Immunisation coverage annual report, 2008

Brynley P Hull, Deepika Mahajan, Aditi Dey, Rob I Menzies, Peter B McIntyre

Abstract

This, the 2nd annual immunisation coverage report, documents trends during 2008 for a range of standard measures derived from Australian Childhood Immunisation Register data, including overall coverage at standard age milestones and for individual vaccines included on the National Immunisation Program (NIP). Coverage by indigenous status and mapping by smaller geographic areas as well as trends in timeliness are also summarised according to standard templates. With respect to overall coverage, Immunise Australia Program targets have been reached for children at 12 and 24 months of age but not for children at 5 years of age. Coverage at 24 months of age exceeds that at 12 months of age, but as receipt of varicella vaccine at 18 months is excluded from calculations of 'fully immunised' this probably represents delayed immunisation, with some contribution from immunisation incentives. Similarly, the decrease in coverage estimates for immunisations due at 4 years of age from March 2008, is primarily due to changing the assessment age from 6 years to 5 years of age from December 2007. A number of individual vaccines on the NIP are not currently assessed for 'fully immunised' status or for eligibility for incentive payments. These include pneumococcal conjugate and meningococcal C conjugate vaccines for which coverage is comparable to vaccines which are assessed for 'fully immunised' status, and rotavirus and varicella vaccines for which coverage is lower. Coverage is also suboptimal for vaccines recommended for Indigenous children only (i.e. hepatitis A and pneumococcal polysaccharide vaccine) as previously reported for other vaccines for both children and adults. Delayed receipt of vaccines is an important issue for vaccines recommended for Indigenous children and has not improved among non-Indigenous children despite improvements in coverage at the 24-month milestone. Although Indigenous children in Australia have coverage levels that are similar to non-Indigenous children at 24 months of age, the disparity in delayed vaccination between Indigenous and non-Indigenous children, which is up to 18% for the 3rd dose of DTP, remains a challenge. *Commun Dis Intell* 2010;34(3):241–258.

Keywords: immunisation coverage, immunisation delay, small area coverage reporting

Introduction

This is the 2nd annual Australian Childhood Immunisation Register (ACIR) coverage report. This series of annual reports was established to consolidate the various forms of regular coverage reports and ad-hoc publications produced by the National Centre for Immunisation Research and Surveillance using ACIR data, highlighting important trends and significant issues over the preceding 12 months.[1–13] It follows the format of the 1st report, providing a detailed summary for 2008 that includes vaccination coverage at standard milestone ages, coverage for vaccines not included in standard coverage assessments, timeliness of vaccination, coverage for Indigenous children, and data for small geographic areas on vaccination coverage and prevalence of conscientious objectors. Readers are referred to the 1st report for a more detailed explanation of the background to this series of annual reports and the range of analyses presented.[14]

This report uses the long-standing international practice of reporting coverage at key milestone ages, to measure coverage against national targets and to track trends over time. The first 2 milestones are unchanged since the previous report (12 months for vaccines due at 6 months and 24 months for vaccines due at 12 months). However, from the beginning of 2008, assessment of the oldest milestone (for vaccines due at 4 years) was changed from 6 years to 5 years.[15] No new vaccines were introduced to the National Immunisation Program (NIP) during 2008, however, this report does include the 1st full year of coverage data for rotavirus vaccine, which was introduced in 2007.

Incentives for vaccination and reporting to the Australian Childhood Immunisation Register

There were important recent changes to the payment of incentives to providers and carers, which had potential impacts on reported coverage. The Australian Government, through the Department of Health and Ageing, advises the ACIR on whether calculation of coverage of the new vaccines/antigens should be included in the completed schedule assessment for eligibility for payments to parents or immunisation providers. In 2008, the ACIR made information payments (up

to $6) to all immunisation providers and general practitioners (GPs), under the General Practice Immunisation Incentive (GPII) Scheme. In the 2008–09 Budget, the Australian Government announced that one of the components of the GPII Scheme, the GPII Service Incentive Payment (SIP), would stop from 1 October 2008. Service Incentive Payments (SIP) ($18.50) were made for reporting a vaccination that completed a schedule point on the NIP.[16] However, the GPII Outcomes Payments, which paid practices that achieve 90% or greater proportions of full immunisation, was maintained. The vaccines/antigens included in assessment for the Outcomes Payment in 2008 were the same as in recent years, i.e. diphtheria, *Haemophilus influenzae* type b (Hib), hepatitis B, measles, mumps, pertussis, polio, rubella and tetanus. Vaccines included in the NIP in 2008 but not part of the completed schedule assessment for provider payments were: meningococcal C vaccine (Men C); 7-valent pneumococcal conjugate vaccine (7vPCV); and rotavirus vaccine. Varicella vaccine was also not included for coverage assessment but eligible providers received an information and SIP payment (up to October 2008) for reporting completion of the current 18-month schedule point. While the ACIR records sub-population vaccines such as hepatitis A and pneumococcal polysaccharide vaccines (23vPPV) and non-National Immunisation Program vaccines, such as bacille Calmette-Guérin, they do not attract a GPII payment. Table 1 shows the Australian National Immunisation Program Schedule in 2008.

In 2004–05, the means test to qualify for the Maternity Immunisation Allowance (MIA) was removed. This payment, of $233 per child in 2008, is likely substantial enough to provide motivation both to complete immunisation and for parents to prompt their provider to notify any outstanding reports to the ACIR before the child reaches 24 months of age. In the 2008–09 budget, in addition to the changes mentioned above, it was announced that the MIA payment would be paid in 2 equal amounts of $167, with eligibility for the 2nd payment assessed at 4–5 years of age. However, this did not come into effect during the period of this report.

Methods

The Australian Childhood Immunisation Register

The ACIR was established on 1 January, 1996, by incorporating demographic data from Medicare on all enrolled children under the age of 7 years.[2] Participation in the ACIR is opt-out so it constitutes a nearly complete population register, as approximately 99% of children are registered with Medicare by 12 months of age.[2] Children not enrolled in Medicare can also be added to the ACIR via a supplementary number. Since 2001, immunisations given overseas may be recorded if a provider endorses their validity. Data are transferred to the ACIR when a recognised immunisation provider supplies details of an eligible immunisation either through the Internet using the Medicare Australia web site or by submitting paper encounter forms, which are scanned at a central location. The existence of medical contraindications and conscientious objection to immunisation are also recorded on the ACIR. All vaccination records for a child remain on the register indefinitely, but no new immunisation encounter records are added after the 7th birthday.

Immunisations recorded on the Register must be rendered in accordance with the guidelines issued by the National Health and Medical Research

Table 1: Australian National Immunisation Program Schedule for children in 2008

Age	Vaccine									
Birth	Hep B									
2 months	Hep B	DTPa	Hib	Polio				7vPCV		Rotavirus
4 months	Hep B	DTPa	Hib	Polio				7vPCV		Rotavirus
6 months	Hep B	DTPa	Hib*	Polio				7vPCV		Rotavirus†
12 months			Hib		MMR		Hep A‡		Men C	
18 months						VZV	Hep A§‡	23vPPV‡		
24 months							Hep A§	23vPPV§		
4 years		DTPa		Polio	MMR					

* The 3rd dose of Hib vaccine at 6 months is dependent on the vaccine brand used in each state or territory.

† The 3rd dose of rotavirus vaccine at 6 months is dependent on the vaccine brand used in each state or territory.

‡ Aboriginal and Torres Strait Islander children in Western Australia and the Northern Territory.

§ Aboriginal and Torres Strait Islander children in Queensland and South Australia.

Council as stated in *The Australian Immunisation Handbook*.[17] Notifications falling outside these guidelines or duplicate notifications prompt an enquiry with the provider, and if their validity cannot be established they are rejected.

Measuring immunisation coverage using the Australian Childhood Immunisation Register

The cohort method has been used for calculating coverage at the population level (national and state or territory)[18] since the ACIR's inception. Cohort immunisation status is assessed at 12 months of age (for vaccines due at 6 months), 24 months of age (for vaccines due at 12 months), and 5 years of age (for vaccines due at 4 years). A minimum 3-month lag period is allowed for late notification of immunisations to the Register, but only immunisations given on or before a child's 1st, 2nd or 5th respective birthdays are considered.[18] If a child's records indicate receipt of the last dose of a vaccine that requires more than 1 dose to complete the series, it is assumed that earlier vaccinations in the sequence have been given. This assumption has been shown to be valid.[4,5]

Three-month birth cohorts are used for time trend analyses, and 12-month cohorts used for other analyses in this report. These cohorts are children born between 1 January and 31 December 2007 for the 12-month milestone age; children born between 1 January and 31 December 2006 for the 24-month milestone age; and children born between 1 January and 31 December 2003 for the 5-year (60-month) milestone age.

The proportion of children designated as 'fully immunised' is calculated using the number of Medicare-registered children completely immunised with the vaccines of interest by the designated age as the numerator, and the total number of Medicare-registered children in the age cohort as the denominator. 'Fully immunised' at 12 months of age is defined as a child having a record on the ACIR of a 3rd dose of a diphtheria (D), tetanus (T) and pertussis-containing (P) vaccine; a 3rd dose of polio vaccine; 2 or 3 doses of PRP-OMP containing Hib vaccine or 3 doses of any other Hib vaccine; and 2 or 3 doses of Comvax hepatitis B vaccine or 3 doses of any other hepatitis B vaccines. 'Fully immunised' at 24 months of age is defined as a child having a record on the ACIR of a 3rd dose of a DTP-containing vaccine; a 3rd dose of polio vaccine; 3 or 4 doses of PRP-OMP containing Hib vaccine or 4 doses of any other Hib vaccine; 3 or 4 doses of Comvax hepatitis B vaccine or 4 doses of any other hepatitis B vaccines; and the 1st dose of a measles, mumps and rubella-containing (MMR) vaccine. 'Fully immunised' at 5 years of age is defined as a child having a record on the ACIR of a 4th or 5th dose of a DTP-containing vaccine; a 4th dose of polio vaccine; and a 2nd dose of an MMR-containing vaccine.

Immunisation coverage estimates were also calculated for individual NIP vaccines, including the 6 NIP vaccines not routinely reported in *Communicable Diseases Intelligence (CDI)*. They were: a 3rd dose of 7vPCV and 2nd or 3rd dose of rotavirus vaccine by 12 months of age; the 1st dose of varicella vaccine and the 1st dose of meningococcal C vaccine by 24 months of age; a 2nd dose of hepatitis A vaccine in Indigenous children by 30 months of age; and the 1st dose of 23-valent pneumococcal polysaccharide vaccine in Indigenous children by 36 months of age.

Timeliness

Age-appropriate immunisation was defined as receipt of a scheduled vaccine dose within 30 days of the recommended age. For example, a child who received the 1st dose of DTP (due at 60 days of age) when he or she was more than 90 days of age, was classified as not age-appropriately immunised (i.e. late for the dose). For descriptive purposes, we categorised the outcome measure for each dose as either vaccines received 'too early' (greater than 30 days prior to when it was due), vaccine received 'acceptably early' (within 30 days prior to when it was due), 'no delay' (age-appropriately immunised), 'delay of between 1 to 6 months', 'delay greater than 6 months', or vaccine dose 'not recorded'. However, we have only reported on the 2 'delay' categories within this report. All children included in the analysis were at least 36 months of age when the data were extracted and, therefore, old enough to potentially experience delays in immunisation greater than 6 months for immunisation due by 24 months of age or earlier. The interval between doses was not evaluated. Timeliness of different vaccines and doses was also compared by plotting the cumulative percentage receiving each vaccine dose by age, with the proportion ever immunised set as 100%.

Remoteness status

The area of residence of children was defined as accessible or remote using the Accessibility/Remoteness Index of Australia (ARIA), which was developed by the Department of Health and Aged Care, and proposed as the national standard measure of remoteness for inclusion in the Australian Bureau of Statistics (ABS) 2001 census.[19] We define the 2 ARIA categories with most restricted

access to services as 'remote' (approximately 2.6% of the Australian population) and all other areas as 'accessible'.

Indigenous status

Indigenous status on the ACIR is recorded as 'Indigenous', 'non-Indigenous' or 'unknown', as reported by the child's carer to Medicare, or by the immunisation provider to the ACIR. For this report we considered 2 categories of children: 'Indigenous' and 'non-Indigenous', children with unknown indigenous status were presumed to be 'non-Indigenous'. Coverage estimate time trends are presented from 2004 only, due to poor rates of reporting indigenous status prior to then.[20]

Small area coverage

Coverage was calculated for ABS-defined Statistical Subdivisions (SSD).[21] We chose ABS-defined SSD as areas to be mapped because each is small enough to show differences within jurisdictions but not too small to render maps unreadable. Maps were created using version 10 of the MapInfo mapping software[22] and the ABS Census Boundary Information. As postcode is the only geographical indicator on the ACIR, the ABS Postal Area to Statistical Local Area Concordance 2006 was used to match ACIR postcodes to SSDs, in order to create a SSD field for each child in the relevant study cohorts.[23]

Conscientious objection/no vaccine recorded

A child must be registered with Medicare before its parent(s) can lodge a conscientious objection to immunisation. Parents can also object to immunisation but refuse to lodge any official objection to the ACIR. We used the percentage of children with no vaccines recorded on the ACIR as a proxy measure of the number of these children. Proportions of conscientious objectors and children with no vaccines recorded by region were calculated from the cohort of children registered with Medicare, and born between 1 January 2001 and 31 December 2007. At the time of data extraction on 31 March 2009, they were between 12 and 72 months of age. We chose this cohort when calculating proportions so that children under the age of 12 months were not included, to allow sufficient time for registration of objection.

Results

Coverage estimates

Overall

The 2008 coverage estimates, calculated for full-year birth cohorts, for the 3 milestone ages of 12 months, 24 months and 5 years are provided in Tables 2, 3 and 4. Nationally, 'fully immunised' coverage and coverage for all individual vaccines for the 12-month and 24-month age groups are greater than the Immunise Australia Program's target of 90%. Recorded coverage for the 5-year age group is well below the target, sitting at just above 80% for all vaccines and even lower in particular jurisdictions. Figure 1 shows time trends in 'fully immunised' childhood vaccination coverage in Australia, assessed at 12 months, 24 months, and at 60 months of age, for 3-month cohorts born from 1 January 1996 to 31 December 2007. The proportion 'fully immunised at 1 year of age increased steadily from 75% for the 1st cohort to 91.7% by the 46th cohort, assessed on 31 December 2008. At the 24 month milestone, coverage estimates also increased steadily from 64% for the 1st cohort to 92.5% by December 2008. Coverage estimates at

Table 2: Percentage of children in 2008 immunised at 12 months of age, by vaccine and state or territory*

	State or territory								
Vaccine	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Total number of children	4,697	96,867	3,802	61,274	19,370	6,432	70,616	30,005	293,063
Diphtheria, tetanus, pertussis (%)	94.2	91.9	90.9	91.5	92.1	91.9	92.8	90.3	91.9
Poliomyelitis (%)	94.2	91.9	91.1	91.9	91.7	92.5	92.8	89.7	91.9
Haemophilus influenzae type b (%)	96.1	94.8	94.1	93.9	94.5	94.6	95.0	93.9	94.5
Hepatitis B (%)	95.9	94.8	94.6	93.8	94.3	94.6	94.8	93.8	94.5
Fully immunised (%)	93.9	91.6	90.4	90.9	91.4	91.7	91.9	89.8	91.4

* For the birth cohort born in 2007.

Table 3: Percentage of children in 2008 immunised at 24 months of age, by vaccine and state or territory*

Vaccine	State or territory								Australia
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	
Total number of children	4,665	93,818	3,630	58,675	18,654	6,338	68,992	29,293	284,065
Diphtheria, tetanus, pertussis (%)	96.5	94.8	95.9	94.6	94.7	95.4	95.7	93.6	94.9
Poliomyelitis (%)	96.5	94.7	95.9	94.5	94.7	95.4	95.7	93.5	94.9
Haemophilus influenzae type b (%)	96.4	95.2	94.5	93.6	93.6	95.4	94.6	93.4	94.4
Hepatitis B (%)	96.9	95.6	97.1	95.3	95.4	96.3	96.3	94.4	95.6
Measles, mumps, rubella (%)	95.5	93.7	95.5	93.6	93.9	94.8	94.8	92.7	94.0
Fully immunised (%)	94.5	92.5	93.8	92.2	92.6	93.8	93.6	90.8	92.6

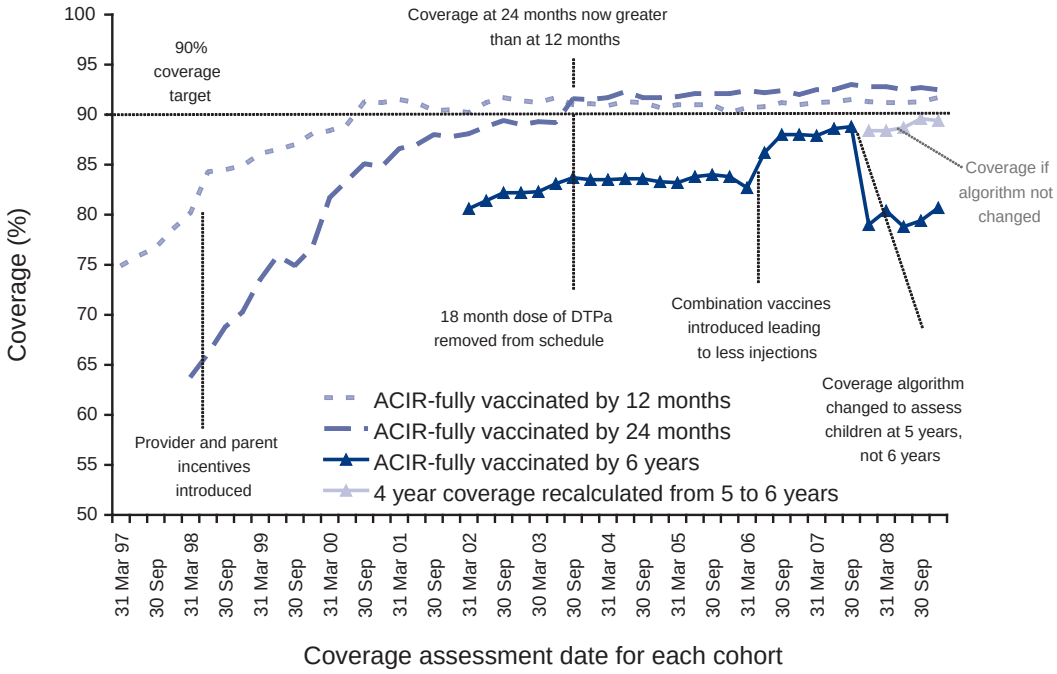
* For the birth cohort born in 2006.

Table 4: Percentage of children in 2008 immunised at 5 years of age, by vaccine and state or territory*

Vaccine	State or territory								Australia
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	
Total number of children	4,276	88,761	3,511	55,480	18,108	5,815	64,769	36,996	267,519
Diphtheria, tetanus, pertussis (%)	86.9	78.1	82.6	82.2	75.3	82.1	84.5	79.2	80.7
Poliomyelitis (%)	86.6	77.9	82.6	82.0	75.2	82.1	84.4	79.0	80.5
Measles, mumps, rubella (%)	86.3	79.4	82.4	81.8	75.1	81.7	84.1	78.9	80.3
Fully immunised (%)	85.9	77.2	81.9	81.3	74.7	81.2	83.8	78.1	79.8

* For the birth cohort born in 2003.

Figure 1: Trends in 'fully immunised' vaccination coverage, Australia, 1997 to 2008, by age cohort



6 years of age, for vaccines due at 4 years, were first reported in *CDI* in 2002, and increased steadily from 80.6% in early 2002 to 87.3% in late 2007, including a noticeable increase in June 2006, corresponding with the introduction of combination vaccines. However, from the beginning of 2008, the assessment age was changed from 6 years to 5 years and this resulted in a dramatic decrease in coverage for this age group, to 80.7% by December 2008. Figure 1 shows that coverage calculated at 6 years was unchanged.

Coverage estimates for the 24-month age group increased substantially and suddenly in September 2003 to 91.6% following the removal from the immunisation schedule of the 4th dose of DTPa (due at 18 months of age) from this quarter onwards. Coverage estimates for the 12-month age group have, however, remained steady over the past 5 years, fluctuating around the 91% level.

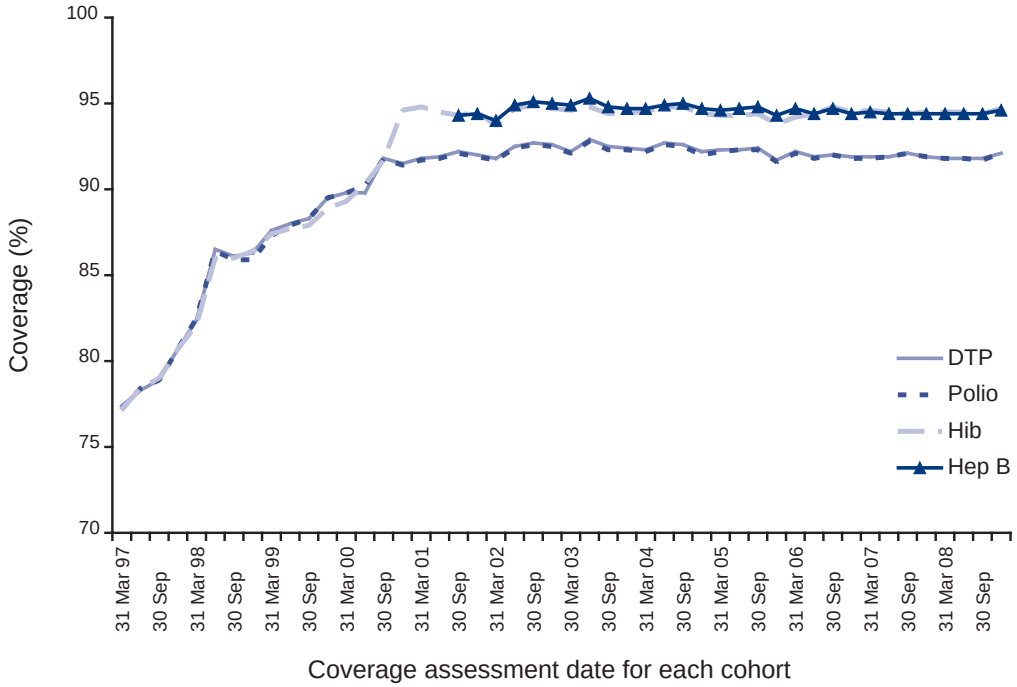
There is a clear trend of increasing vaccination coverage over time for children of all age groups assessed, with the 2 youngest age cohorts having the highest coverage. Coverage at 24 months of age exceeded that at 12 months of age for the first time at the end of 2003 and has remained higher since that time.

Individual vaccines

The trends in childhood vaccination coverage in Australia for individual vaccines at 12 months of age (DTP, polio, Hib and hepatitis B) are shown in Figure 2, for 3-month cohorts born from 1 January 1996 to 31 December 2007. Coverage estimates for all vaccines remained relatively stable throughout the latter part of 2001 to 2008. Coverage for the Hib and hepatitis B vaccines are greater than DTP and polio coverage. This is likely to be largely due to the change in the immunisation schedule in mid-2000, altering the algorithm used to calculate coverage at 12 months of age such that a record of 2 doses of Hib and hepatitis B on the ACIR renders a child 'fully immunised' for these vaccines.

The trends in childhood vaccination coverage in Australia for individual vaccines at 24 months of age (DTP, polio, Hib, hepatitis B and MMR) are shown in Figure 3, for 3-month cohorts born from 1 January 1996 to 31 December 2006. The significant increase in coverage for DTP during 2003 has been previously mentioned. For most of the study period, hepatitis B coverage was higher than for all other vaccines, just below 96%, due to the coverage algorithm changes described above. Coverage was lowest for MMR and Hib, which are the only

Figure 2: Trends in vaccination coverage estimates for individual vaccines at 12 months of age (DTP, polio, hepatitis B and Hib)*

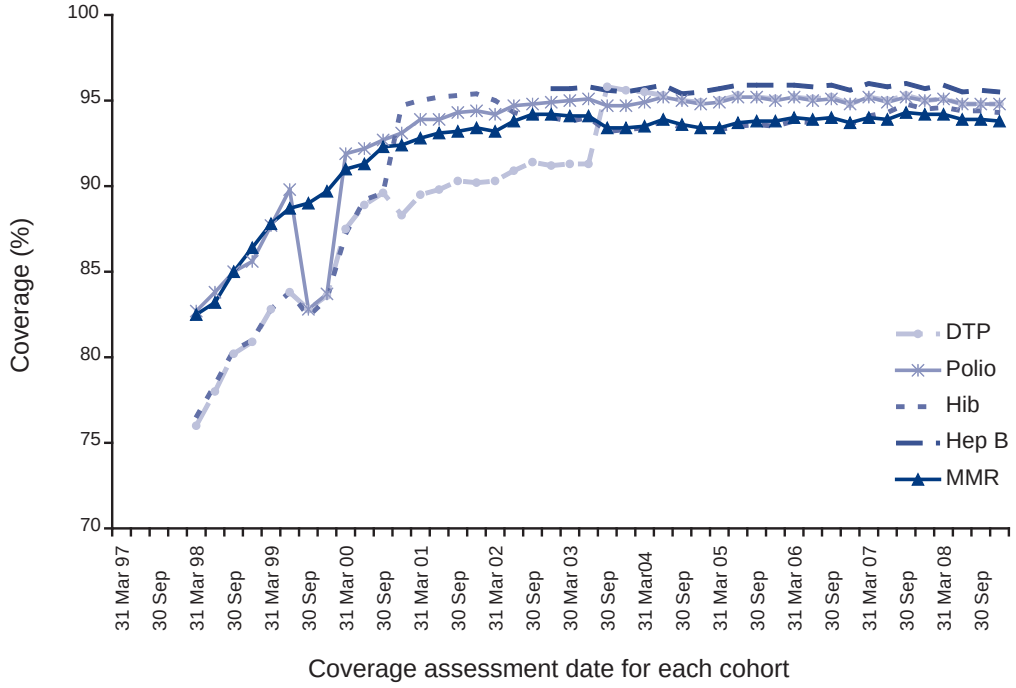


Source: Australian Childhood Immunisation Register.

By 3-month birth cohorts born between 1 January 1996 and 31 December 2007. Coverage assessment date was 12 months after the last birth date of each cohort.

* 3rd dose of DTP and polio, 2nd or 3rd dose of Hib and Hep B.

Figure 3: Trends in vaccination coverage estimates for individual vaccines at 24 months of age (DTP, polio, hepatitis B, Hib and MMR)*



Source: Australian Childhood Immunisation Register.

By 3-month birth cohorts born between 1 January 1996 and 31 December 2006. Coverage assessment date was 24 months after the last birth date of each cohort.

* 3rd or 4th dose of DTP, 3rd dose of polio, 3rd or 4th dose of Hib, 2nd or 3rd dose of Hep B, and 1 dose of MMR.

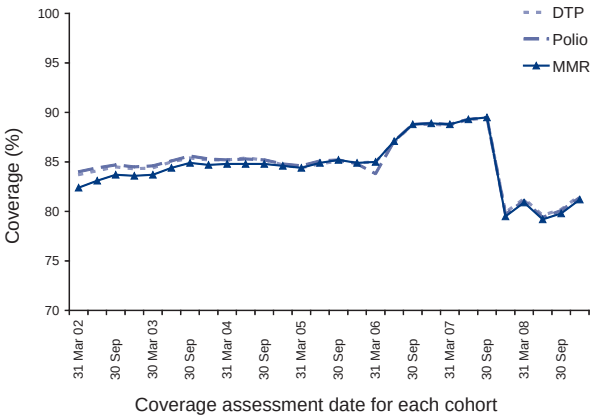
vaccines that have a 12 month dose included in the algorithm for calculation of coverage. However, coverage for all vaccines currently assessed at this age has been stable over recent years.

The trends in childhood vaccination coverage in Australia for individual vaccines (DTP, polio and MMR) at 6 years of age (5 years of age from December 2007) are shown in Figure 4 for 3-month cohorts born from 1 January 1996 to 31 December 2003. Coverage for all 3 vaccines was almost identical and remained steady across the whole period, at approximately 85%, until mid-2006 when a sharp increase of almost 5% was recorded. This increase may have been related to either or both of the campaigns to promote parental awareness of the 4-year milestone and school entry provisions in many jurisdictions becoming simpler to administer due to uniform ACIR certificates. The large decrease in coverage from December 2007, due to the change in assessment age discussed previously, is also evident for all vaccines due by 5 years of age.

Coverage estimates for Indigenous children

Vaccination coverage estimates in 2007 for the 3 milestone ages for individual vaccines by

Figure 4: Trends in vaccination coverage estimates for individual vaccines (DTP, polio, and MMR)* at 6 years of age (5 years from December 2007)



Source: Australian Childhood Immunisation Register.

By 3-month birth cohorts born between 1 January 1996 and 31 December 2003. Coverage assessment date was 72 months after the last birth date of each cohort up to December 2007 and then 60 months after the last birth date of each cohort.

* 4th dose of DTP and polio, 2nd dose of MMR.

Indigenous status are shown in Table 5. These show that coverage is lower for Indigenous children than non-Indigenous at the 12-month and 5-year age milestones, with the difference being greatest at 12 months of age. The difference in coverage at 12 months of age has been relatively consistent for the past 6 years. However, the coverage differential between Indigenous and non-Indigenous children for individual vaccines varies, with coverage at 24 months of age for most vaccines being almost identical for both groups and greater among Indigenous children for hepatitis B vaccine.

The trends in 'fully immunised' childhood vaccination coverage in Australia at 12 months, 24 months, and 6 years of age (5 years of age from December 2007) for Indigenous children since 2004 are shown in Figure 5, for 3-month cohorts assessed from 1 March 2004 to 31 December 2008. Coverage for all vaccines due by 24 months of age has consistently remained higher than at 12 months and 6 years of age. Since the beginning of 2006, coverage for Indigenous children at 6 years of age eclipsed coverage at 12 months of age until it plummeted below 80% in December 2007 due to the change in assessment age.

Table 6 shows 'fully immunised' vaccination coverage estimates in 2008 for Indigenous children at the 3 milestone ages by state or territory. At age 12 months, the proportion of Indigenous children fully vaccinated was 84.6%, compared with 91.4% for all Australian children (i.e. includes both Indigenous and non-Indigenous children, Table 2) and was lower among Indigenous children in all jurisdictions. The extent of the difference varied among jurisdictions, reaching more than 13 percentage points in some. However, by age 24 months, coverage disparities between Indigenous and all Australian children had almost disappeared nationally and in most jurisdictions, with the proportion fully vaccinated at 91.1% for Indigenous and 92.6% for all Australian children (Tables 3 and 6).

Table 5: Vaccination coverage estimates, 2008, by age, vaccine and indigenous status

Vaccine	Milestone age	Indigenous	Non-Indigenous
DTP	12 months*	85.1	92.3
	24 months†	94.9	94.9
	5 years‡	77.9	80.8
Polio	12 months*	85.1	92.2
	24 months†	94.3	94.4
	5 years‡	77.9	80.7
Hib	12 months*	92.7	94.7
	24 months†	93.0	94.5
	5 years‡	n/a§	n/a§
Hep B	12 months*	93.0	94.5
	24 months†	96.9	95.6
	5 years‡	n/a§	n/a§
MMR	12 months*	n/a§	n/a§
	24 months†	93.6	94.0
	5 years‡	77.9	80.3

* Birth cohort born 1 January 2007 to 31 December 2007.
† Birth cohort born 1 January 2006 to 31 December 2006.
‡ Birth cohort born 1 January 2003 to 31 December 2003.
§ Not included in coverage estimates for that group.

Figure 5: Trends in 'fully immunised' vaccination coverage for Indigenous children in Australia, 2004 to 2008, by age cohorts

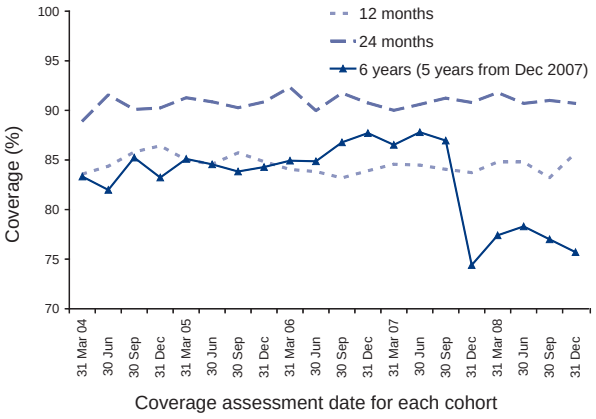


Table 6: Percentage of Indigenous children fully immunised at 12 months, 24 months and 5 years of age, 2008, by state or territory

	State or territory								
Vaccine	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aust
12 months – fully immunised (%)	89.8	85.5	87.2	86.2	78.6	91.0	86.0	77.4	84.6
24 months – fully immunised (%)	87.5	91.2	94.4	92.5	89.8	93.1	90.0	85.8	91.1
5 years – fully immunised (%)	81.4	72.4	88.5	78.8	65.3	77.9	80.4	73.6	77.1

At 5 years of age, the proportion recorded as being 'fully vaccinated' was lower than that at earlier age milestones. There was little difference between Indigenous and all Australian children at the national level (77.1% and 79.8%, respectively) while, for individual jurisdictions, coverage in Indigenous children ranged from 9% lower (in South Australia) to 7% higher (in the Northern Territory) than in all Australian children (Tables 3 and 6).

Coverage for National Immunisation Program vaccines not routinely reported elsewhere

7vPCV and rotavirus

The 7vPCV vaccine was first added to the NIP in January 2005. Since coverage was first calculated for this vaccine in early 2006, it has remained at high levels, with a slight increase from 89% to 91%. Coverage is similar in all jurisdictions at greater than or approaching 90% (Table 7).

Rotavirus vaccine was added to the NIP in July 2007 so coverage for 2 or 3 doses (depending on vaccine) at 12 months of age could be calculated only from the December 2008 quarter. Rotavirus coverage was lower nationally, and had greater variation between jurisdictions compared with other vaccines given at 2, 4 and 6 months, which is expected from the vaccine most recently introduced onto the NIP. Reported coverage for 2 or 3 doses (depending on vaccine) of rotavirus at 12 months of age varied from 78.7% in Western Australia to 84.9% and 88.0% in New South Wales and the Australian Capital Territory, respectively (Table 7).

Meningococcal C and varicella

Meningococcal C vaccine was added to the NIP in January 2003. Since coverage was first calculated for this vaccine in early 2006, it has remained at high levels, with an increase over 2 years from 88% to around 93% (Figure 6), and there was little variation by jurisdiction, with all jurisdictions at greater than 92% (Table 7).

Varicella vaccine was added to the NIP in November 2005. Figure 6 shows coverage for this vaccine has consistently been 10–15 percentage points lower than that for meningococcal C vaccine, with coverage just above 80% for the latest assessment. This is probably partly due to the shorter time varicella has been on the NIP and the recommendation to give the vaccine at 18 months of age, which was historically associated with lower coverage and is not as well established as a milestone, especially following removal of the 18-month pertussis booster in 2003. However, varicella vaccine coverage varies by jurisdiction from 77.8% in Western Australia to greater than 83% in Queensland, the Northern Territory and the Australian Capital Territory (Table 7). Data

Table 7: Vaccination coverage for 7vPCV, rotavirus, meningococcal C, varicella, hepatitis A (Indigenous only) and 23vPPV (Indigenous only) for the last 3-month cohort assessable in 2008, by state or territory

State or territory	Vaccine type					
	7vPCV*	Rotavirus†	Men C‡	Varicella§	Hep A‖	23vPPV¶
ACT	94.1	88.0	95.1	85.4	na	na
NSW	91.7	84.9	93.1	78.5	na	na
NT	89.5	81.1	94.5	83.7	82.1 (90.3)	78.9
Qld	90.5	80.7	93.3	83.8	43.6 (60.8)	52.7
SA	91.3	82.1	92.9	78.1	25.4 (45.3)	36.0
Tas	91.7	82.6	94.4	82.0	na	na
Vic	91.9	81.3	94.5	81.7	na	na
WA	88.4	78.7	92.0	77.8	55.2 (73.0)	64.0
Australia	91.1	82.3	93.4	80.5	52.3 (68.1)**	59.1**

Na Not applicable.

* 3 doses at 12 months of age.

† 2 or 3 doses at 12 months of age.

‡ 1 dose at 24 months of age.

§ 1 dose at 24 months of age.

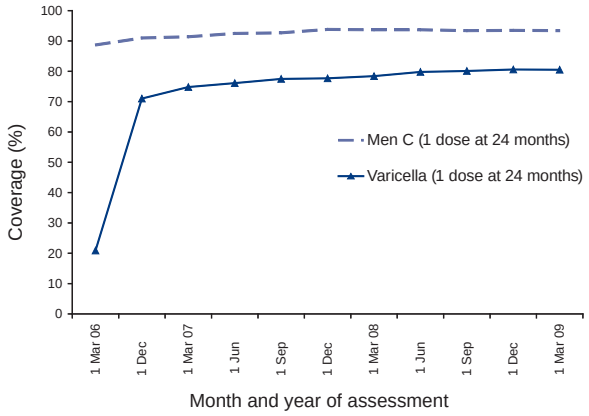
‖ Indigenous only: 2 doses at 30 months of age (1 dose at 24 months of age).

¶ Indigenous only: 1 dose at 36 months of age.

** Northern Territory, Queensland, South Australia and Western Australia only.

are also available from the ACIR on the number of reports from GPs stating that children born since May 2004, have natural immunity to varicella and do not require varicella vaccination. Reports of natural immunity to varicella during 2008 were around 1,000 reports per quarter (not shown), corresponding to approximately 1.7% of the cohort. However, it is likely that these are underestimates due to possible under-reporting.

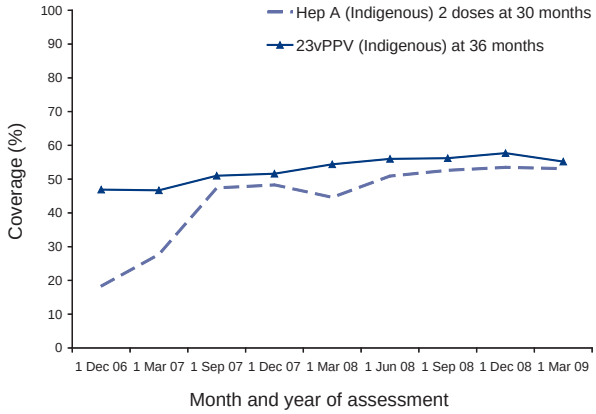
Figure 6: Trends in coverage for meningococcal C (Men C) and varicella vaccines



Hepatitis A and 23vPPV

Hepatitis A vaccine was available in Australia prior to the development of the ACIR in 1996 and has been included on the NIP for Indigenous children in the Northern Territory, South Australia, Western Australia, and in Queensland since November 2005. Since December 2006, coverage of 2 doses of hepatitis A vaccine by 30 months of age for Indigenous children has increased from below 20% to just over 50% (Figure 7). An additional 16% had received 1 dose by 24 months (Table 7). The 23vPPV has been available in Australia since 1983 and recommended for Indigenous children in the same 4 jurisdictions as a booster at 18–24 months of age since 2001; coverage has gradually increased from 47% in December 2006 to a high of 59% in December 2008 (Figure 7). There is a large variation in reported hepatitis A vaccine coverage by jurisdiction, from a low of 25.4% in South Australia to a high of 82.1% in the Northern Territory (Table 7). Similarly, there is variation in 23vPPV coverage by jurisdiction from a low of 36% in South Australia to a high of 78.9% in the Northern Territory (Table 7).

Figure 7: Trends in coverage for hepatitis A and pneumococcal polysaccharide (23vPPV) vaccines for Indigenous children



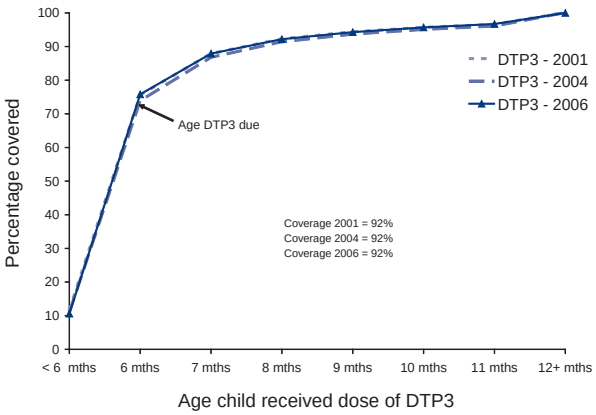
Timeliness of immunisation

Timeliness has been examined for vaccines requiring both multiple doses (DTP, 7vPCV and MMR) and a single dose (Men C) at 12 and 24 months of age.

Since 2001, the proportion with timely receipt of the 3rd dose of DTP vaccine has increased very slightly from 88% to 89% (Figure 8). Across the 6-year period, 2001–2006, timely receipt of 1 dose of MMR vaccine initially decreased by 3 percentage points but then rose 1.5 percentage points, although estimated coverage by 24 months of age remained stable at almost 94% (Figure 9).

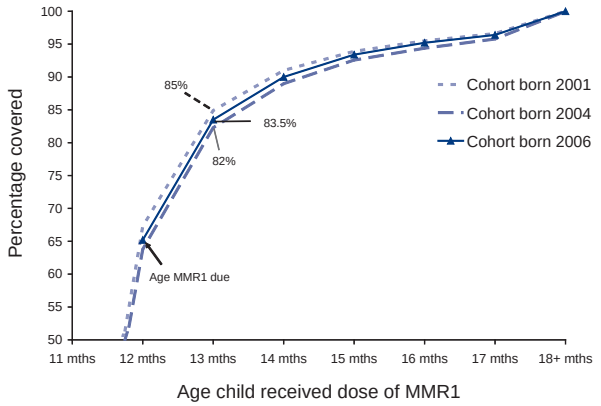
A comparison of vaccination delay for the 3rd dose of DTP, due at 6 months of age, and the 1st doses of MMR and meningococcal C, due at 12 months of age, for the 2004 cohort is shown in Figure 10. As demonstrated in previous studies, the proportion with vaccination delay increased with vaccine

Figure 8: Trends in timeliness of the 3rd dose of DTP vaccine (DTP3) – cohorts born in 2001, 2004 and 2007*



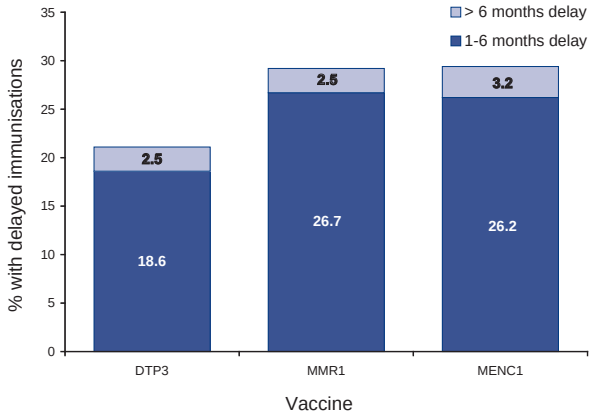
* Percentage covered = number of children who received vaccine dose at particular ages/the total number of children who received the vaccine dose.

Figure 9: Trends in timeliness of the 1st dose of MMR vaccine (MMR1) – cohorts born in 2001, 2004 and 2006*



* Percentage covered = number of children who received vaccine dose at particular ages/the total number of children who received the vaccine dose.

Figure 10: Vaccination delay for the 3rd dose of DTP vaccine (DTP3), and the 1st doses of MMR (MMR1) and Men C (MENC1) vaccines for Australia – cohort born in 2006



doses given at an older age. The greatest proportion with any delay was seen with meningococcal C vaccine with just under 30% of doses given late and over 3.2% given more than 6 months late.

Timeliness of the 3rd dose of DTP and the 1st dose of MMR vaccine by indigenous status and remoteness is shown in Table 8. Vaccination was delayed by more than 1 month for 40%–45% of Indigenous children and 20%–30% of non-Indigenous children. The proportion with long delays (i.e. greater than 6 months) was 3–4 times higher in Indigenous children than in non-Indigenous children, with no real differences between accessible and remote areas or vaccines. Delays of 1–6 months were also more frequent for Indigenous children, although less marked. The proportion with short delays was greater among Indigenous children residing in remote areas than in accessible areas for the 3rd dose of DTP vaccine (35% versus 31%), but not for the 1st dose of MMR.

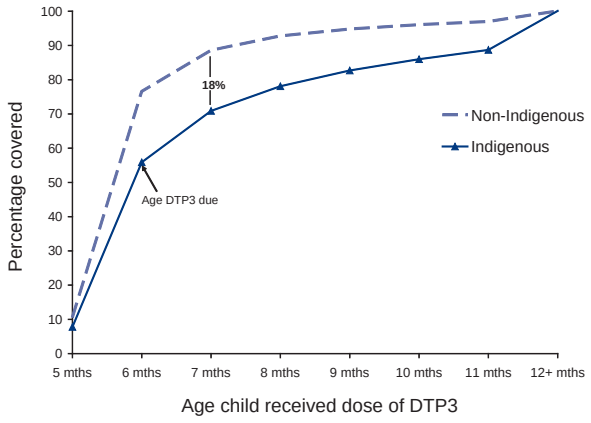
Figures 11 and 12 provide a comparison of timeliness of immunisation between Indigenous and non-Indigenous children in Australia for the 3rd dose of DTP vaccine, and the 1st dose of MMR vaccine, respectively. For the 3rd dose of DTP, there was significantly greater delay for Indigenous children than non-Indigenous children, with an 18% differential at 7 months of age. The same pattern was found for timeliness of the 1st dose of MMR, but with a smaller differential of 11%. Although Indigenous children had similar coverage levels to non-Indigenous children by 24 months of age, they were more likely to have delayed vaccination.

Vaccination delay for Indigenous children by jurisdiction was measured for 7vPCV, with greater delays in Western Australia and South Australia (Figure 13). The degree of long delay in vaccination for the 3rd dose of 7vPCV vaccine in South Australian Indigenous children was twice that which occurred in Queensland Indigenous

Table 8: Vaccination delay for the cohort of children born in 2006, Australia, by indigenous and remoteness status

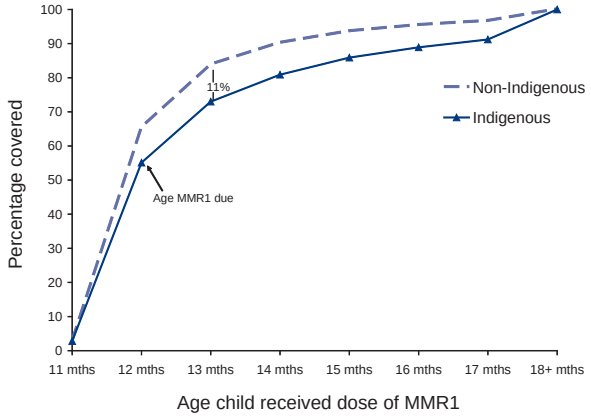
Vaccine dose	Indigenous status	Remoteness	1–6 months delay %	> 6 months delay %
DTP3	Indigenous	Accessible	31	9
		Remote	35	9
	Non-Indigenous	Accessible	18	2
		Remote	19	2
MMR1	Indigenous	Accessible	34	7
		Remote	33	6
	Non-Indigenous	Accessible	26	2
		Remote	28	2

Figure 11: Timeliness of the 3rd dose of DTP vaccine (DTP3) by Indigenous status – cohort born in 2006*



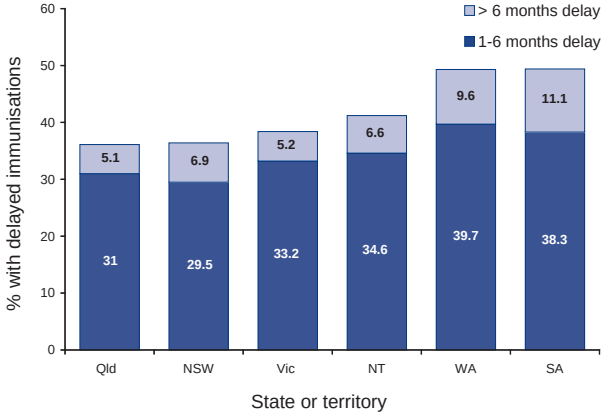
* Percentage covered = number of children who received vaccine dose at particular ages/the total number of children who received the vaccine dose.

Figure 12: Timeliness of the 1st dose of MMR vaccine (MMR1) by Indigenous status – cohort born in 2006*



* Percentage covered = number of children who received vaccine dose at particular ages/the total number of children who received the vaccine dose.

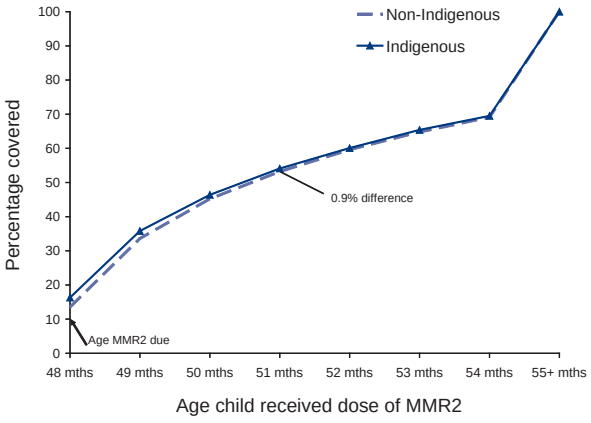
Figure 13: Vaccination delay for Indigenous children for the 3rd dose of 7vPCV in selected jurisdictions – cohort born in 2006



children. There were no important differences in vaccination delay for non-Indigenous children by jurisdiction (not shown).

In contrast to earlier ages, analysis of timeliness of immunisation for a vaccine due at 4 years of age, the 2nd dose of MMR, showed similar delay in receiving this vaccine for non-Indigenous children and Indigenous children, with only a 0.9% differential at 4 years and 3 months of age (Figure 14).

Figure 14: Timeliness of the 2nd dose of MMR vaccine (MMR2) by Indigenous status – cohort born in 2002*



* Percentage covered = number of children who received vaccine dose at particular ages/the total number of children who received the vaccine dose.

Small area coverage

'Fully immunised' coverage for Australia by SSD for the 12-month, 24-month and 5-year milestone age groups, respectively, is shown in Figures 15–17. All 3 maps demonstrate that immunisation coverage in Australia in 2007 varies substantially within jurisdictions, with some having recorded coverage below the level required to prevent outbreaks of some highly contagious diseases such as measles. In particular, there are very few small areas in Australia with 'fully immunised' coverage for vaccines due at 4 years of age at levels required to prevent disease.

The proportions of children recorded as conscientious objectors and with no vaccines recorded are presented by SSD in Figures 18 and 19, respectively. No vaccines recorded may represent either non-immunisation (parents refusing any vaccines) or, and probably much less commonly, non-reporting by a provider. The percentage of children with no vaccines recorded nationally (3.5%) is greater than those recorded as conscientious objectors (1.4%).

Figure 15: 'Fully immunised' coverage at 12 months of age, by Statistical Subdivision, Australia, 2008

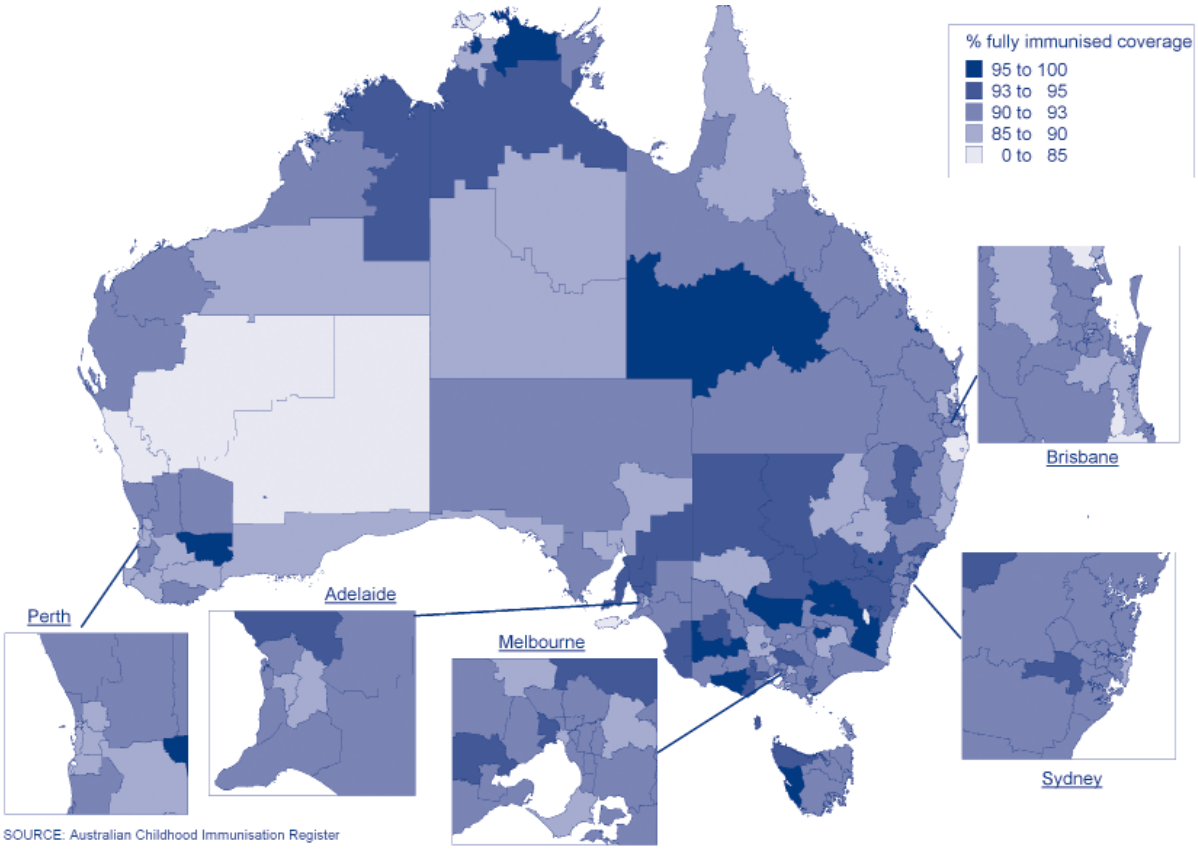


Figure 16: 'Fully immunised' coverage at 24 months of age, by Statistical Subdivision, Australia, 2008

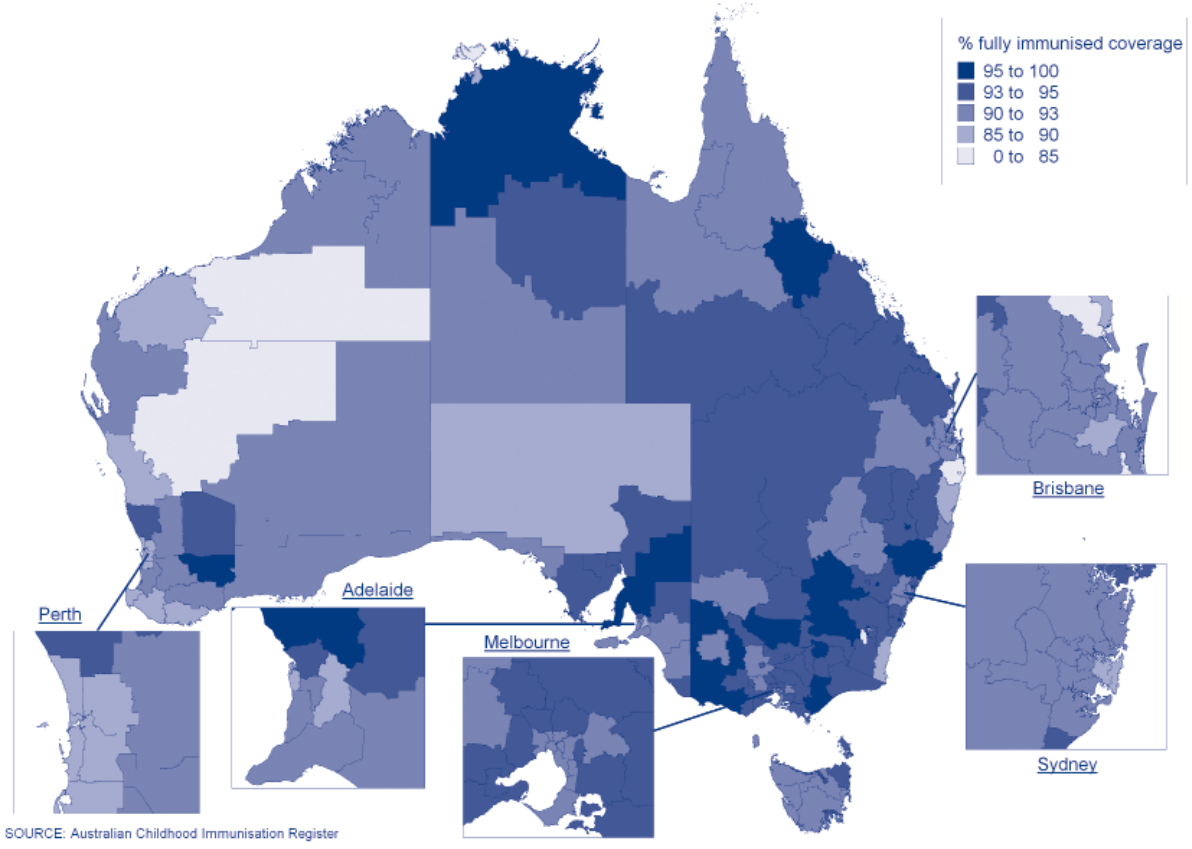
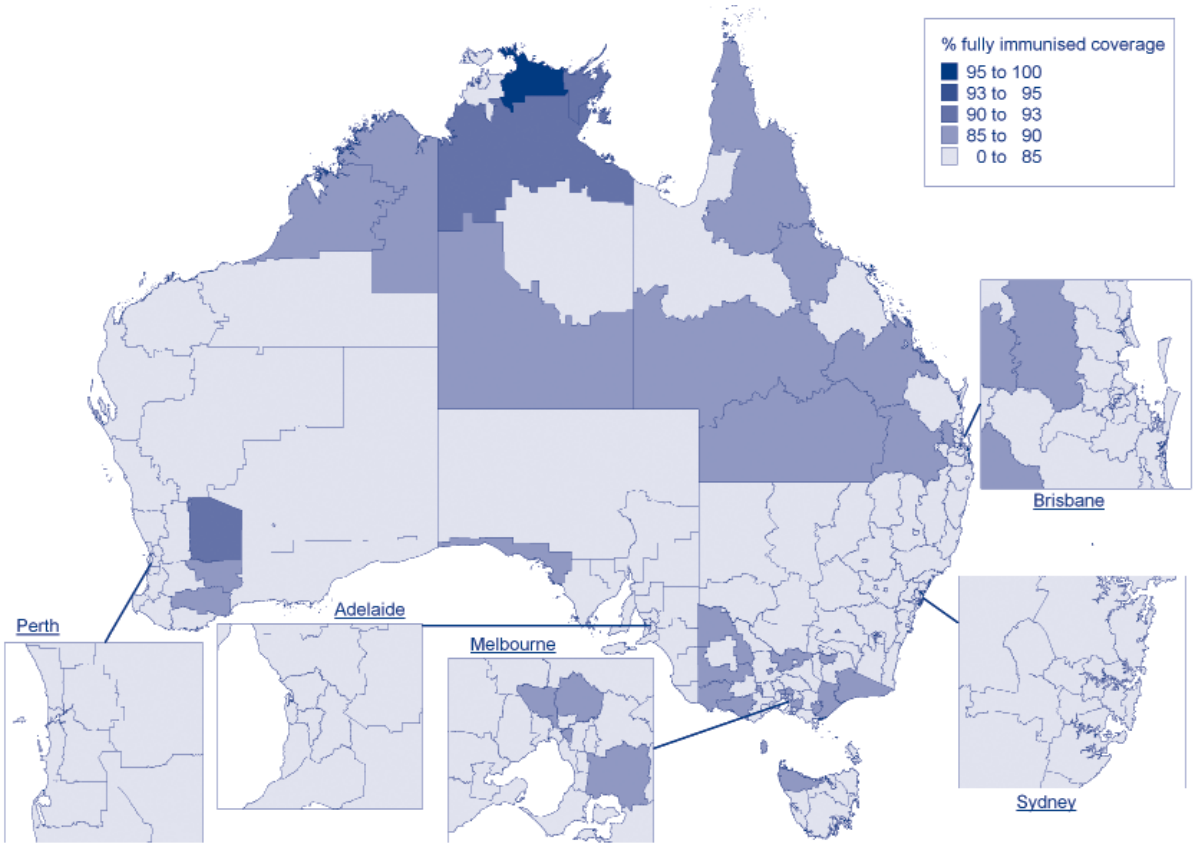


Figure 17: 'Fully immunised' coverage at 5 years of age, by Statistical Subdivision, Australia, 2008



The map of the proportion of conscientious objectors to immunisation (Figure 18) shows pockets of high levels of objection within jurisdictions in 2008, particularly in coastal areas of South East Queensland, northern New South Wales, Adelaide and south west Western Australia, which would be hidden if these data were reported at broader geographical levels.

The map of the proportion of children with no vaccines recorded (Figure 19) shows some additional areas not evident from maps of official conscientious objection, such as the eastern suburbs of Sydney and regional Victoria.

Provider type

The proportion of immunisations recorded on the ACIR as given by GPs, municipal councils and other providers in Australia by jurisdiction is shown in Figure 20. GPs administer the large majority of immunisations in Australia; the proportion given by GPs has increased over the past 10 years by almost 5% (not shown). Local government clinics also administer a substantial proportion of immunisations, especially in some jurisdictions. The only other category of provider administering major numbers of immunisations nationally is community health centres. Regional differences are marked, with immunisations almost entirely administered by GPs in some jurisdictions, while in others a majority are given by local government and community health clinics.

Discussion

These data reveal that Immunise Australia Program coverage targets have been reached for children both 12 and 24 months of age. However, this is not the case for children 5 years of age where coverage is poor in all jurisdictions.

Coverage at 24 months of age exceeds that at 12 months of age, and this is likely related to the exclusion of varicella vaccine at 18 months from calculation of 'fully vaccinated', the absence of any other vaccines administered between those ages, and the impact of immunisation incentives. The change in December 2007 in assessment age from 6 to 5 years for vaccines due at 4 years, resulted in a dramatic drop in coverage estimates for vaccines due at this age and has revealed that many children are not fully protected in a timely way for the diseases these vaccines guard against. This has been of particular concern during the pertussis epidemic of 2008 and 2009, when children aged 5 to 9 years were seriously affected.[24]

Figure 18: Proportion of official conscientious objectors to immunisation, Australia, 2008 (cohort born January 2001 – December 2007)

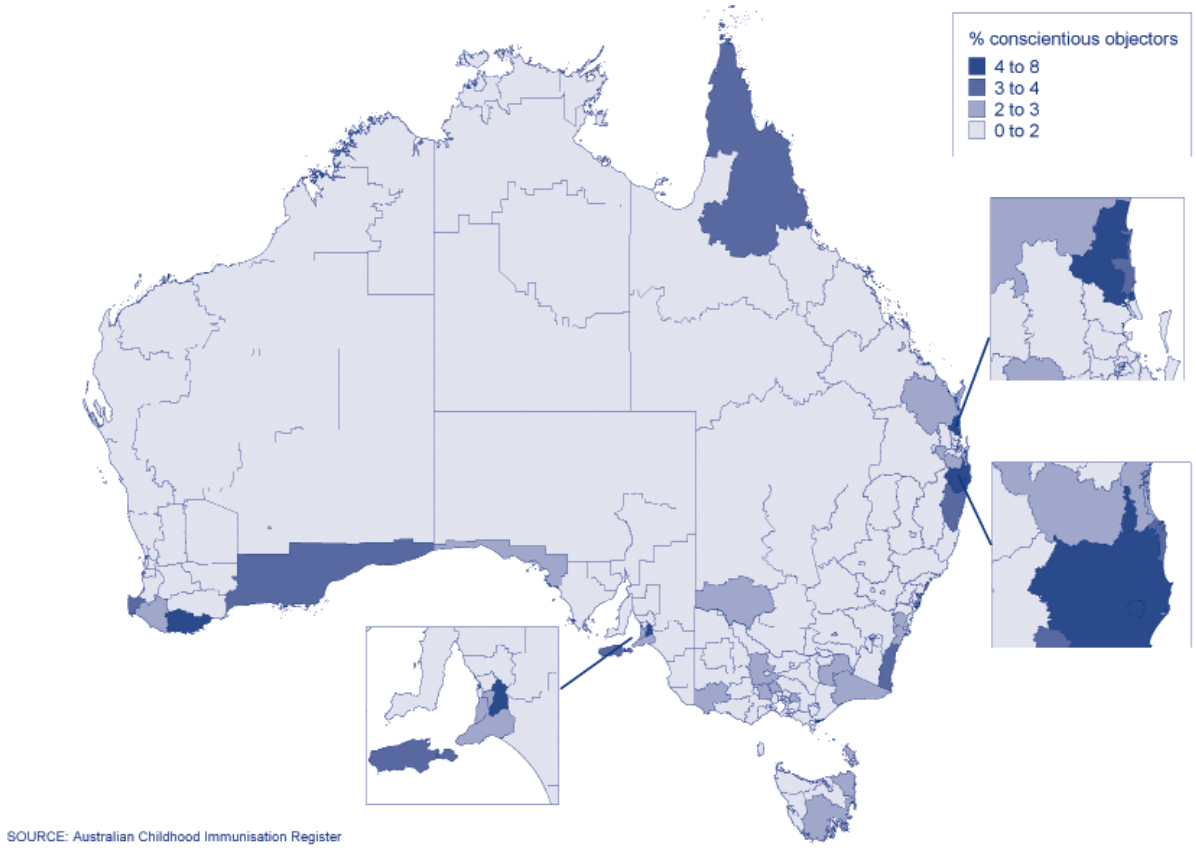


Figure 19: Proportion of children with no vaccines recorded on the ACIR, Australia, 2008 (cohort born January 2001 – December 2007)

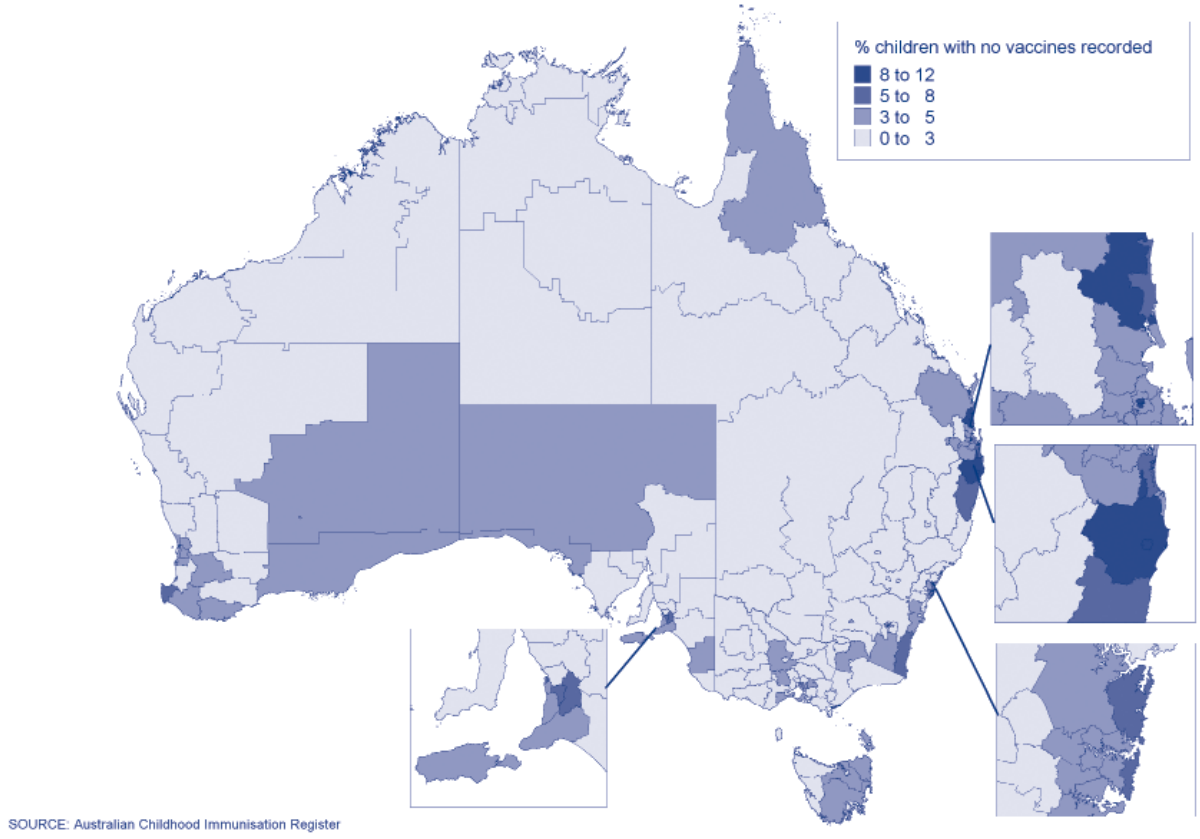
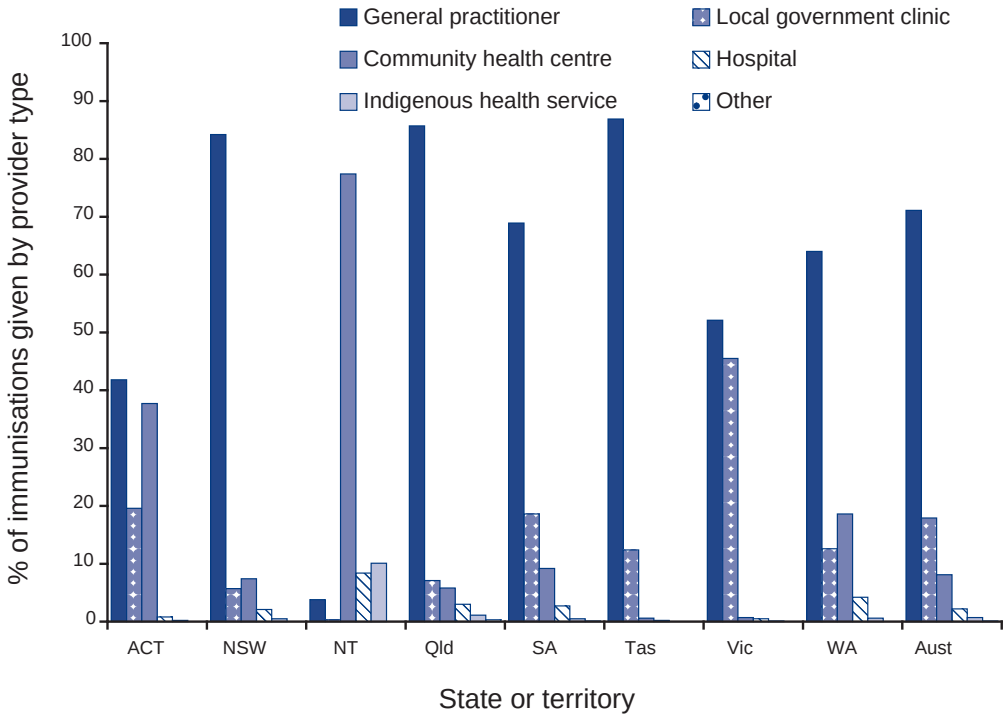


Figure 20: Proportion of immunisations on the ACIR given by various provider types, by state or territory, 2008



Immunisation incentives have positively impacted coverage estimates over time[12] and significant changes were made to these during 2008 for both providers and parents, as outlined in the Introduction. While it is too early to assess any impact on reported coverage in this analysis, it will be important to monitor the specific impacts of the 2008 changes to the incentives in the near future.

A number of vaccines that are included in the NIP are not included when calculating 'fully immunised' status or in eligibility for incentive payments. While these annual reports provide coverage data on these vaccines for the first time, data for the more long-standing and established vaccines are also available in quarterly *CDI* reports and in data provided to GP Divisions and immunisation providers. Coverage estimates for 7vPCV and meningococcal C vaccines are comparable with estimates for vaccines that are included in 'fully vaccinated' calculations, but estimates for varicella and rotavirus are lower. Strict upper age limits applying with rotavirus vaccination probably explains lower rotavirus coverage whilst varicella is the only vaccine due at 18 months, which makes this milestone a weak one. As these vaccines have been routinely incorporated into the childhood immunisation schedule for some time, their inclusion in the official coverage assessments for 'fully immunised', and wider dissemination, should be considered to facilitate monitoring of program delivery, although this will inevitably decrease official 'fully immunised' coverage estimates.

Coverage for vaccines recommended for Indigenous children only (i.e. hepatitis A and pneumococcal polysaccharide vaccine) remain sub-optimal. The extent of under-reporting to the ACIR for these vaccines is unknown but likely to be more than for 'universal' vaccines, given the lack of incentive payments for notification to the ACIR. However, lower coverage for vaccines targeted at Indigenous people has been a relatively consistent finding using a range of different methods for both children[11] and adults.[25] A lack of provider knowledge about the recommendations, and poor identification of Indigenous children by immunisation providers, are also likely to be important contributing factors. Differences in schedules between jurisdictions may also contribute. For hepatitis A, the 1st dose is given at 12 months of age in the Northern Territory and Western Australia, whereas in Queensland and South Australia it is given at 18 months of age. Coverage in jurisdictions where it is given at 12 months of age is higher. Failure to receive a 2nd dose by 16% of children also contributed to the low coverage for hepatitis A vaccine. However, protective antibody responses after 1 dose is expected from a majority of children.[26] Differences in the scheduling of pneumococcal polysaccharide vaccine by jurisdiction may also partially explain the variation in coverage seen for that vaccine, with the Northern Territory and Western Australia giving the 1st dose of this vaccine at 18 months of age, while Queensland and South Australia give it at 24 months of age.

Although coverage data reveal that most children eventually complete the scheduled vaccination series by the 24-month milestone, many still do not do so in a timely manner. While there have been significant improvements in coverage in Australia over the past 4–5 years, vaccination delay as measured in this report has improved only marginally. This is a concern, especially for diseases where multiple vaccine doses are required for protection and the disease risk among young infants is significant (e.g. pertussis). Immunisation at the earliest appropriate age should be a public health goal for countries such as Australia where high levels of vaccine coverage at milestone ages have been achieved.

In comparison with other countries, reported coverage at 12 months of age is higher in many other countries.[27] However, with more than 3% of children not vaccinated due to ideological reasons, the greater than 91% of Australian infants fully immunised at 12 months of age is above the national target and would be difficult to improve upon. Rather, the ACIR has shown the rapid uptake of new vaccines and consistently high coverage for all vaccines, unlike some other developed countries.[28,29] The reporting of national small area coverage data has not been noted elsewhere and vaccination timeliness has been reported elsewhere but not routinely.[7]

In conclusion, data provided by the ACIR in this report reflect the successful delivery of the NIP in Australia, while identifying some areas for improvement. Coverage for varicella and rotavirus vaccines are below that for other vaccines, coverage is low in some small geographic areas, timeliness of vaccination could be improved, particularly for Indigenous infants, and coverage for vaccines recommended only for Indigenous infants is lower than for other vaccines. The ACIR continues to be a very useful tool for administering the NIP and monitoring its implementation.

Author details

Brynley Hull
Deepika Mahajan
Aditi Dey
Rob Menzies
Peter McIntyre

National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases, The Children's Hospital at Westmead and University of Sydney, Westmead New South Wales

Corresponding author: Mr Brynley Hull, National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases, The Children's Hospital at Westmead and University of Sydney, Locked Bag 4001, Westmead, NSW 2145.

References

1. Hull B, Lawrence G, MacIntyre CR, McIntyre P. *Immunisation coverage: Australia 2001*. Canberra: Australian Government Department of Health and Ageing, 2002.

2. Hull BP, McIntyre PB, Heath TC, Sayer GP. Measuring immunisation coverage in Australia. A review of the Australian Childhood Immunisation Register. *Aust Fam Physician* 1999;28(1):55–60.

3. Hull BP, Lawrence GL, MacIntyre CR, McIntyre PB. Immunisation coverage in Australia corrected for under-reporting to the Australian Childhood Immunisation Register. *Aust N Z J Public Health* 2003;27(5):533–538.

4. Hull BP, McIntyre PB. Immunisation coverage reporting through the Australian Childhood Immunisation Register – an evaluation of the third-dose assumption. *Aust N Z J Public Health* 2000;24(1):17–21.

5. Hull BP, Lawrence GL, MacIntyre CR, McIntyre PB. Estimating immunisation coverage: is the 'third dose assumption' still valid? *Commun Dis Intell* 2003;27(3):357–361.

6. Hull BP, McIntyre PB. Timeliness of childhood immunisation in Australia. *Vaccine* 2006;24(20):4403–4408.

7. Hull BP, McIntyre PB. What do we know about 7vPCV coverage in Aboriginal and Torres Strait Islander children? *Commun Dis Intell* 2004;28(2):238–243.

8. Hull BP, McIntyre PB, Couzos S. Evaluation of immunisation coverage for Aboriginal and Torres Strait Islander children using the Australian Childhood Immunisation Register. *Aust N Z J Public Health* 2004;28(1):47–52.

9. Hull BP, Lawrence GL, MacIntyre CR, McIntyre PB. Is low immunisation coverage in inner urban areas of Australia due to low uptake or poor notification? *Aust Fam Physician* 2003;32(12):1041–1043.

10. Hull BP, McIntyre PB, Sayer GP. Factors associated with low uptake of measles and pertussis vaccines – an ecologic study based on the Australian Childhood Immunisation Register. *Aust N Z J Public Health* 2001;25(5):405–410.

11. Hull BP, Deeks S, Menzies R, McIntyre PB. What do we know about 7vPCV coverage in Aboriginal and Torres Strait islander children? A 2007 update. *Commun Dis Intell* 2008;32(2):257–260.

12. Lawrence GL, MacIntyre CR, Hull BP, McIntyre PB. Effectiveness of the linkage of child care and maternity payments to childhood immunisation. *Vaccine* 2004;22(17–18):2345–2350.

13. Lawrence GL, Hull BP, MacIntyre CR, McIntyre PB. Reasons for incomplete immunisation among Australian children. A national survey of parents. *Aust Fam Physician* 2004;33(7):568–571.

14. Hull B, Deeks S, Menzies R, McIntyre P. Immunisation coverage annual report, 2007. *Commun Dis Intell* 2009;33(2):170–187.

15. Australian Government Department of Health and Ageing. Communicable Diseases Surveillance – additional reports: Australian childhood immunisation coverage. *Commun Dis Intell* 2008;32(3):357–359.

16. Australian Government Department of Health and Ageing, Medicare Australia. *General Practice Immunisation Incentives Scheme, 2007.* Accessed on 18 December 2007. Available from: http://www.medicare.gov.au/provider/incentives/gpii/index.jsp#N100D3

17. National Health and Medical Research Council. *The Australian Immunisation Handbook* 9th edn. Canberra, Australia: Australian Government Department of Health and Ageing; 2008.

18. O'Brien ED, Sam GA, Mead C. Methodology for measuring Australia's childhood immunisation coverage. *Commun Dis Intell* 1998;22(3):36–37.

19. Australian Government Department of Health and Aged Care. *Measuring Remoteness: Accessibility/Remoteness Index of Australia*. Occasional Papers, New Series No. 14. Canberra: Department of Health and Aged Care, 2001.

20. Rank C, Menzies RI. How reliable are Australian Childhood Immunisation Register coverage estimates for indigenous children? An assessment of data quality and coverage. *Commun Dis Intell* 2007;31(3):283–287.

21. Australian Bureau of Statistics. Australian Standard Geographical Classification, 2001. Cat. no. 1216.0. Canberra: Australian Bureau of Statistics, 2001.

22. MapInfo version 10.0 [computer program]. Version 7. New York: MapInfo Corporation, 2009.

23. Australian Bureau of Statistics. Statistical Subdivision from Postal Area 2006 Concordance. Canberra: Australian Bureau of Statistics, 2007. Accessed on 6 December 2008. Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/39433889d406eeb9ca2570610019e9a5/5942283858e38743ca25730c00009f2e!OpenDocument

24. Australian Government Department of Health and Ageing. Communicable Diseases Surveillance – Tables: National Notifiable Diseases Surveillance System. *Commun Dis Intell* 2009;33(1):63–69.

25. Menzies R, Turnour C, Chiu C, McIntyre P. Vaccine Preventable Diseases and Vaccination Coverage in Aboriginal and Torres Strait Islander People, Australia 2003 to 2006. *Commun Dis Intell* 2008;32(Suppl):S2–S67.

26. Plotkin S, Orenstein W, Offit P. *Vaccines*. 5th edn. Elsevier, 2008.

27. World Health Organization. *Reported estimates of DTP3 coverage. 2009.* Accessed on 6 November 2009. Available from: http://www.who.int/immunization_monitoring/en/globalsummary/timeseries/tscoveragedtp3.htm

28. Centers for Disease Control and Prevention. National, state, and local area vaccination coverage among children aged 19–35 months—United States, 2008. *MMWR Morb Mortal Wkly Rep* 2009;58(33):921–926.

29. Health Protection Agency. *NHS Immunisation Statistics, England 2008–09 Report*. The Health and Social Care Information Centre, 2009. Accessed on 6 November 2009.