Invasive pneumococcal disease in Australia, 2009 and 2010

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Abstract

Enhanced surveillance for invasive pneumococcal disease (IPD) was conducted in all Australian states and territories in 2009 and 2010 with comprehensive comparative data available since 2002. There were 1,556 cases of IPD notified to the National Notifiable Diseases Surveillance System in Australia in 2009, a notification rate of 7.2 cases per 100,000 population. In 2010 there were 1,640 cases, a notification rate of 7.4 cases per 100,000. The overall rate of IPD in Indigenous Australians was almost 6 times the rate in non-Indigenous Australians in both 2009 and 2010. In 2009 and 2010, notification rates of IPD caused by serotypes included in the 7-valent pneumococcal conjugate vaccine (7vPCV) continued to decrease across all age groups. Rates of IPD caused by non-7vPCV serotypes continued to show an increasing trend in both Indigenous and non-Indigenous children aged less than 5 years. In Indigenous adults (≥50 years), rates of IPD caused by both 23-valent pneumococcal polysaccharide vaccine (23vPPV) serotypes and non-23vPPV serotypes continued to show an overall increase, particularly in 2010. There were 110 deaths attributed to IPD in 2009 and 137 in 2010, although it should be noted that deaths may be under-reported. The number of invasive pneumococcal isolates with reduced penicillin susceptibility remained low and reduced susceptibility to third generation cephalosporins was rare. *Commun Dis Intell* 2015;39(2):E265–E279.

Keywords: Australia, invasive pneumococcal disease, communicable disease surveillance, epidemiology, annual report

Introduction

Streptococcus pneumoniae infection is a major cause of vaccine preventable disease worldwide.[1,2] The organism colonises the nasopharynx of healthy carriers who show no symptoms of disease. In susceptible groups, the bacterium can spread to the respiratory tract and sterile sites, such as the blood, cerebrospinal fluid or pleural fluid, and cause disease ranging from mild, such as otitis media and sinusitis, to more severe, such as pneumonia, septicaemia and meningitis.[3] The burden of disease is greatest in infants and the elderly. The 23-valent pneumococcal polysaccharide vaccine (23vPPV) was first recommended in Australia prior to 1991 for certain high risk groups. A 7-valent pneumococcal conjugate vaccine (7vPCV) program with a 3+0 schedule (i.e. 2, 4 and 6 month schedule without a conjugate vaccine booster) was first funded by the National Immunisation Program (NIP) for Aboriginal and Torres Strait Islander infants in mid-2001 with children in areas of very high incidence also funded for a 23vPPV booster at 18–24 months.[4] The 23vPPV is currently funded nationally for all individuals aged 65 years or over and Aboriginal and Torres Strait Islanders aged 50 years or over. From January 2005, NIP-funded 7vPCV was extended to all infants nationally, together with catch-up vaccination for all children aged less than 2 years. High vaccination uptake of over 90% has been maintained since the implementation of universal infant pneumococcal vaccination.[4] Enhanced surveillance of risk factors, invasive pneumococcal disease (IPD)-specific clinical details, microbiological and vaccination history is carried out for IPD, which has been nationally notifiable in Australia since 2001. Some states and territories hold data from earlier years. Surveillance reports have been published in *Communicable Diseases Intelligence* for 2002 to 2008.[5–10] This report describes epidemiological, microbiological and disease trends for the years 2009 and 2010.

Methods

Data collection

IPD is a nationally notifiable disease in Australia and is monitored using the National Notifiable Diseases Surveillance System (NNDSS). Complete data have been reported to the NNDSS from all states and territories since 2002. To varying degrees across jurisdictions, medical practitioners, public health laboratories and other health professionals are required under state and territory public health legislation to report cases of IPD to state and territory health authorities. The *National Health Security Act 2007* provides the legislative basis for the national notification of communicable diseases and authorises the exchange of health information between the Commonwealth and the states and territories.[11] Notified cases of IPD that meet the national surveillance case definition are transferred by state and territory health departments to the NNDSS regularly.[12] The primary responsibility for public health action resulting from notification resides with state and territory health departments.

The Communicable Diseases Network Australia (CDNA) established the Enhanced Invasive Pneumococcal Disease Surveillance Working Group (EIPDSWG) in 2000 to assist in the development and implementation of a nationally standardised approach to the enhanced surveillance of IPD in Australia. In 2009 and 2010, core organism and diagnosis data were collected for all notified cases, whereas enhanced data, which includes clinical categories and risk factors, were collected to varying degrees across states and territories (Table 1).

Data presented in this report represent a point in time analysis of notified cases of IPD. This report presents data extracted in July 2014 and analysed by date of diagnosis. Date of diagnosis is a derived field within the NNDSS and represents the onset date, or when the onset date was not known, the earliest of the specimen collection, notification, or notification receive dates. Due to the dynamic nature of the NNDSS, data in this report may vary from data reported in other NNDSS reports and reports of IPD notifications at the state or territory level.

Australian Bureau of Statistics mid-year estimated resident populations were used to calculate notification rates.[13]

Case definition

Cases of IPD were notified according to the CDNA case definition for IPD.[14] A confirmed case requires definitive evidence only. Laboratory definitive evidence for IPD is the isolation from or detection by nucleic acid amplification test of *S. pneumoniae* in blood, cerebrospinal fluid or other sterile site.

Indigenous status

Cases of IPD were reported indicating the Indigenous status of the individual. The definition of an Aboriginal or Torres Strait Islander within the NNDSS aligns with the Commonwealth definition, that is, an Aboriginal or Torres Strait Islander is determined by descent, self-identification and community acceptance.

Cases reported with an unknown Indigenous status (2009:195/1,556, 13%; 2010: 193/1,640, 12%) were excluded from the analyses in this report relating to Indigenous status.

Vaccination

Pneumococcal vaccination for various specified age groups and other high risk populations has been recommended within Australia since before 1991. In 2009–2010, primary pneumococcal vaccination and specified boosters were recommended and funded under the NIP for the following groups:

- all infants;
- children aged under 10 years with specified underlying medical conditions;
- Aboriginal and Torres Strait Islander children aged 18–24 months and living in high risk areas;
- Aboriginal and Torres Strait Islander people aged 15–50 years with specified underlying medical conditions;
- all Aboriginal and Torres Strait Islander people aged 50 years or over; and
- all adults aged 65 years or over.

NIP pneumococcal vaccination schedules for these groups were unchanged from those used in 2008.[10] From October 2009, the 10-valent pneumococcal conjugate vaccine (10vPCV) was funded as a replacement to the 7vPCV in the Northern Territory for all children. However, in this report, Northern Territory cases were not analysed separately. There are now 4 vaccines available in Australia with each targeting multiple serotypes (Table 2); however, the13-valent pneumococcal conjugate vaccine (13vPCV) was not yet introduced to the Australian NIP during the years of this study, 2009 and 2010.

More information on the scheduling of the pneumococcal vaccination can be found on the Immunise Australia web site (www.immunise.health.gov.au). A detailed history on vaccination recommendations and practices is available through the National Centre for Immunisation Research and Surveillance (NCIRS).[15]

The evaluation of vaccination status in this report is described in Table 3. These definitions are applied to the vaccination fields reported to the NNDSS and are agreed to by the EIPDSWG.

Table 1: Enhanced invasive pneumococcal disease surveillance data collection performed by states and territories in 2009 and 2010

Age group	State or territory
Under 5 years	New South Wales, Queensland (Metro South and Gold Coast Public Health Units only).
Over 50 years	New South Wales.
All ages	Australian Capital Territory, Northern Territory, Queensland (except Metro South and Gold Coast Public Health Units), Tasmania, South Australia, Victoria, Western Australia.

Table 2: Serotypes targeted by pneumococcal vaccines

Vaccine type	Serotypes targeted by the vaccine
7-valent pneumococcal conjugate vaccine (7vPCV)	4, 6B, 9V, 14, 18C, 19F and 23F.
10-valent pneumococcal conjugate vaccine (10vPCV)	1, 4, 5, 6B, 7F, 9V, 14, 18C, 19F and 23F.
13-valent pneumococcal conjugate vaccine (13vPCV)	1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F and 23F.
23-valent pneumococcal polysaccharide vaccine (23vPPV)	1, 2, 3, 4, 5, 6B, 7F, 8, 9N, 9V, 10A, 11A, 12F, 14, 15B, 17F, 18C, 19F, 19A, 20, 22F, 23F and 33F.

Table 3: Definitions of vaccination status and vaccine failure used in this report

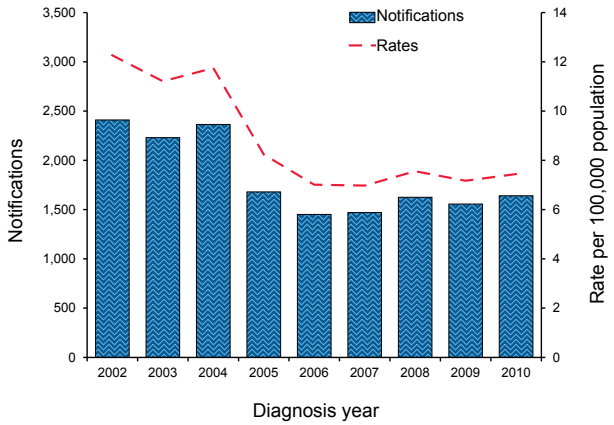
Category	Definition
Fully vaccinated	Those who have completed the primary course of the relevant vaccine(s) required for their age according to the most recent edition of *The Australian Immunisation Handbook,* at least 2 weeks prior to disease onset with at least 28 days between doses of vaccine. This includes the following; • a child who received a vaccine as 'catch up' and therefore did not require a full 3 dose primary schedule. Providing they have had the number of doses required for the age they were at first dose they should be considered fully vaccinated. NB: A young child who has had all the required doses for their age but is not old enough to have completed the primary course would not be assessed as fully vaccinated.
Vaccination validation	Written confirmation of vaccination through the Australian Childhood Immunisation Register, state or territory immunisation register or health record.
Vaccine failure	A fully vaccinated child (as defined above) with disease due to a serotype found in the corresponding vaccine.

Results

Invasive pneumococcal disease notifications

There were 1,640 cases of IPD notified in 2010, representing an annual notification rate of 7.4 per 100,000 population. This was a 5% increase on the 1,556 cases reported in 2009 (7.2 per 100,000). The number of cases of IPD notified to the NNDSS has been stable since 2005, when the universal pneumococcal conjugate vaccine program for young children was introduced (Figure 1).

Figure 1: Notification and notification rate for invasive pneumococcal disease, Australia, 2002 to 2010



A summary of the number and rates of notifications by jurisdiction is shown in Table 4. As in previous years, New South Wales accounted for the largest number of cases notified by a state or territory in 2009 (n=478) and 2010 (n=499) and the Northern Territory reported the highest notification rate in both 2009 (38.5 per 100,000) and 2010 (24.4 per 100,000). The Australian Capital Territory reported the smallest number of cases in both 2009 (n=30) and 2010 (n=25) and Queensland recorded the lowest notification rate in both 2009 (6.0 per 100,000) and 2010 (6.2 per 100,000).

The number of cases of IPD was greatest in the winter months with the peak number of notifications for both 2009 (n=226) and 2010 (n=218) occurring in July. The effect of season was more evident in the distribution of cases aged 5 years or over compared with younger children (Figure 2).

Invasive pneumococcal disease by age and sex

In almost all age groups, there was a greater notification rate of IPD in males than females. Consistent with 2007–2008, the highest rates in 2009 and 2010 combined were again among the elderly aged 85 years or over (34.4 per 100,000) and in children aged 1 year (30.8 per 100,000) (Figure 3).

Table 4: Notified cases and notification rate for invasive pneumococcal disease, Australia, 2009 and 2010 by state or territory, age group and Indigenous status

Age and Indigenous status	State or territory								
	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Aust.
2009									
Notified cases aged <5 years									
Indigenous	0	3	16	3	0	0	0	4	26
Non-Indigenous	7	70	3	37	21	1	40	26	205
Total*	7	73	19	55	21	1	45	30	251
Notified cases aged 5–64 years									
Indigenous	1	5	57	27	12	3	8	29	142
Non-Indigenous	16	138	4	102	55	25	157	56	553
Total*	17	225	61	145	68	28	196	85	825
Notified cases ≥ 65 years									
Indigenous	0	2	5	3	1	0	0	1	12
Non-Indigenous	6	178	2	39	55	9	102	33	424
Total*	6	180	7	59	56	10	128	34	480
Total									
Indigenous	1	10	78	33	13	3	8	34	180
Non-Indigenous	29	386	9	178	131	35	299	115	1,182
Total*	30	478	87	259	145	39	369	149	1,556
Rate (per 100,000 population)	8.5	6.8	38.5	6.0	9.0	7.7	6.9	6.7	7.2
Indigenous status completeness	100%	83%	100%	81%	99%	97%	83%	100%	87%
2010									
Notified cases aged <5 years									
Indigenous	0	4	10	6	2	0	1	14	37
Non-Indigenous	5	91	2	32	22	4	47	32	235
Total*	5	95	12	42	24	4	58	46	286
Notified cases aged 5–64 years									
Indigenous	2	9	32	29	16	1	7	52	148
Non-Indigenous	14	124	9	115	58	18	183	63	584
Total*	16	224	41	164	74	19	216	115	869
Notified cases ≥ 65 years									
Indigenous	0	4	2	2	0	0	0	3	11
Non-Indigenous	4	176	1	44	41	23	109	34	432
Total*	4	180	3	65	41	23	132	37	485
Total									
Indigenous	2	17	44	37	18	1	8	69	196
Non-Indigenous	23	391	12	191	121	45	339	129	1,251
Total*	25	499	56	271	139	46	406	198	1,640
Rate (per 100,000 population)	6.9	7.0	24.4	6.2	8.5	9.0	7.4	8.6	7.4
Indigenous status completeness	100%	82%	100%	84%	100%	100%	85%	100%	88%

* Total includes cases reported with a not stated or not reported Indigenous status.

Figure 2: Notifications of invasive pneumococcal disease, Australia, 2009 and 2010, by month and year of diagnosis and age group

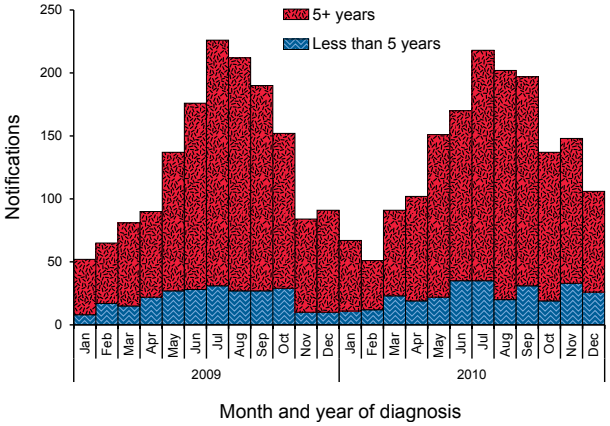
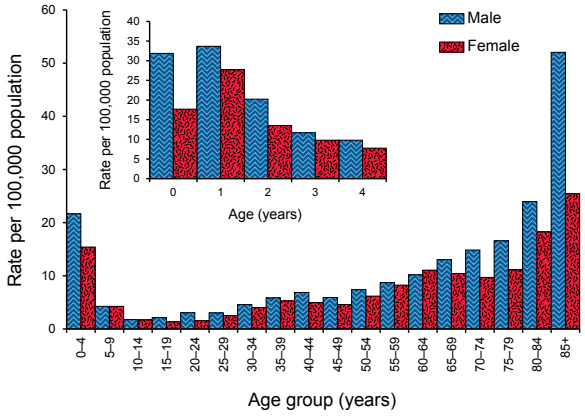


Figure 3: Notification rate for invasive pneumococcal disease, Australia, 2009 and 2010, by age group and sex



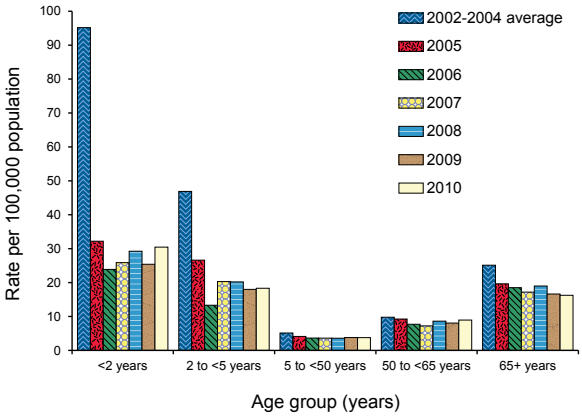
In 2009, the rate of IPD in children aged under 2 years was 25.4 per 100,000 (Figure 4). In 2010, the rate in this age group increased to 30.5 per 100,000; however, overall the rate maintains the large decrease experienced in this age group as a result of the introduction of the universal 7vPCV immunisation program in 2005. Prior to the vaccination program the notification rate in this age group was close to 100 cases per 100,000 (Figure 4).

The overall rate of IPD in adults aged 65 years or over continued to slowly decline in 2009 (16.6 per 100,000) and 2010 (16.2 per 100,000).

Invasive pneumococcal disease in Aboriginal and Torres Strait Islander people

Indigenous status was reported in 87% of notifications in 2009 and in 88% of notifications in 2010 (Table 4). In 2009, there were 180 cases of IPD reported as Indigenous (11.6% of all cases). This represents a rate of 33 cases per 100,000; a rate almost 6 times that seen in the non-Indigenous population (6.0 per 100,000). The rate of IPD among Indigenous people in 2010 was similar to 2009 with 196 cases representing 12.0% of all cases. Further analyses of the Indigenous population group are provided throughout this report.

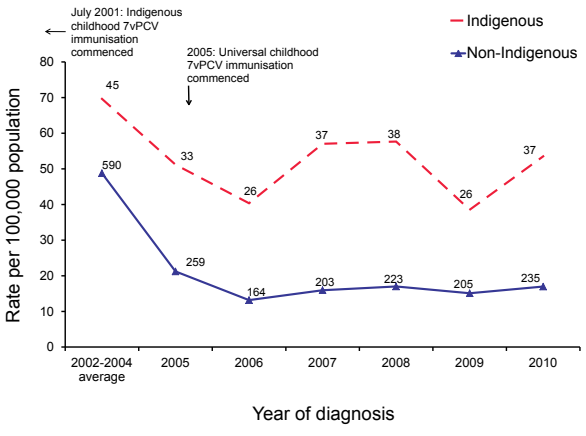
Figure 4: Notification rate for invasive pneumococcal disease, Australia, 2002 to 2010, by age group



Invasive pneumococcal disease in children

The rate of IPD in Indigenous children aged less than 5 years in 2009 was 38.5 cases per 100,000 (n=26) and in 2010 was 53.5 cases per 100,000 (n=37) (Figure 5). The rate of IPD in non-Indigenous children aged less than 5 years in 2009 was 15.1 cases per 100,000 (n=205) and in 2010 was 17.0 cases per 100,000 (n=235).

Figure 5: Notification rate for invasive pneumococcal disease in children aged less than 5 years, Australia, 2002 to 2010, by Indigenous status

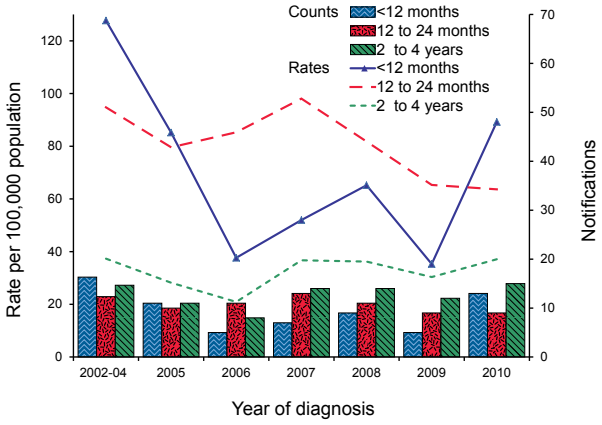


Data point labels represent the number of notifications.

The rate of IPD in Indigenous children aged:

- less than 12 months was 35 cases per 100,000 (n=5) in 2009 and 89 cases per 100,000 in 2010 (n=13) (Figure 6a);
- 12 to 23 months was 65 cases per 100,000 (n=9) in 2009 and 64 cases per 100,000 in 2010 (n=9); and
- 24 months to less than 60 months was 30 cases per 100,000 (n=12) in 2009 and 37 cases per 100,000 in 2010 (n=15).

Figure 6a: Notification rate for invasive pneumococcal disease in Indigenous children aged less than 5 years, Australia, 2002 to 2010, by Indigenous status and age group



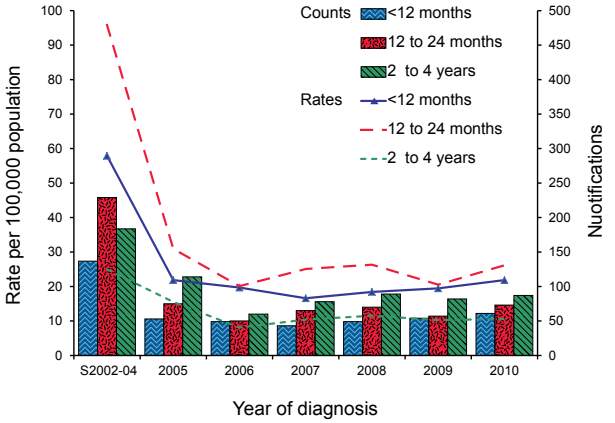
Simple average of data from 2002 to 2004.

The rate of IPD in Indigenous children fluctuated over the period due to the small number of notifications.

Less variability was seen in non-Indigenous children. Despite a slight increase in the rate of IPD in non-Indigenous children between 2009 and 2010, there has been an overall decrease in the rate since the implementation of the universal 7vPCV immunisation program in 2005. The IPD rate in non-Indigenous children aged:

- less than 12 months was 20 cases per 100,000 (n=54) in 2009 and 22 cases per 100,000 in 2010 (n=61) (Figure 6b);
- 12 to 23 months was 21 cases per 100,000 (n=57) in 2009 and 26 cases per 100,000 in 2010 (n=73); and
- 24 to less than 60 months was 10 cases per 100,000 (n=82) in 2009 and 11 cases per 100,000 in 2010 (n=87).

Figure 6b: Notification rate for invasive pneumococcal disease in non-Indigenous children aged less than 5 years, Australia, 2002 to 2010, by Indigenous status and age group



Simple average of data from 2002 to 2004.

Mortality of invasive pneumococcal disease cases

Mortality data were reported for 63% (n=987) of IPD cases notified in 2009 and 62% (n=1,013) in 2010 (Table 5). One hundred and ten and 137 deaths associated with IPD were reported in 2009 and 2010, respectively.

Overall, case fatality rates (CFR) in notifications reported as non-Indigenous were higher than in those reported as Indigenous. In 2009, death associated with IPD was reported in 9 Indigenous cases (CFR=5.0%) and in 96 non-Indigenous cases (CFR=8.1%). In 2010, death associated with IPD was reported in 10 Indigenous cases (CFR=5.1%) and in 122 non-Indigenous cases (CFR=9.8%).

In those aged less than 5 years, there were 3 deaths associated with IPD in 2009 and 10 deaths in 2010 giving case fatality rates of 1.2% and 3.5% respectively. Three of the deaths that occurred in 2010 were in cases reported as Indigenous children. Further details, including serotype and vaccination history, of the 13 children aged less than 5 years whose deaths were associated with IPD are shown in Table 6.

Risk factors for invasive pneumococcal disease

Risk factor data were provided for 69% (2,221/3,196) of cases reported in 2009 and 2010. Of the cases with risk factor data reported, 76% (1,696) of cases reported at least 1 risk factor and 11% (243) of cases reported that no risk factors were identified.

Table 5: Deaths and case fatality rates* for invasive pneumococcal disease, Australia, 2009 and 2010, by age group, Indigenous status and state or territory

Age group	State or territory								
	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Aust.
2009									
Notified cases aged <5 years									
Deaths	0	0	1	1	0	0	1	0	3
Case fatality rate*	0.0	N/A	5.3	1.8	N/A	0.0	2.2	0.0	1.2
Notified cases aged 5–64 years									
Deaths	0	12	2	8	2	1	11	4	40
Case fatality rate*	0.0	N/A	3.3	5.5	2.9	3.6	5.6	4.7	4.8
Notified cases ≥ 65 years									
Deaths	0	41	1	3	3	3	12	4	67
Case fatality rate*	0.0	N/A	14.3	N/A	5.4	30.0	9.4	11.8	14.0
Total									
Indigenous	0	0	4	2	1	0	0	2	9
Non-Indigenous	0	53	0	10	4	4	19	6	96
Total†	0	53	4	12	5	4	24	8	110
Death reporting completeness (%)	100	11	100	54	87	100	98	100	63
2010									
Notified cases aged <5 years									
Deaths	0	1	0	2	1	0	1	5	10
Case fatality rate*	0.0	N/A	0.0	N/A	4.2	0.0	1.7	10.9	3.5
Notified cases aged 5–64 years									
Deaths	0	14	1	6	3	1	10	6	41
Case fatality rate*	0.0	N/A	2.4	N/A	4.1	5.3	4.6	5.2	4.7
Notified cases ≥ 65 years									
Deaths	2	40	1	1	5	7	22	8	86
Case fatality rate*	50.0	N/A	33.3	N/A	12.2	30.4	16.7	21.6	17.7
Total									
Indigenous	0	1	2	1	0	0	1	5	10
Non-Indigenous	2	54	0	8	9	8	27	14	122
Total†	2	55	2	9	9	8	33	19	137
Death reporting completeness (%)	100	11	100	32	100	100	100	100	62

* Jurisdictional specific case fatality rates have not been presented for those jurisdictions where completeness of data was less than 50%; denoted as 'N/A'. Rates shown should be interpreted with caution given the proportion of cases without mortality data reported to the NNDSS, as well as the variability across jurisdictions in reporting death as primary and secondary causes.

† All notified cases include cases reported with a not stated or not reported Indigenous status.

Table 7 shows data on the risk factors for IPD in specified population sub-groups for 2009 and 2010 combined.

In children aged less than 5 years, the most frequently reported risk factor in the Indigenous population was premature birth (< 37 weeks gestation, 25% of cases with a risk factor reported), while childcare attendance was the most frequently reported risk factor in the non-Indigenous population (35% of cases with risk factor data reported). Among the adult population groups, Indigenous cases aged greater than 50 years and non-Indigenous cases aged greater than 65 years, chronic illness was the most frequently reported risk factor, with 46% and 41% of cases with a risk factor reported respectively.

Table 6: Characteristics of deaths from invasive pneumococcal disease in children aged less than 5 years of age, Australia, 2009 and 2010

Case	Year of diagnosis	Sex	Age (months)	Indigenous status	Serotype	Doses of 7vPCV	Risk factors
Deaths potentially preventable by 7vPCV							
1	2009	Male	16	Non-Indigenous	19F	3	Other*
Deaths not preventable by 7vPCV							
2	2009	Male	10	Indigenous	16F	2	Chronic illness and other
3	2009	Female	16	Non-Indigenous	8	0	Unknown
4	2010	Male	5	Indigenous	1	1	Anatomic or functional asplenia
5	2010	Female	55	Non-Indigenous	11A	0	Unknown
6	2010	Female	10	Non-Indigenous	18A	3	Unknown
7	2010	Female	6	Non-Indigenous	19A	3	No risk factor identified
8	2010	Male	12	Non-Indigenous	19A	3	Information not supplied
9	2010	Male	1	Non-Indigenous	23B	0	No risk factor identified
10	2010	Female	1	Non-Indigenous	35B	0	No risk factor identified
11	2010	Male	2	Non-Indigenous	7F	0	Premature (<37 weeks gestation) and Congenital or chromosomal abnormality
12	2010	Male	23	Non-Indigenous	Non-typable	3	Unknown
13	2010	Female	3	Indigenous	Untyped	1	No risk factor identified

* Other risk factors include but are not limited to exposure to smoke, asthma and previous pneumonia.

Mortality caveat:

NNDSS is generally a passive surveillance system that contains a minimum dataset including whether or not the case 'died of the notifiable condition'. The specific manner in which these data items are collected has not been standardised and therefore varies from jurisdiction to jurisdiction. There is consensus that data reported here includes deaths within the first one to two weeks of diagnosis.

Table 7: Numbers of risk factors* for invasive pneumococcal disease population sub-groups, Australia, 2009 and 2010

Risk factor	Children aged less than 5 years		Indigenous aged 50 years or over	Non-Indigenous aged 65 years or over
	Indigenous	Non-Indigenous		
Premature (<37 weeks gestation)	14	29	N/A	N/A
Congenital or chromosomal abnormality	5	14	1	0
Anatomic or functional asplenia	1	1	2	12
Immunocompromised	3	18	14	203
Chronic illness	7	14	56	386
Childcare attendee	4	61	N/A	N/A
Previous episode of IPD	2	1	5	7
Other†	21	34	43	344
No risk factor identified	14	88	3	29
Unknown or not reported	14	217	13	186
Total	63	440	81	856

* Case may be reported with more than one risk factor.

† Other risk factors include but are not limited to exposure to smoke, asthma and previous pneumonia.

N/A Not applicable.

Pneumococcal serotypes causing invasive disease

While serotype information does not influence initial clinical care, it is necessary to monitor the effectiveness of vaccination programs and inform future policy. It is also recognised that specific serotypes may be associated with certain disease presentation and severity and may have identifiable antibiotic susceptibility patterns. Pneumococcal serotypes were identified for 95% (1,483/1,556) of all notified cases in 2009 and for 94% (1,546/1,640) in 2010.

Of all the cases reported with a serotype in 2009 and 2010, 12% (370/3,029) were due to serotypes covered by the 7vPCV. This ranged from 2% (1/61) of Indigenous cases aged less than 5 years to 15% (81/554) of non-Indigenous cases aged 5–49 years. The 3 additional serotypes (1, 5 and 7F) covered by the 10vPCV accounted for an additional 10% (300/3,029) of cases in 2009 and 2010, which ranged from 3% (27/815) of non-Indigenous adults aged 65 years or over to 19% (103/554) of non-Indigenous cases aged 5–49 years. The 3 additional serotypes (3, 6A and 19A) covered by the 13vPCV accounted for an additional 34% (1,027/3,029) of cases, ranging from 9% (19/220) of Indigenous cases aged 5–49 years to 57% (234/409) of non-Indigenous cases aged less than 5 years.

There are an additional 16 serotypes covered by the 23vPPV, in addition to the seven covered by the 7vPCV. Of all the cases reported with a serotype in 2009 and 2010, 65% (1,982/3,029) of all cases were due to these additional 16 serotypes. This ranged from 53% (431/815) of non-Indigenous adults aged 65 years or over to 74% (303/409) of non-Indigenous cases aged less than 5 years.

Table 8 and the remainder of the analyses included in this section consider the number and proportions of IPD cases due to serotypes covered by the various pneumococcal vaccines and their target age groups. Note that 13vPCV is included in Table 8 pending its introduction to the NIP in 2011.

7-valent pneumococcal conjugate vaccine serotypes

Overall, the notification rate of IPD due to 7vPCV serotypes has continued to decrease across all age groups since 2002 (Figure 7). Since the 2005 introduction of the universal 7vPCV immunisation program, the notification rate of IPD in all age groups decreased by 78% in 2009 (4.5 to 1.0 per 100,000) and 84% in 2010 (4.5 to 0.7 per 100,000).

Figure 8 shows rates of IPD caused by 7vPCV serotypes in Indigenous and non-Indigenous children aged less than 5 years since 2002. The rate of IPD due to 7vPCV serotypes in Indigenous children remained low in 2009 (0 per 100,000) and 2010 (1.4 per 100,000). Similarly, rates also remained low in non-Indigenous children in 2009 (1.1 per 100,000) and 2010 (0.9 per 100,000).

Figure 7: Notification rate for invasive pneumococcal disease caused by 7vPCV serotypes, Australia, 2002 to 2010, by age group

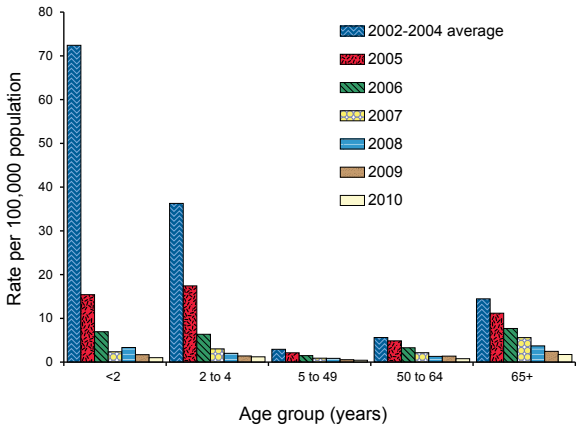
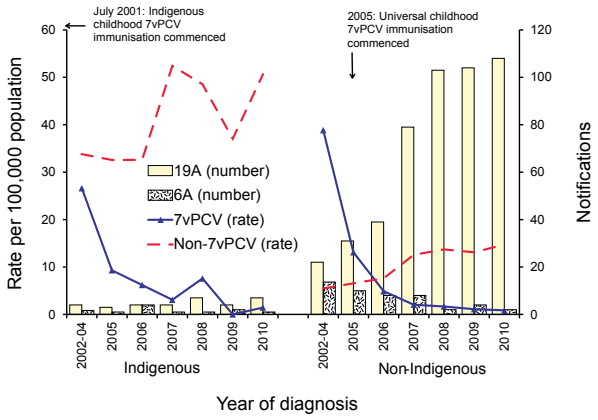


Figure 8: Notification rate for 7vPCV and non-7vPCV serotypes causing cases of invasive pneumococcal disease in children aged less than 5 years, 2002 to 2010, by Indigenous status



Simple average of data from 2002 to 2004.

	Indigenous		Non-Indigenous	
	7vPCV (n)	Non-7vPCV (n)	7vPCV (n)	Non-7vPCV (n)
2002-04*	17	22	470	66
2005	6	21	160	80
2006	4	21	61	95
2007	2	34	26	160
2008	5	32	22	180
2009	0	25	15	178
2010	1	35	12	204

Table 8: Notified cases of invasive pneumococcal disease, Australia, 2009 and 2010, by pneumococcal vaccine serotypes

Age group	Vaccine type	Indigenous			Non-Indigenous		
		Number	%	Cumulative (%)	Number	%	Cumulative (%)
<5 years	7vPCV	1	2	2	27	7	7
	10vPCV (non-7vPCV)	11	18	20	25	6	13
	13vPCV (non-10vPCV)	15	25	44	234	57	70
	Non-conjugate vaccine serotypes	34	56	100	123	30	100
	Total	61	100		409	100	
	23vPPV (non-7vPCV)	45	74		303	74	
5–49 years	7vPCV	17	8	8	81	15	15
	10vPCV (non-7vPCV)	34	15	23	103	19	33
	13vPCV (non-10vPCV)	19	9	32	161	29	62
	Non-conjugate vaccine serotypes	150	68	100	209	38	100
	Total	220	100		554	100	
	23vPPV (non-7vPCV)	140	64		366	66	
50–64 years	7vPCV	3	5	5	76	14	14
	10vPCV (non-7vPCV)	8	14	19	47	9	23
	13vPCV (non-10vPCV)	11	19	39	181	34	57
	Non-conjugate vaccine serotypes	35	61	100	227	43	100
	Total	57	100		531	100	
	23vPPV (non-7vPCV)	37	65		342	64	
65+ years	7vPCV	1	5	5	112	14	14
	10vPCV (non-7vPCV)	2	10	14	27	3	17
	13vPCV (non-10vPCV)	4	19	33	268	33	50
	Non-conjugate vaccine serotypes	14	67	100	408	50	100
	Total	21	100		815	100	
	23vPPV (non-7vPCV)	12	57		431	53	
Total	7vPCV	22	6	6	296	13	13
	10vPCV (non-7vPCV)	55	15	21	202	9	22
	13vPCV (non-10vPCV)	49	14	35	844	37	58
	Non-conjugate vaccine serotypes	233	65	100	967	42	100
	Total	359	100		2,309	100	
	23vPPV (non-7vPCV)	234	65		571	25	

Notifications with Indigenous status and/or serotype reported as unknown are excluded.

Since 2002, the rate of IPD disease caused by non-7vPCV serotypes has increased overall for both Indigenous and non-Indigenous children aged less than 5 years. The rate of IPD due to non-7vPCV serotypes in Indigenous children was 37 per 100,000 in 2009 and 51 per 100,000 in 2010, and in non-Indigenous children was 13 per 100,000 in 2009 and 15 per 100,000 in 2010.

Increasing rates of invasive pneumococcal disease caused by serotypes not contained in the 7vPCV has been observed since 2005 with serotypes 19A and 6A the more commonly occurring replacement serotypes. The number of cases due to serotype 19A has continued to show an overall increase since 2002 in both Indigenous and non-Indigenous children aged less than 5 years. The number of cases due to the 19A serotype in Indigenous children was four in 2009 and seven in 2010. The number of cases due to the 19A serotype in non-Indigenous children was 104 in 2009 and 108 in 2010. The number of cases due to serotype 6A has

remained steady in Indigenous children aged less than 5 years with two cases notified in 2009 and a single case notified in 2010. The number of cases due to the 6A serotype in non-Indigenous children was four in 2009 and two in 2010.

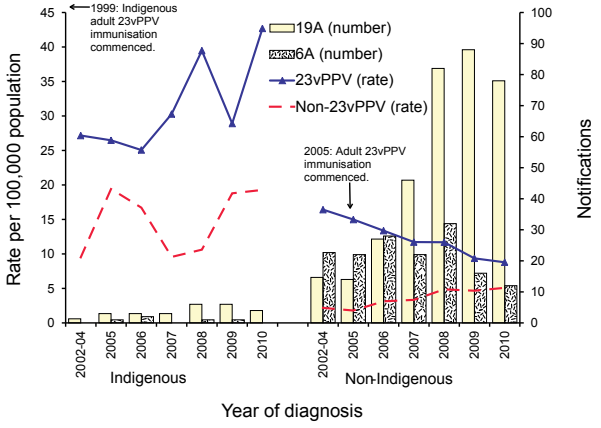
23-valent pneumococcal polysaccharide vaccine serotypes

Figure 9 shows rates of IPD caused by 23vPPV serotypes in the groups targeted to receive the vaccine including Indigenous adults aged 50 years or over and non-Indigenous adults aged 65 years or over. In Indigenous adults, the rate of disease caused by 23vPPV serotypes continued to show an overall increase with a rate of 29 per 100,000 in 2009 and 43 per 100,000 in 2010. Conversely, in non-Indigenous adults the rate continued to show a decreasing trend with a rate of 9.4 per 100,000 in 2009 and 8.8 per 100,000 in 2010.

The rate of disease caused by non-23vPPV serotypes continued to show an overall increase in both Indigenous and non-Indigenous adults. The rate of IPD disease caused by non-23vPPV was 19 per 100,000 in both 2009 and 2010 for Indigenous adults and 4.7 per 100,000 in 2009 and 5.1 per 100,000 in 2010 for non-Indigenous adults.

The number of cases due to serotype 19A in Indigenous adults showed a slight overall increase since 2002 with 6 cases in 2009 and 4 cases in 2010. The number of cases due to serotype 19A in non-Indigenous adults showed a more marked increase since 2002 with 88 cases in 2009 and 78 cases in 2010. The number of cases due to serotype 6A has remained steady in Indigenous adults with 1 case in 2009 and no cases in 2010. The number of cases due to serotype 6A showed an overall increase from 2002 to 2008; however, have since decreased with 16 cases in 2009 and 12 cases in 2010.

Figure 9: Notification rate for 23vPPV and non-23vPPV serotypes causing cases of invasive pneumococcal disease in Indigenous adults (aged 50 years or over) and non-Indigenous adults (aged 65 years or over), 2002 to 2010



Simple average of data from 2002 to 2004.

	Indigenous		Non-Indigenous	
	23vPPV (n)	Non-23vPPV (n)	23vPPV (n)	Non-23vPPV (n)
2002-04*	14	5	413	55
2005	15	11	393	47
2006	15	10	358	84
2007	19	6	322	92
2008	26	7	329	137
2009	20	13	269	134
2010	31	14	261	151

Vaccine failures

In 2009 and 2010, a total of 17 children who were considered fully vaccinated, were notified with disease due to 7vPCV serotypes (Table 9). Sixteen of the 17 cases were reported as non-Indigenous and 1 case did not have Indigenous status identified. Serotype 19F was reported in 76% (n=13) of these cases.

Antibiotic resistance

Antimicrobial resistance in invasive pneumococci is an emerging problem in Australia.[16] Antibiotic susceptibility testing was performed across all jurisdictions by a range of different methods. Penicillin and ceftriaxone/cefotaxime susceptibility data were analysed only for jurisdictions that reported susceptibility data for more than 50% of cases. Penicillin susceptibility completeness was suitable for reporting for all jurisdictions in 2009 and all jurisdictions, excluding Victoria in 2010. Similarly, ceftriaxone/cefotaxime susceptibility completeness was suitable for reporting for all jurisdictions, in 2009 and for all jurisdictions, excluding Victoria in 2010.

Throughout the report period, the proportion of isolates with reduced susceptibility to penicillin increased from 10% (2009: 133/1,306) to 16% (2010: 180/1,139) of total isolates tested, mainly due to a 50% increase in the number of isolates with intermediate susceptibility (Table 10). This compares with a steady rate of 11% for 2007 and 2008. Of the isolates in 2009 with reduced susceptibility to penicillin, 131 were serotyped, with 22% (29/131) of these cases due to a serotype in the 7vPCV and 85% (113/131) due to a serotype in the 23vPPV; in 2010, 176 were serotyped, with 18% (32/176) of these cases due to a serotype in the 7vPCV and 72% (130/180) due to a serotype in the 23vPPV.

Table 9: Characteristics of 7vPCV vaccine failures in children aged less than 5 years, Australia, 2009 and 2010

Case	Year of diagnosis	Age (months)	Indigenous status	Serotype	Doses of 7vPCV	Clinical category	Risk factors
1	2009	28	Non-Indigenous	19F	3	Bacteraemia	Unknown
2	2009	31	Non-Indigenous	19F	3	Pneumonia	Yes
3	2009	37	Non-Indigenous	19F	3	Bacteraemia	Unknown
4	2009	58	Not reported	14	3	Pneumonia	No
5	2009	16	Non-Indigenous	19F	3	Bacteraemia	Yes
6	2009	30	Non-Indigenous	19F	3	Bacteraemia	Unknown
7	2009	22	Non-Indigenous	19F	3	Bacteraemia	Unknown
8	2009	43	Non-Indigenous	23F	3	Bacteraemia	Yes
9	2009	51	Non-Indigenous	18C	3	Pneumonia	Unknown
10	2010	13	Non-Indigenous	23F	3	Bacteraemia	Unknown
11	2010	51	Non-Indigenous	19F	3	Meningitis	Yes
12	2010	56	Non-Indigenous	19F	3	Pneumonia	Unknown
13	2010	25	Non-Indigenous	19F	3	Pneumonia	Yes
14	2010	34	Non-Indigenous	19F	3	Pneumonia	Unknown
15	2010	45	Non-Indigenous	19F	3	Bacteraemia	Unknown
16	2010	47	Non-Indigenous	19F	3	Pneumonia	Unknown
17	2010	10	Non-Indigenous	19F	3	Pneumonia	No

Of the isolates with reduced susceptibility to penicillin in 2009, 77 were serotype 19A, eight were 9V, and 11 were 19F, accounting for 72% (96/133) of isolates with reduced penicillin susceptibility and with a known serotype. Of the isolates with reduced susceptibility to penicillin in 2010, 110 were serotype 19A, three were 9V, and 13 were 19F, which together account for 70% (126/180) of isolates with reduced penicillin susceptibility and with a known serotype.

With respect to ceftriaxone/cefotaxime, the proportion of isolates with reduced susceptibility has remained consistent at 2% (2009: 21/1,090) to 3% (2010: 27/986). These results were similar to 2007 and 2008, which were 3% (25/834) and 2% (16/910) respectively. All of the isolates in 2009 with reduced susceptibility to ceftriaxone/cefotaxime were serotyped, with 29% (6/21) due to a serotype in the 7vPCV and 62% (13/21) to a serotype in the 23vPPV. Of the isolates in 2010 with reduced susceptibility to ceftriaxone/cefotaxime, 26 were serotyped, with 38% (10/26) due to a serotype in the 7vPCV and 69% (18/26) due to a serotype in the 23vPPV.

Of the isolates with reduced susceptibility to ceftriaxone/cefotaxime in 2009, 12 were serotype 19A, one was 9V, and five were 19F, accounting for 86% (18/21) of isolates with reduced ceftriaxone/cefotaxime susceptibility and with a known serotype. Of the isolates with reduced susceptibility to ceftriaxone/cefotaxime in 2010, 15 were serotype 19A, one was 9V, and six were 19F, accounting for 85% (22/26) of isolates with reduced ceftriaxone/cefotaxime susceptibility and with a known serotype.

Discussion

In 2009, 1,556 cases of IPD were notified in Australia compared with 1,640 in 2010. The overall rate of IPD in Australia has been stable since 2006, the first year following introduction of the universal 7vPCV program in children. During the study period, the highest notification rates were among adults aged 80 years or over (27 per 100,000) and among children under 5 years of age (19 per 100,000). However, small increases in notification rates across most age groups were observed in 2010.

The number of IPD notifications due to serotypes included in the 7vPCV has continued to decline since the introduction of the universal infant (3+0 schedule) vaccination program in 2005. Since 2005, the most marked reduction has been in children aged less than 5 years, where disease burden due to 7vPCV serotypes has declined by 97%. In contrast, notifications of disease due to non-7vPCV serotypes increased by 71% in this age group over the same period suggesting serotype replacement. Substantial impacts on IPD due to serotypes covered by vaccines in vaccinated age groups, herd immunity impacts on adults, as well as variable levels of serotype replacement have

Table 10: *Streptococcus pneumoniae* susceptibility to penicillin and ceftriaxone/cefotaxime,* for selected states and territories, 2009 and 2010

	9V	19F	All 7vPCV serotypes	19A	All 23vPPV	Not specified	All isolates
2009							
Penicillin							
Resistant	4	5	14	14	29	1	36
Intermediate	4	6	15	63	84	1	97
Sensitive	9	33	151	230	861	40	1,173
Total tested	17	44	180	307	974	42	1,306
Total isolates with reduced susceptibility (%)	8 (47%)	11 (25%)	29 (16%)	77 (25%)	113 (12%)	2 (5%)	133 (10%)
Cetriaxone							
Resistant	0	2	2	3	3	0	5
Intermediate	1	3	4	9	10	0	16
Sensitive	11	34	142	245	752	25	1,069
Total tested	12	39	148	257	765	25	1,090
Total isolates with reduced susceptibility (%)	1 (8%)	5 (13%)	6 (4%)	12 (5%)	13 (2%)	0 (0%)	21 (2%)
2010							
Penicillin							
Resistant	3	6	14	13	18	1	29
Intermediate	5	7	18	97	112	3	151
Sensitive	4	12	69	164	653	38	959
Total tested	12	25	101	274	783	42	1,139
Total isolates with reduced susceptibility (%)	8 (67%)	13 (52%)	32 (32%)	110 (40%)	130 (17%)	4 (10%)	180 (16%)
Cetriaxone							
Resistant	0	1	2	3	4	0	5
Intermediate	1	5	8	12	14	1	22
Sensitive	9	17	78	216	667	25	959
Total tested	10	23	88	231	685	26	986
Total isolates with reduced susceptibility (%)	1 (10%)	6 (26%)	10 (11%)	15 (6%)	18 (3%)	1 (4%)	27 (3%)

* Susceptibility data are restricted to jurisdictions with completeness suitable for reporting (greater than 50% completeness). Penicillin and ceftriaxone/cefotaxime susceptibility completeness was suitable for reporting in both 2009 for all jurisdictions. However, penicillin and ceftriaxone/cefotaxime susceptibility completeness was not suitable for reporting in 2010 in Victoria.

also been seen in other countries with established 7vPCV programs including England, Wales and the United States of America.[17, 18]

During 2009–2010 the most prevalent serotypes reported to cause IPD were 19A, 22F, 3, 7F and 6C, which together accounted for almost half of all notifications. Across all age categories, increases in the number of IPD infections due to serotypes 19A and 22F in particular were noted.

For the 2009–2010 study period, the proportion of cases due to infection with serotype 6C (6.7% of cases for which information on serotype was available) was a marked increase compared with 2008 (2.5%) and 2007 (1.9%). The majority of cases were in adults aged 65 years or over. The increased prevalence in nasopharyngeal carriage of serotype 6C after vaccination has been previously described in a study of seven cohorts of Massachusetts children between 1994 and 2007.[19] Currently, serotype 6C is not covered by any of the licensed vaccines. However, there is evidence that 13vPCV has the potential to confer cross-protection against serotypes not directly covered by the vaccine, namely serotypes 6C and 7A.[20, 21] These findings support the idea of introducing 13vPCV into national vaccination schemes.

Among the most prevalent serotypes, serotypes 19A (n=55) and 3 (n=22) accounted for the highest number of deaths. Serotype 19A has emerged worldwide to be an important serotype associated with IPD, pneumonia, acute otitis media, and haemolytic uremic syndrome.[22,23] It has been proposed that the high incidence of multidrug-resistant 19A provides it with an advantage over other serotypes through selective pressure.[24] Serotype 3 has been associated with more severe disease and increased mortality in other countries, but the mechanisms underlying this are currently unknown.[25] Serotype 6B isolates frequently exhibit resistance to antibiotics and accounted for the second highest serotype-specific fatality rate (23%) during the study period.[26,27] However, the relationship between antibiotic resistance and mortality has not been formally evaluated. In Australia, analysis of serotype-specific fatality rates should be interpreted with caution due to the small number of cases for which serotype and death are known (n=214).

One of the major objectives of IPD surveillance is in assessment of serotype replacement, which is defined as the reduction of serotypes included in the vaccines and the rise of non-vaccine serotypes. This phenomenon has been widely described [17,28–30] and in Australia, was particularly evident in children aged less than 5 years and in non-Indigenous adults.

Penicillin and ceftriaxone/cefotaxime are the first and second line antibiotics recommended for use in Australia because of high levels of reported resistance to macrolides, especially erythromycin (17.6%).[31] The proportion of IPD cases with reduced susceptibility to penicillin did not change between 2006 and 2009 (10–11% in each year), but in 2010 the overall rate of resistance increased to 16% with resistance most common in serotypes 19A and 19F.

Post-immunisation surveillance in Australia is essential to monitor trends in IPD, to inform future control strategies, including the targeting of existing and new vaccines and the best options for antibiotic treatment. The Australian Government through the National IPD Laboratory Surveillance Project, provides funding to support the serotyping of all *S. pneumoniae* isolates causing invasive disease.

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