccine doses received over the subsequent four-year follow-up period (to 31 March 2012 for pre-NJNP and to 31 March 2019 for post-NJNP cohort) were ascertained from the AIR, by the end of which all children had reached the age of at least five and up to seven years. As vaccine doses given to children aged over seven years were not included on the AIR until 2016, and RO status was not recorded from 2016 onwards, a four-year follow-up period for two birth cohorts of identical two-year width was the most recent and complete data suitable for longitudinal analysis by RO status at baseline.

Outcome variables

The primary outcomes were number and proportion of children in each sub-cohort who, by the end of the four-year follow-up period, when all cohort members were aged five to less than seven years, had received all vaccines required under NJNP to satisfy criteria for fully vaccinated and qualify for payment eligibility. Fully vaccinated was defined as: four doses of DTP, three doses of polio and hepatitis B, two doses of MMR and one dose of both meningococcal C conjugate and varicella-containing vaccine (13vPCV was not included as healthy children aged five years and over do not require vaccination even if no prior doses have been received).[29] Secondary outcomes included the number and proportion of children who: a) received at least one vaccine dose during the follow-up period but did not meet fully vaccinated criteria; b) remained zero-dose for all vaccines; and c) received individual vaccine doses required for fully vaccinated status. In the pre-NJNP cohort, we assessed vaccines given between 1 April 2008 and 31 March 2012, using AIR data available on 31 March 2013. In the post-NJNP cohort, we assessed vaccines given between 1 April 2015 and 31 March 2019, using AIR data available on 31 March 2020. As well as calculating the proportion of children in the post-NJNP cohort who met fully vaccinated criteria, we compared the observed number of children fully vaccinated with that expected. Expected numbers were calculated by applying proportions observed in the pre-NJNP cohort to the corresponding number of children in the post-NJNP cohort. We separately calculated the number and proportion of children in each cohort who had received a full course of each individual vaccine by the end of follow-up and, of children completely unvaccinated at baseline, the number and proportion who remained zero-dose at the end of follow-up for individual vaccines.

Statistical analysis

This study design was observational, using a retrospective cohort and before/after outcome measures. The proportion of children meeting relevant criteria at the end of the four-year follow-up period in the post-NJNP versus the pre-NJNP cohorts was compared by calculating odds ratios (ORs) and 95% confidence intervals (95% CIs) for each outcome of interest. All analyses were performed using SAS 9.4 (SAS Institute).

Role of the funding source

The Australian Government Department of Health and Aged Care had no role in study design, data collection, data analysis, data interpretation, writing of the manuscript, nor in the decision to submit the manuscript for publication.

Results

Vaccination and registered objection status at baseline

In the pre-NJNP cohort (Fig. 1), 517,623 (92.1%) of 562,316 children aged one to less than three years with a record on AIR met our criteria for fully vaccinated at baseline (31 March 2008). As expected, very few (650; 0.1%) of these fully vaccinated children had registered (non-medical) objection (RO). Of the remaining 44,693 (7.9%) under-vaccinated (i.e. partially vaccinated or zero-dose children), 5414 (12.1%) had RO, of whom 4001 (73.9%) were zero-dose. Of the 39,279 under-vaccinated children without RO, 12,718 (32.4%) were zero-dose. In the post-NJNP cohort (Fig. 1), the number of children aged one to less than three years was 615,607 at baseline on 31 March 2015, 9.5% higher than pre-NJNP. Among them, 570,748 (92.7%) were fully vaccinated (0.6 of a percentage point higher than pre-NJNP). Of the remaining 44,859 (7.3%) under-vaccinated children, 8090 (18.0%) had RO, 5.9 percentage points higher than pre-NJNP, with a similar proportion zero-dose (6145; 75.9%). There were fewer

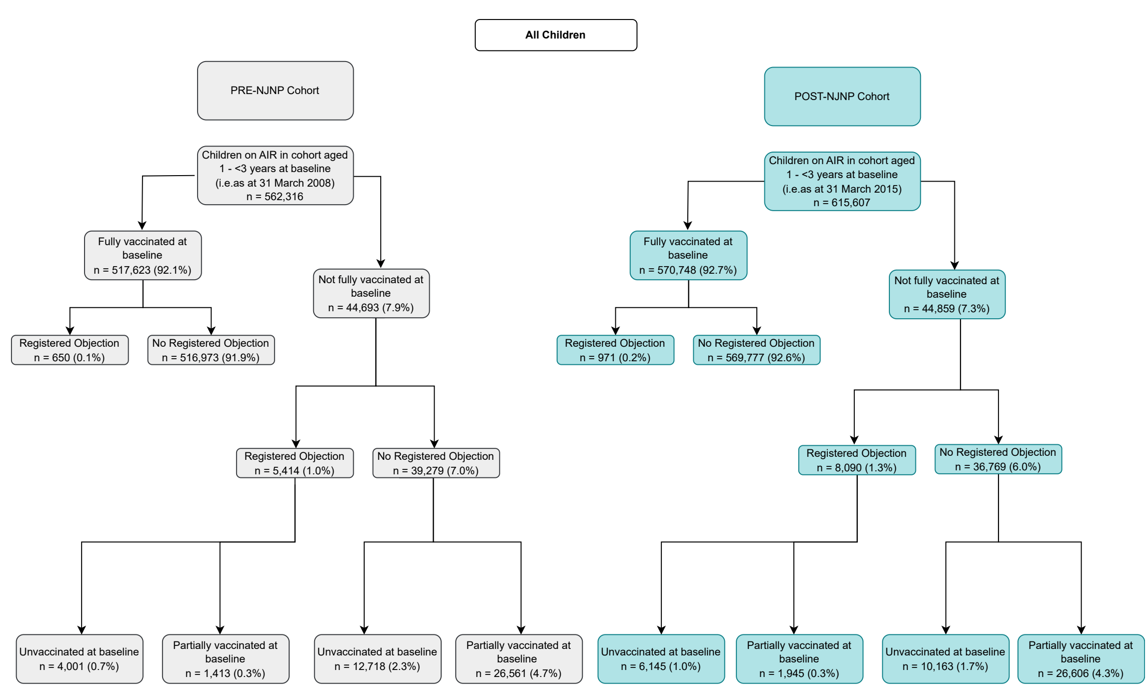

Fig. 1: Pre- and post-NJNP cohorts at baseline (31 March 2008 and 31 March 2015, respectively). Note: Due to rounding, the percentages presented for each component may not sum to the total percentage shown.

	N (%) pre-NJNP cohort	N (%) post-NJNP cohort	Odds ratio (95% CI)[c]
Unvaccinated at baseline (age 1–<3 years)			
N = 4001 pre-NJNP			
N = 6145 post-NJNP			
1. Became fully vaccinated by end of follow-up (age 5–<7 years)	48/4001 (1.2%)	897/6145 (14.6%)	14.1 (10.5–18.9)
2. Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	433/4001 (10.8%)	738/6145 (12.0%)	1.1 (1.0–1.3)
Partially vaccinated at baseline (age 1–<3 years)			
N = 1413 pre-NJNP			
N = 1945 post-NJNP			
1. Became fully vaccinated by end of follow-up (age 5–<7 years)	118/1413 (8.4%)	812/1945 (41.7%)	7.9 (6.4–9.7)
2. Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	645/1413 (45.6%)	513/1945 (26.4%)	0.4 (0.4–0.5)
Fully vaccinated at baseline (age 1–<3 years)			
N = 650 pre-NJNP			
N = 971 post-NJNP			
1. Remained fully vaccinated at end of follow-up (age 5–<7 years)	197/650 (30.3%)	670/971 (69.0%)	5.1 (4.1–6.4)
2. Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	300/650 (46.2%)	138/971 (14.2%)	0.2 (0.2–0.3)
All three categories above combined at baseline			
N = 6064 pre-NJNP			
N = 9061 post-NJNP			
1. Fully vaccinated at end of follow-up (age 5–<7 years)	363/6064 (6.0%)	2379/9061 (26.3%)	5.6 (5.0–6.3)
2. Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	1378/6064 (22.7%)	1389/9061 (15.3%)	0.6 (0.6–0.7)

[a]Aged 1–<3 years at baseline i.e. on 31 March 2008 (pre-NJNP) or 31 March 2015 (post-NJNP); Aged 5–<7 years at end of four-year follow-up i.e. on 31 March 2012 (pre-NJNP) or 31 March 2019 (post-NJNP). [b]Vaccination activity over 4-year period between 1 April 2008 and 31 March 2012 for pre-NJNP and between 1 April 2015 and 31 March 2019 for post-NJNP cohort. [c]Post-NJNP versus pre-NJNP cohort.

Table 1: **Children[a] with registered objection: vaccination activity over four-year follow-up period, post-versus pre-NJNP cohort.[b]**

under-vaccinated children without RO (36,769) in the post-NJNP cohort, and the proportion of them who were zero-dose (27.6%) was 4.8 percentage points lower than pre-NJNP.

Vaccine receipt during follow-up period by registered objection status

The proportion of five to less than seven-year-old children meeting fully vaccinated criteria at end of the four-year follow-up period was significantly higher in the post- than pre-NJNP cohort across all six sub-cohorts, most marked in children with RO (Table 1, Fig. 2). Among children with RO who were zero-dose at baseline (aged one to less than three years), 1.2% pre- versus 14.6% post-NJNP became fully vaccinated (13.4 percentage points higher; OR 14.1; 95% CI 10.5–18.9). Among children with RO who were partially vaccinated at baseline, the proportion becoming fully vaccinated increased from 8.4% pre- to 41.7% post-NJNP (33.3 percentage points higher; OR 7.9; 95% CI 6.4–9.7). Similarly, among the few children with RO who were fully vaccinated at baseline full vaccination at the end of follow-up also increased (by 38.7 percentage points; from 30.3% pre- to 69.0% post-NJNP, OR 5.1; 95% CI 4.1–6.4).

For children without RO (Table 2, Fig. 2), relative differences were less marked, but absolute changes in the number in each category of vaccination status were much greater than for children with RO. For those zero-dose at baseline, the proportion meeting fully vaccinated criteria by the end of follow-up at five to less than seven years was 5.2 percentage points higher in post- than pre-NJNP (10.1% versus 4.9%, OR 2.2; 95% CI 2.0–2.4) and 4.7 points higher for those initially partially vaccinated (39.2% versus 34.5%, OR 1.2; 95% CI 1.2–1.3). For children without RO and fully vaccinated at baseline, the category with by far the largest numbers of children (516,974 pre- and 606,777 post-NJNP), the proportion fully vaccinated at end of follow-up was 7.3 percentage points higher post- than pre-NJNP (92.9 versus 85.6%, OR 2.2; 95% CI 2.2–2.3).

Differences in the proportion of children who received one or more vaccine doses in the four-year follow-up period but did not meet criteria for fully vaccinated varied. There was a 1.2 percentage point increase among those with RO and zero-dose at baseline post-NJNP (12.0%) compared with pre-NJNP (10.8%) (OR 1.1; 95% CI 1.0–1.3). However, among those with RO who were initially partially vaccinated, the proportion who received one or more vaccine doses but did not meet criteria for fully vaccinated was 19.2 percentage points lower (26.4% versus 45.6%, OR 0.4; 95% CI 0.4–0.5) (Table 1, Fig. 2). For the small group with RO and initially fully vaccinated, the proportion not fully vaccinated at end of follow-up was 32.0 percentage points lower (14.2% versus 46.2%, OR

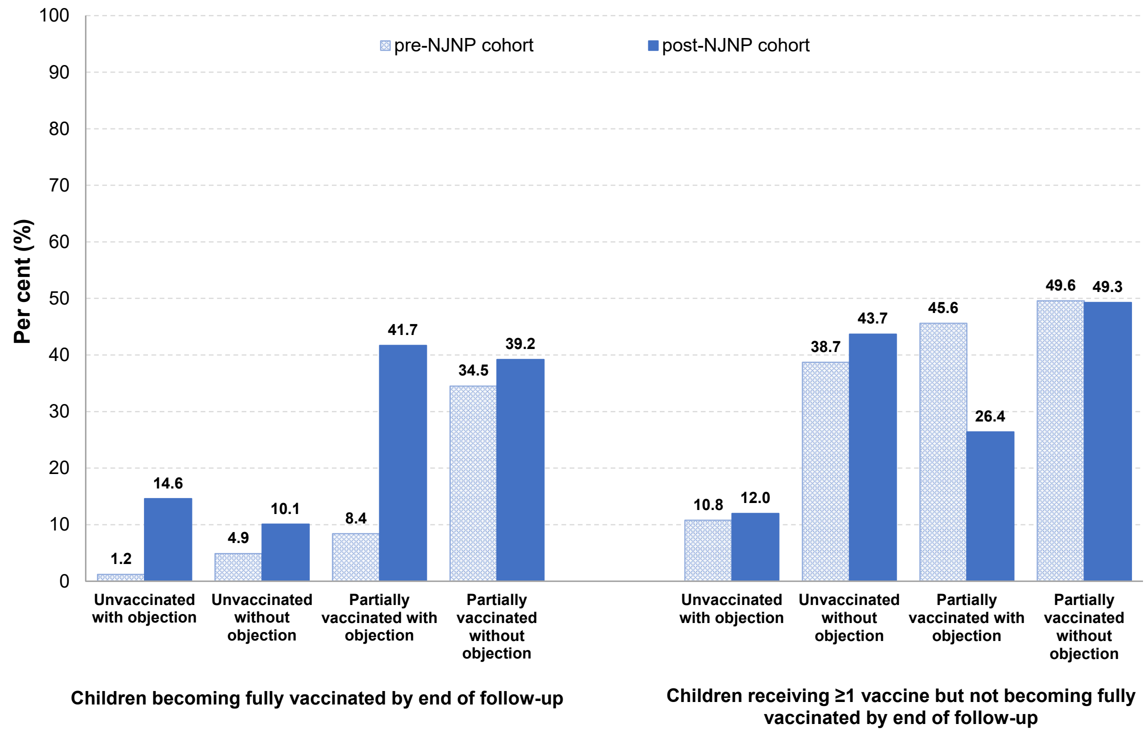

Fig. 2: Percentage of under-vaccinated children fully vaccinated by end of 4-year follow-up period,[a] or receiving ≥1 vaccine but not fully vaccinated, by objection and vaccination status at baseline, pre- and post-NJNP cohort[b]. [a]Vaccination activity over 4-year period (between 1 April 2008 and 31 March 2012 for pre-NJNP and between 1 April 2015 and 31 March 2019 for post-NJNP cohort. [b]Children aged 1–<3 years on 31 March 2008 (pre-NJNP denominator at baseline: n = 562,316) or 31 March 2015 (post-NJNP denominator at baseline: n = 615,607) - aged 5–<7 years on 31 March 2012 (pre-NJNP) or on 31 March 2019 (post-NJNP). Sub-cohort denominators at baseline (% of total cohort): Unvaccinated with objection: n = 4001 (0.7%, pre-NJNP) and n = 6145 (1.0%, post-NJNP); Unvaccinated without objection: n = 12,718 (2.3%, pre-NJNP) and n = 10,163 (1.7%, post-NJNP) Partially vaccinated with objection: n = 1413 (0.3%, pre-NJNP) and n = 1945 (0.3%, post-NJNP); Partially vaccinated without objection: n = 26,561 (4.7%, pre-NJNP) and n = 26,606 (4.3%, post-NJNP).

0.2; 95% CI 0.2–0.3) (Table 1). Among children without RO (Table 2), the proportion who received vaccines but did not meet criteria for fully vaccinated by the end of follow-up was 5.0 percentage points higher in those zero-dose at baseline in the post- (43.7%) than the pre-NJNP (38.7%) cohort (OR 1.2; 95% CI 1.2–1.3) but slightly lower in children initially partially vaccinated (49.3% versus 49.6%, OR 1.0; 95% CI 0.96–1.0). In the largest group (without RO and initially fully vaccinated, 516,973 pre- and 569,777 post-NJNP) the proportion who received vaccines but did not meet criteria for fully vaccinated by the end of follow-up was 50% lower at four-year follow-up (5.8% post-versus 12.1% pre-NJNP, OR 0.5; 95% CI 0.4–0.5) (Table 2).

Overall changes in vaccine uptake in post-NJNP versus pre-NJNP cohorts

Changes in receipt of all vaccines required to meet fully vaccinated criteria

When children in all three vaccination status categories at baseline (zero-dose, partially vaccinated, fully vaccinated) were combined, the proportion who met fully vaccinated criteria by the end of follow-up was 20.3 percentage points higher in those with RO in the post-NJNP (26.3%; 2379/9061) than the pre-NJNP cohort (6.0%; 363/6064), and 7.9 points higher for those without RO (89.2%; 540,795/606,546 versus 81.3%; 452,489/556,252) (Tables 1 and 2). When expected numbers in the post-NJNP cohort were calculated based on the proportions observed pre-NJNP, an additional 49,510 children (1836 with RO and 47,674 without RO), representing 8.0% of the total post-NJNP cohort, met fully vaccinated criteria than expected. In contrast, there was a decrease in the proportion of children who received at least one vaccine dose but did not meet fully vaccinated criteria—7.4 percentage points lower for children with RO post- (15.3%) than pre-NJNP (22.7%), and 6.2 points lower (8.3% versus 14.5%) for those without RO (Tables 1 and 2).

Changes in receipt of all required doses of individual vaccines

The number and proportion of children who had received all required doses of each of the individual vaccines required to meet fully vaccinated criteria at the

	N (%) pre-NJNP cohort	N (%) post-NJNP cohort	Odds ratio (95% CI)[c]
Unvaccinated at baseline (age 1–<3 years)			
N = 12,718 pre-NJNP			
N = 10,163 post-NJNP			
1. Became fully vaccinated by end of follow-up (age 5–<7 years)	617/12,718 (4.9%)	1022/10,163 (10.1%)	2.2 (2.0–2.4)
2. Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	4925/12,718 (38.7%)	4445/10,163 (43.7%)	1.2 (1.2–1.3)
Partially vaccinated at baseline (age 1–<3 years)			
N = 26,561 pre-NJNP			
N = 26,606 post-NJNP			
1. Became fully vaccinated by end of follow-up (age 5–<7 years)	9153/26,561 (34.5%)	10,425/26,606 (39.2%)	1.2 (1.2–1.3)
2. Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	13,184/26,561 (49.6%)	13,130/26,606 (49.3%)	1.0 (0.96–1.0)
Fully vaccinated at baseline (age 1–<3 years)			
N = 516,973 pre-NJNP			
N = 569,777 post-NJNP			
1. Remained fully vaccinated by end of follow-up (age 5–<7 years)	442,719/516,973 (85.6%)	529,348/569,777 (92.9%)	2.2 (2.2–2.3)
2. Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	62,462/516,973 (12.1%)	32,882/569,777 (5.8%)	0.5 (0.4–0.5)
All three categories above combined at baseline			
N = 556,252 pre-NJNP			
N = 606,546 post-NJNP			
Fully vaccinated at end of follow-up (age 5–<7 years)	452,489/556,252 (81.3%)	540,795/606,546 (89.2%)	1.9 (1.8–1.9)
Received ≥1 vaccine over follow-up period but not fully vaccinated by end of it (age 5–<7 years)	80,571/556,252 (14.5%)	50,457/606,546 (8.3%)	0.5 (0.5–0.5)

[a]Aged 1–<3 years at baseline i.e. on 31 March 2008 (pre-NJNP) or 31 March 2015 (post-NJNP); Aged 5–<7 years at end of four-year follow-up i.e. on 31 March 2012 (pre-NJNP) or 31 March 2019 (post-NJNP). [b]Vaccination activity over 4-year period between 1 April 2008 and 31 March 2012 for pre-NJNP and between 1 April 2015 and 31 March 2019 for post-NJNP cohort. [c]Post-NJNP versus pre-NJNP cohort.

Table 2: **Children[a] with no registered objection: vaccination activity over four-year follow-up period, post-versus pre-NJNP cohort.[b]**

end of the follow-up period is shown for each cohort in Table 3. The proportion who had received all required doses was higher in the post- than pre-NJNP cohort for all individual vaccines, with increases ranging from 1.1 percentage points for the fourth dose of DTP to 7.2 points for a single dose of varicella vaccine.

Vaccine uptake among zero-dose children by vaccine type

Among children who had no recorded doses of any assessed vaccine at baseline (aged one to less than three years), the proportion who remained zero-dose at the end of the four-year follow-up period was lower post- than pre-NJNP both overall (i.e. no doses of any assessed vaccine) and for each individual vaccine (Table 4). For individual vaccines, among children with no recorded vaccine doses at baseline, the odds of remaining zero-dose four years later in the post- versus pre-NJNP cohort were significantly lower in children with RO, with OR ranging from 0.16 (95% CI 0.13–0.19) for varicella to 0.36 (95% CI 0.32–0.41) for DTP, than in children without RO for whom ORs ranged from 0.50 (95% CI 0.47–0.53) for Hib to 0.73 (95% CI 0.69–0.77) for MMR. The number of initially zero-dose children who had received no vaccine doses by the end of the four-year follow-up period was 10,696 pre- and 9206 post-NJNP, a decrease of 1490 or 7.5%. The odds of remaining zero-dose for all vaccines were significantly lower among children with RO (0.38; 95% CI 0.34–0.42) than those without RO (0.66; 95% CI 0.63–0.70).

Discussion

Although Australia introduced immunisation eligibility requirements for government family assistance payments in 1998,[16] the NJNP legislation in 2016 substantially increased stringency of requirements. Major

Cohort	Vaccine/antigen and dose number				
	DTP[a] dose 4 N (%)	Hib[b] dose 4 N (%)	MenC[c] dose 1 N (%)	MMR[d] dose 2 N (%)	Varicella dose 1 N (%)
Pre-NJNP (N = 562,316)	524,802 (93.3)	518,604 (92.2)	527,619 (93.8)	524,408 (93.3)	489,355 (87.0)
Post-NJNP (N = 615,607)	579,609 (94.2)	580,813 (94.3)	589,247 (95.7)	587,826 (95.5)	579,701 (94.2)

[a]Diphtheria-tetanus-pertussis-containing vaccine. [b]*Haemophilus influenzae* type b. [c]Meningococcal C conjugate. [d]Measles-mumps-rubella.

Table 3: **Proportion of children receiving all required doses of specific vaccines by end of four-year follow-up period, pre- and post-NJNP cohort.**

Objection status	Cohort (N with no vaccine doses recorded at baseline)	Number remaining zero-dose (percent decrease[a]) at end of follow-up					
		DTP[b]	Hib[c]	MenC[d]	MMR[e]	Varicella	All assessed vaccines[f]
Children with registered objection	Pre-NJNP (N = 4001)	3551 (11.2%)	3708 (7.3%)	3796 (5.1%)	3741 (6.5%)	3868 (3.3%)	3520 (12.0%)
	Post-NJNP (N = 6145)	4552 (25.9%)	4671 (24.0%)	4805 (21.8%)	4749 (22.7%)	5030 (18.1%)	4510 (26.6%)
	Odds ratio (95% CI) for remaining zero-dose[g]	0.36 (0.32–0.41)	0.25 (0.22–0.29)	0.19 (0.17–0.23)	0.24 (0.21–0.27)	0.16 (0.13–0.19)	0.38 (0.34–0.42)
Children without registered objection	Pre-NJNP (N = 12,718)	7628 (40.0%)	9978 (21.5%)	9450 (25.7%)	7876 (38.1%)	9686 (23.8%)	7176 (43.6%)
	Post-NJNP (N = 10,163)	5018 (50.6%)	6549 (35.6%)	6230 (38.7%)	5500 (45.9%)	6795 (33.1%)	4696 (53.8%)
	Odds ratio (95% CI) for remaining zero-dose[g]	0.65 (0.62–0.69)	0.50 (0.47–0.53)	0.55 (0.52–0.58)	0.73 (0.69–0.77)	0.63 (0.60–0.67)	0.66 (0.63–0.70)
All children	Pre-NJNP (N = 16,719)	11,179 (33.1%)	13,686 (18.1%)	13,246 (20.8%)	11,617 (30.5%)	13,554 (18.9%)	10,696 (36.0%)
	Post-NJNP (N = 16,308)	9570 (41.3%)	11,220 (31.2%)	11,035 (32.3%)	10,249 (37.1%)	11,825 (27.5%)	9206 (43.5%)
	Odds ratio (95% CI) for remaining zero-dose[g]	0.70 (0.67–0.74)	0.49 (0.46–0.51)	0.55 (0.52–0.58)	0.74 (0.71–0.78)	0.62 (0.59–0.65)	0.73 (0.70–0.76)

[a]Percent decrease in number of children zero-dose at end of follow-up, from number zero-dose at baseline. [b]Diphtheria-tetanus-pertussis. [c]*Haemophilus influenzae* type b. [d]Meningococcal C conjugate. [e]Measles-mumps-rubella. [f]13-valent pneumococcal conjugate vaccine, poliomyelitis, hepatitis B, DTP, Hib, MenC, MMR and varicella. [g]Post-NJNP versus pre-NJNP cohort.

Table 4: **Unvaccinated children remaining zero-dose for specific vaccines at four-year follow-up, by objection status, post-versus pre-NJNP cohort.**

changes to existing policy settings[17] included: 1) financial penalties newly applying to some families previously exempt (those with registered objection); 2) increased frequency and duration of compliance checks for all families (annual to 20 years of age instead of at one, two and five years of age); and 3) narrowing of the allowable medical exemptions.

We found that all outcomes measured showed significant increases in vaccine uptake in the post-compared with the pre-NJNP cohort. Consistent with removal of registered (non-medical) objection as an exemption from full vaccination requirements for government family assistance payments, the highest relative increases in full vaccination were in children with registered objection. Among children with registered objection who were partially vaccinated at baseline, the proportion becoming fully vaccinated was around three times higher (41.7%) than in those who were zero-dose at baseline (14.6%), consistent with more selective and likely less fully committed objection. However, children with registered objection made up a very small percentage and number of all children (1.1% and 6064 pre-NJNP; 1.5% and 9061 post-NJNP), and three-quarters of those in the post-NJNP cohort were not fully vaccinated at follow-up.

In the sub-cohorts of children without registered objection, while relative increases in full vaccination were much lower (ORs 1.2–2.2) than among those with registered objection (ORs 5.1–14.1), their contribution to total numbers was much greater—they made up more than 95% of the estimated additional 49,510 children (8.0% of total post-NJNP cohort) fully vaccinated after four years follow-up compared with numbers expected by extrapolation from the pre-NJNP cohort.

Based on this, it is likely that the up to three additional eligibility assessments (at 3, 4 and 6 years of age) experienced by our post-NJNP cohort made a much greater contribution to the increased numbers of fully vaccinated children than removal of non-medical objection as an exemption, which affected a much smaller number of families. The narrowing of allowable medical exemptions was effective at preventing any migration from non-medical objection to medical exemptions, with new exemptions in children aged six months to 10 years totalling 508 in 2017 compared to 635 in 2014.[30]

Levels of full vaccination were relatively high at baseline in both study cohorts, and modestly (0.6%) higher in 2015 (i.e. post-NJNP [92.7%]) than in 2008 (i.e. pre-NJNP [92.1%]). However, these two-year wide cohorts each contained at baseline around 45,000 under-vaccinated children, of whom approximately 12% (pre-NJNP) and 18% (post-NJNP) had registered objection, giving good statistical power. Some important characteristics of children with and without registered objection emerged from our analysis. First, only a minority of zero-dose children had a registered objection. Second, substantial catch-up vaccination occurred among partially vaccinated children without registered objection pre-NJNP, with 34.5% becoming fully vaccinated and a further 49.6% receiving some additional vaccine doses by five to less than seven years, compared with 4.9% and 38.7% in unvaccinated children without registered objection. This is in keeping with the hypothesis that many children who remained zero-dose by one to less than three years of age had parents with objections to vaccination similar to those who registered their objection, but did not register because they were either philosophically opposed to registration or did not have sufficient financial motivation.[19] Although we were not able to compare NJNP impacts by socioeconomic status, it is likely that this is a significant factor given the magnitude of the financial sanctions. Previous Australian studies have found larger increases in vaccination coverage post-NJNP in children aged one to less than five years living in areas with greater socioeconomic disadvantage (three percentage point increase in lowest income areas compared to minimal change in highest income areas),[26] and a two to four-fold higher level of MMR2 catch-up vaccination in older children and adolescents living in areas in the lowest than the highest decile of socioeconomic status.[17] While concerns have previously been expressed about potentially disproportionate negative impacts of financial mandates on socioeconomically disadvantaged families,[24,25] a broader evaluation would be required to assess such issues.

Decreases in childhood vaccination coverage have been documented globally, including in high income countries, due to delivery and acceptance challenges induced by the COVID-19 pandemic.[31] In Europe MMR2 coverage fell to 91% in 2022,[32] and in the United Kingdom to 85.5% at 5 years of age,[33] with an associated marked resurgence of measles in the European region.[32,34] It is possible that the NJNP policy environment, along with other factors, may have contributed to the relative resilience of childhood coverage in Australia. Reductions in coverage after 2020 were modest, with fully vaccinated coverage at key assessment milestones in 2022 declining by 1.1–1.5 percentage points compared with pre-pandemic and MMR2 coverage at 5 years of age in 2022 remaining relatively high at 96.3%.[35,36]

At global level, reducing the number of zero-dose children by at least 50% is a key objective of Immunisation Agenda 2030, as these children are at highest risk of severe outcomes, including death, from vaccine-preventable diseases.[37] High-income countries account for only 9% (12 million) of the global infant population, with an estimated 2.8% zero-dose,[37] consistent with our data. While financial sanctions for non-vaccination would be unethical in settings without robust and highly accessible vaccination services, they may be appropriate to consider in high-income countries like Australia where data on vaccination status is recorded at individual level by a high functioning immunisation information system which enables accurate and timely assessment of criteria for payment. Although decreases in the number of persistently zero-dose children in our post-NJNP cohort were modest, they were statistically significant, with more than 1000 additional children receiving at least one dose of DTP and MMR-containing vaccines during the four-year follow-up period compared to pre-NJNP. Across the whole post-NJNP cohort, the target of >95% of children receiving two doses of MMR-containing vaccine was reached by end of follow-up (95.5% compared with 93.3% pre-NJNP) and varicella vaccine coverage reached 94.2% (compared to 87.0% in pre-NJNP). However, these increases in MMR and varicella coverage are likely also attributable in part to the change from monovalent varicella to a measles-mumps-rubella-varicella combination vaccine at 18 months of age in July 2013, prior to which MMR2 was scheduled at four years of age.

Strengths of our study include that it is the first to examine changes in individual level vaccination status post-NJNP in children of vaccine-refusing families, and robust methodology using Australia's national population-based immunisation register. Limitations include that: first we were only able to compare vaccination uptake between study cohorts aged one to less than 3 years at baseline; second we used year-wide age-based coverage algorithms as annual assessment of eligibility for payments continued until 2018, although point-in-time assessment is now in place; third that not all vaccine-refusing families registered objection; and fourth that some children recorded as not receiving vaccines over the four-year follow-up period may have spent time out of Australia or emigrated. However, we believe that our study design comparing cohorts reduces the likelihood of differential bias from these factors. We note the increasing trend in vaccination uptake prior to introduction of NJNP,[23,27] which if continuing could have contributed to the overall increase in uptake observed post-NJNP, but not the marked variation we document by registered objection status. We were also unable to account for impacts of other initiatives to increase vaccination over the post-NJNP period. These included policies introducing similar fully-vaccinated criteria for enrolment in childcare services in some but not all of the eight Australian states and territories (known as 'No Jab No Play'[23,38]) and changes in the application of other program and system measures to promote access to and uptake of vaccination, such as recall of overdue children. The increased vaccination uptake that we document in the post-NJNP cohort, particularly in those without registered objection, could also be due in part to better reporting of vaccine doses to the immunisation register, including doses given overseas to migrant children, which may have improved secondary to the increased frequency of compliance assessments.[25] We were however unable to assess any differences in vaccination uptake by ethnicity or country of birth, as this information is not available in the AIR. We did not analyse by gender of child, as per standard practice in Australia[17,19,23,26–28,30,35,36] where childhood vaccination uptake does not vary materially by gender.

We have presented evidence that NJNP has acted as an incremental financial lever to increase vaccination in the Australian context, albeit at a modest level. This policy has had community and bipartisan political support and is likely to continue. France and Italy have recently introduced vaccine mandates which require vaccination for child care attendance but do not include financial penalties and have shown short-term impact.[39,40] In the United States, long-standing requirements for documentation of measles vaccination status at school entry are a major contributor to high coverage by that milestone and successful maintenance of measles elimination status.[41] Countries considering the merits of financial sanctions should consider the countervailing issues of limited impact on vaccine-refusing families, as documented in our study, and potential to exacerbate inequity through greater impacts on socioeconomically disadvantaged families who are more likely to receive and need financial assistance.[10] There is also evidence that mandating vaccines can lead to increased resistance towards non-mandated vaccines,[42] and that healthcare providers charged with enforcing narrow criteria for granting of medical exemptions can be targets of abuse. Alternate forms of vaccination requirement can remind, increase access for, and incentivise those not fully vaccinated while retaining exemptions for committed vaccine refusers, which has been shown to lead to fewer exemptions overall.[43] Mandatory documentation could involve annual recertification of non-medical objection, which would be inconvenient and provide regular opportunities for parents to reconsider their decision, either with or without mandatory counselling or education sessions.[44,45] Overall, the justification for mandates including financial sanctions is arguably strongest for vaccines where being completely unvaccinated poses a lifetime risk and high population immunity levels are needed to provide community protection—such as pertussis, measles and varicella. If financial or other sanctions are imposed, these individual vaccines could theoretically be a more appropriate and more readily assessed target than inevitably arbitrary definitions of 'fully vaccinated', which become less relevant with increasing age, although potential disadvantages of selective mandates from a practical perspective need to be considered.[46]

Contributors
FB and PM conceptualised the study. FB, AJH, AD and PM contributed to study design and methodology. FB, AJH, HFG and PM contributed to data analysis. FB, AJH and PM contributed to data visualisation. All authors contributed to data interpretation. FB and PM wrote the original draft of the manuscript and all authors contributed to the editing and final review of the manuscript. FB, AJH, HFG and PM have directly accessed and verified the raw data.

Data sharing statement
Individual-level Australian Immunisation Register data are not publicly available and cannot be shared.

Declaration of interests
KM has received funding support by independent specialist societies for travel to be a plenary speaker at vaccine conferences, as well as funding support to travel to WHO Global Advisory Committee meetings of which KM is a member. JL has received investigator grant and performance funding to their institution, as well as funding support from Sanofi for travel to attend a Global Pertussis Initiative meeting. The funding support declared by KM and JL is not directly related to this study. All other authors have no relevant relationships, activities or interests to declare.

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