Original article

Australian vaccine preventable disease epidemiological review series: measles 2000–2011

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Abstract

Background: Since the introduction of measles vaccine to the vaccination schedule, the burden of measles has substantially fallen in Australia. Despite this, a number of recent measles outbreaks have occurred. The aim of this study was to examine the burden of measles in Australia using notification, hospitalisation and mortality data with the objectives of setting a baseline for comparison prior to the introduction of the combined measles-mumps-rubella-varicella vaccine.

Methods: Data were obtained from the Australian National Notifiable Diseases Surveillance System, the National Hospital Morbidity Database and the National Mortality Database to obtain notification, hospitalisation and death data, respectively from 2000 to 2011. Rates were calculated and compared over time by age group and jurisdiction.

Results: Since 1993, measles notifications have fallen considerably in Australia. However, between 2000 and 2011, measles notification rates and hospitalisation rates fluctuated. Between 2000 and 2011, there were 990 measles notifications in Australia. The average annual notification rate was 0.4 per 100,000 population. Children aged 0–4 years were the most susceptible group, particularly infants less than 1 year of age (average annual rate, 1.6 per 100,000 population). High incidence was also observed in adolescents (average annual rate, 0.7 per 100,000 population) and young adults (average annual rate, 0.8 per 100,000 population). Jurisdictional variation occurred with differing patterns of notifications and hospitalisations.

Conclusions: Although a marked reduction in measles notifications and hospitalisations has occurred in the past decade, susceptible individuals should be vaccinated to prevent outbreaks and to maintain a low incidence of measles and Australia's elimination status. *Commun Dis Intell* 2015;39(1):E1–E9.

Keywords: epidemiology; measles; vaccine preventable diseases

Introduction

This report is part of an ongoing series produced by the National Centre for Immunisation Research and Surveillance documenting vaccine preventable disease epidemiological trends.

Measles is an acute and highly infectious disease caused by a paramyxovirus. Infection is characterised by cough, coryza, fever and the onset of a generalised maculopapular rash several days after initial symptom onset. Although most individuals recover from infection, complications can occur including otitis media, pneumonia, croup, diarrhoea, encephalitis and, very rarely, subacute sclerosing panencephalitis.[1]

A live attenuated measles vaccine was first licensed in 1968 in Australia.[2] Although the vaccine was introduced in all states and territories of Australia by 1972, it was not included in the first national childhood vaccination schedule at 12 months of age until 8 years later.[2] A 2nd dose was introduced for those aged 10–16 years at the end of 1993, following a large measles epidemic that resulted in approximately 10,000 cases and 4 deaths.[3,4] By 1995, measles incidence and hospitalisations had decreased substantially and the last death was recorded during this year.[5–8]

Despite these reductions in measles incidence, modelling studies indicated that gaps in immunity due to suboptimal vaccine coverage and the large gap between the 1st and 2nd doses of vaccine were likely to result in further outbreaks, leading to the 1998 National Measles Control Campaign.[5] The campaign included school-based mass vaccination of children 5–12 years of age[8] and lowering the age for the 2nd dose to 4–5 years.[3] Following the campaign, population immunity increased substantially.[8] In 1999, following a large Victorian outbreak that predominantly affected young adults, the Australian Government funded measles vaccine for young adults aged 18–30 years.[9] However, this campaign had suboptimal uptake; no subsequent increase in immunity among young adults could be demonstrated and outbreaks continued in the young adult age group.[10] Despite this, overall measles incidence continued to fall in Australia since 2005.[3]

In 2010, coverage for the 1st dose of a measles-containing vaccine, usually given as measles-mumps-rubella vaccine (MMR), was estimated at 94% for children at 24 months of age, compared with 90% for the 2nd dose at 60 months of age.[11] Based on some degree of under-reporting to the Australian Childhood Immunisation Register, these are likely to be minimum estimates[12] and from July 2013, a combined measles-mumps-rubella-varicella vaccine (MMR-V) was included in the National Immunisation Program for children aged 18 months, which is expected to increase 2nd dose measles coverage.[13]

This epidemiologic review documents age-specific trends in measles infection using data on measles notifications, hospitalisations and mortality with the objectives of setting a baseline for comparison prior to the introduction of the combined MMR-V vaccine.

Methods

Data sources

Notifications

Measles is a notifiable condition in all jurisdictions in Australia and both confirmed and probable cases are notified to health authorities.[14] A confirmed case of measles requires laboratory definitive evidence or clinical evidence with an established epidemiological link. Alternatively, a probable case of measles requires clinical and laboratory evidence suggesting measles infection.[15]

De-identified national data for both confirmed and probable measles notifications were obtained from the National Notifiable Diseases Surveillance System (NNDSS) from January 2000 to December 2011.[16] Notification data from 1993 to 1999 were also obtained to show historical trends prior to the reporting period of the study. The following fields were included in the analysis: date of diagnosis, age at onset, state or territory of residence and genotype of measles specimen. The date of diagnosis is a NNDSS derived field and is defined as the onset date (if known) or where the date of onset was not known, the earliest of the specimen collection date, the notification date, or the notification receive date.

Hospitalisations

Data coded for measles using the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification International Classification of Disease (ICD)-10-AM/ICD-10 code B05 were obtained from the Australian Institute of Health and Welfare National Hospital Morbidity Database.[17] The database collects information on patients admitted to public and private hospitals in Australia. Hospital admissions between January 2000 and December 2011 were analysed. Our analysis includes measles hospitalisations recorded in any field as well as by principal diagnosis (i.e. the diagnosis primarily responsible for prompting an episode of admitted or residential care or presentation at a healthcare institution). The variables used in the analysis included date of admission, diagnosis, age on admission, state or territory of residence, length of stay and the mode of separation (i.e. the process by which an admitted patient is discharged e.g. discharge, death, transfer or change in care type).

Deaths

De-identified aggregated mortality data were obtained from the Australian Bureau of Statistics (ABS) National Mortality Database for this reporting period.[17] Registered deaths with measles as the underlying cause based on the cause of death classification ICD-10 were analysed. A more detailed explanation of the methodologies used has been previously described.[8]

No ethics approval was sought as de-identified aggregate population based data were used in this epidemiological review.

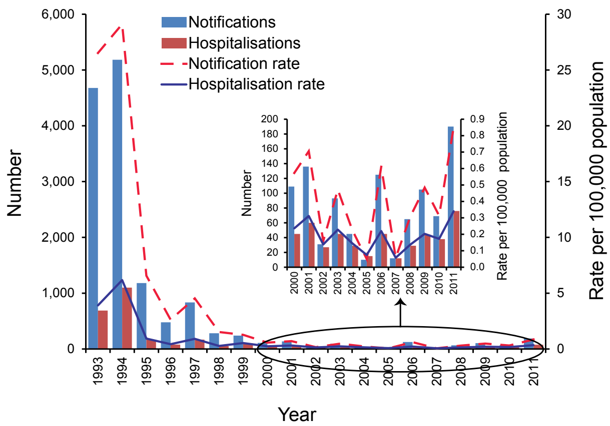
Data analysis

Crude and age-specific annual rates were calculated using mid-year population estimates obtained from the ABS.[18] Median length of stay was calculated for hospital admissions by days. The analyses focused on the most recent period, January 2007 to December 2011.

Results

Historical measles data show that notified cases peaked at 4,678 in 1993 and 5,184 in 1994, and since then measles notifications dropped dramatically to as low as 10 cases during 2005 (Figure 1). For the reporting period of the study, between 2000 and 2011, small peaks were observed in 2001 (n = 136; 0.7 per 100,000 population), 2006 (n = 125; 0.6 per 100,000 population) and, more recently 2011 (n=190; 0.9 per 100,000 population). The number of hospitalisations also decreased since 1993, with peaks corresponding to notifications in 2001 (n=60; 0.3 per 100,000 population); 2006 (n = 45; 0.2 per 100,000 population) and 2011 (n = 76; 0.3 per 100,000 population).

Figure 1: Number and rates of notifications and hospitalisations,* Australia, 1993 to 2011, by year of diagnosis or admission



* Hospitalisations (all diagnoses of measles).

Source: Australian Institute of Health and Welfare National Hospital Morbidity Database and the National Notifiable Diseases Surveillance System.

Age distribution

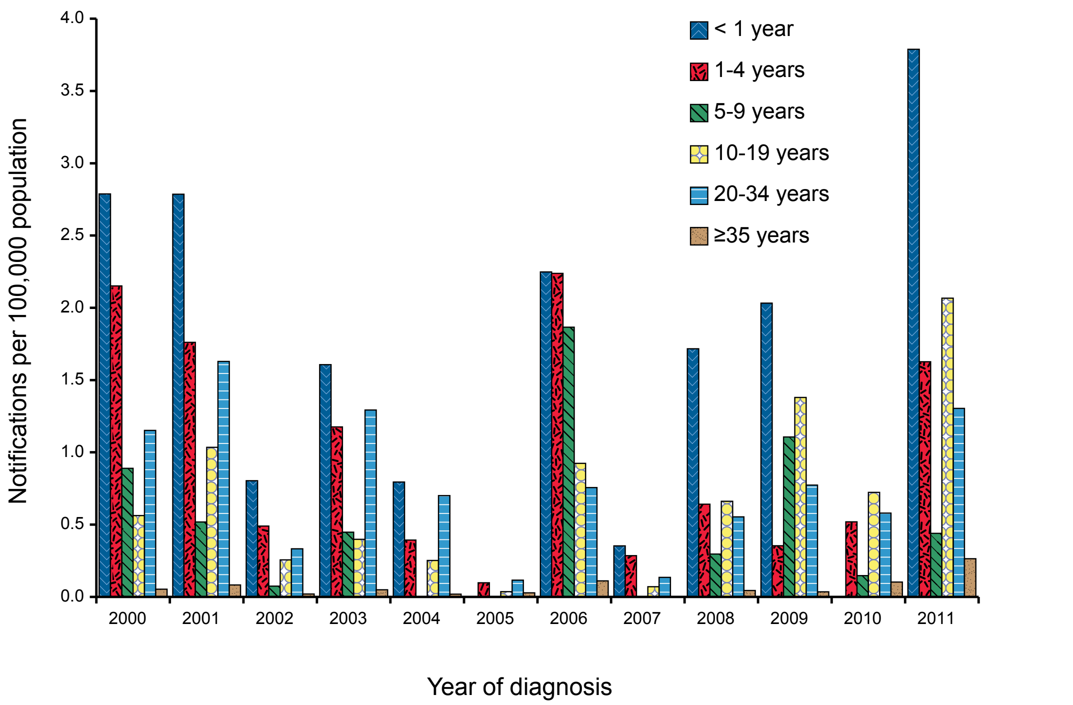
Between 2000 and 2011, no specific age group consistently had the highest annual notification rate, which fluctuated considerably due to the small number of cases (Figure 2). Infants less than 12 months of age, who were not eligible to receive the vaccine, had the highest notification rates in most years, except during 2005 and 2010, when no infant cases were notified. In 2011, the notification rate in infants was 3.8 per 100,000 population, the highest notification rate of all age groups during the 12-year period. During most years, children 1–4 years of age, who were eligible for 2 doses of the vaccine, had the second highest notification rate followed by adolescents aged 10–19 years of age and young adults aged 20–34 years since 2009 (Figure 2).

State and territory variations

Over the time period studied, there was considerable variation in notification rates among state and territories (Figure 3). Between 2000 and 2011, the 3 most populous states (New South Wales, Victoria and Queensland) accounted for 76% of all measles cases nationwide. New South Wales reported the highest rate of measles notifications, of which 27% occurred during 2011 (1.2 per 100,000 population). Only in 2009 did all states and territories report at least 1 measles case. The trend in hospitalisation rates follows a similar pattern to the rates of notifications (Figure 3).

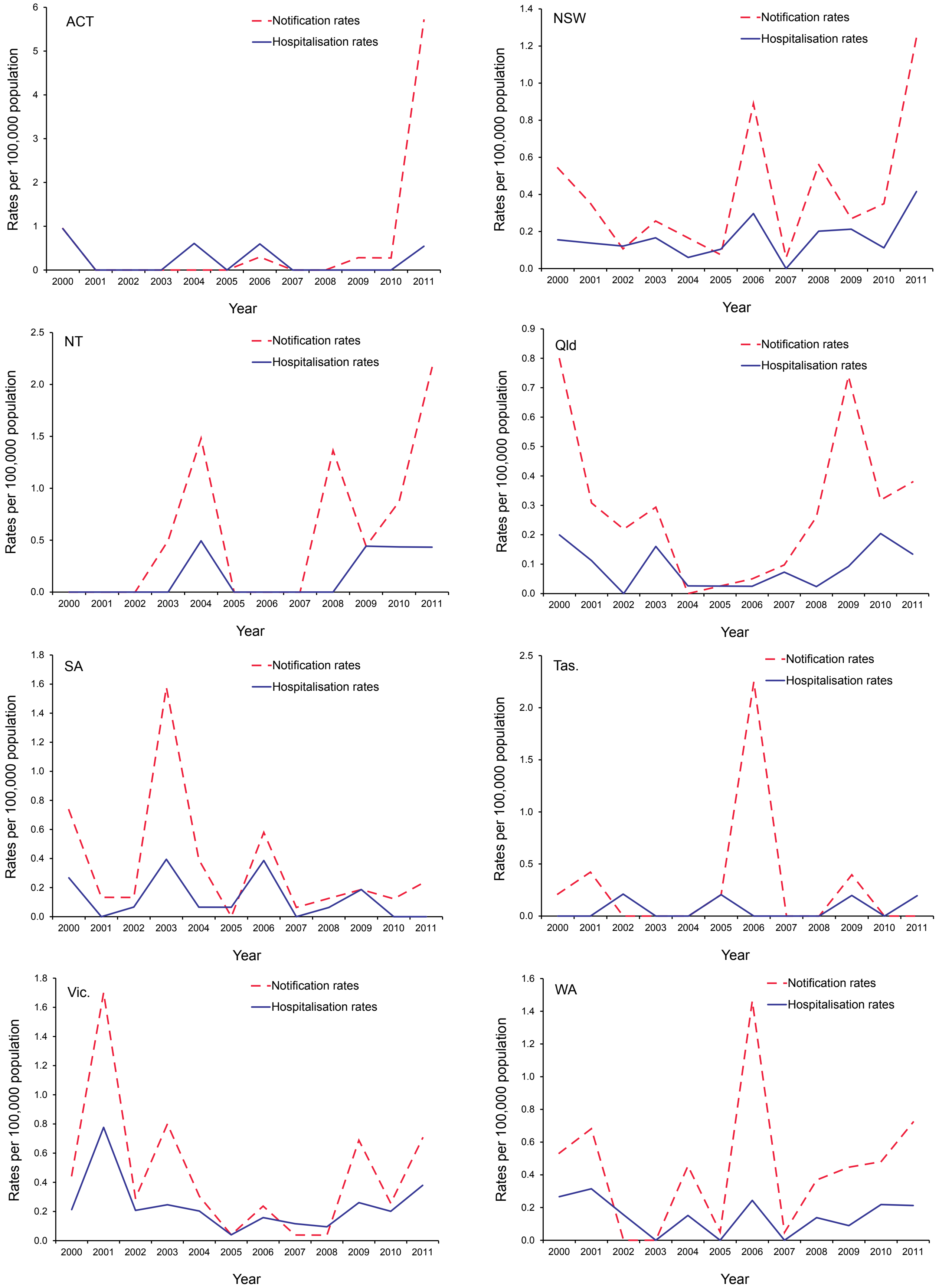
Overall, notification and hospitalisation rates remained low throughout the time period considered. Nationally, notification rates remained below 1 per 100,000 population for 2007 to 2011, except in New South Wales, the Northern Territory and the Australian Capital Territory in 2011.

Figure 2: Measles notification rates, Australia 2000–2011, by age group and year of diagnosis



Source: National Notifiable Diseases Surveillance System.

Figure 3: Measles notification and hospitalisation rates, 2000 to 2011,*,† by state or territory



* Scales vary between jurisdictions.

† Hospitalisations by principal diagnosis only.

Source: Australian Institute of Health and Welfare National Hospital Morbidity Database and the National Notifiable Diseases Surveillance System.

Genotypes

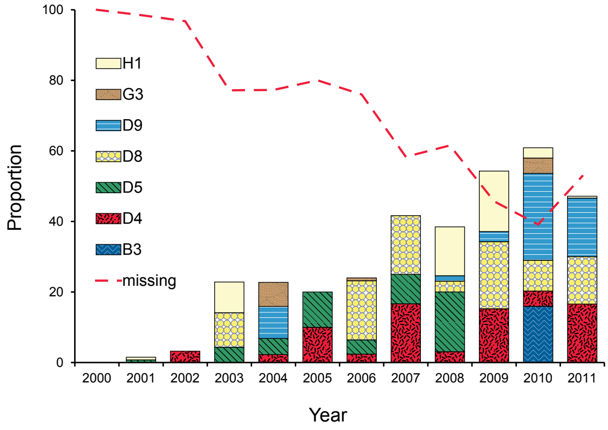
At the national level, the proportion of measles notifications with data on genotype increased from zero (no genotype data available) in 2000 to 61% in 2010 (Figure 4). There was no single dominant genotype over this period. The genotypes detected were B3, D4, D5, D8, D9, G3 and H1 and the majority of reported cases were imported or linked to imported cases. During this period, sporadic unknown source cases were also identified.

Severe morbidity and mortality

As observed with notifications, the number of hospitalisations has substantially declined over the past 2 decades, with the less than 1 year age group having the highest hospitalisation rates for most years followed by children aged 1–4 years and young adults (aged 20–34 years) (Figure 5). Overall, adults aged 35 years or more had the lowest hospitalisation rates.

During 2000 to 2011, the all age average ratio of notification to hospitalisation was 1.9. For the same period, the average age specific notification to hospitalisation ratio was 0.9 for infants (< 1 year); 1.7 for 1–4 years; 4.7 for 5–9 years; 4.4 for 10–19 years; 2.1 for 20–34 years and 1.3 for 35 years and older.

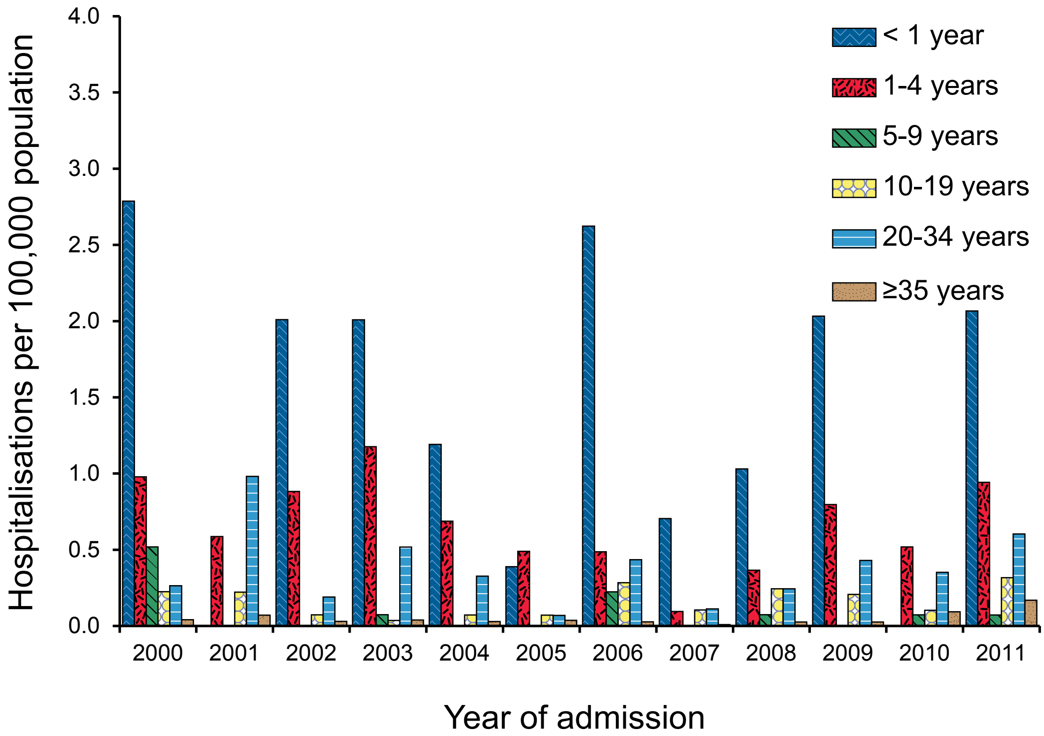
Figure 4: Proportion of measles notification, Australia, 2000 to 2011, by genotype



Source: National Notifiable Diseases Surveillance System.

In 2007 to 2011, of the 199 measles-related hospital admissions, 173 (87%) had measles recorded as the principal diagnosis and complications were recorded for 26 (15 %) admissions (Table 1). Of these, 10 were coded as having pneumonia and 16 as complications other than pneumonia, otitis media, encephalitis and meningitis such as

Figure 5: Measles hospitalisation rates, Australia, 2000 to 2011, by age group and year of admission



Source: Australian Institute of Health and Welfare National Hospital Morbidity Database keratitis, keratoconjunctivitis and intestinal complications. No deaths were recorded in patients hospitalised with measles.

Length of stay per admission by age group is displayed in Table 2. Between 2007 and 2011, the total number of 173 hospital admissions by principal diagnosis accounted for 491 bed days and the median length of stay was 3 days.

Between 2002 and 2011, the National Mortality Database recorded measles as the underlying cause of death in 1–4 cases. These deaths were registered in 2010 and occurred in males only. To protect confidentiality, cells in the dataset with non-zero values of less than five are assigned a value of 1–4 by the ABS.[17]

Discussion

Our results provide an overview of the burden of measles in Australia over the last 12 years demonstrating that measles incidence is low and consistent with the elimination of indigenous measles. Overall, the notification rate fluctuated, falling to less than 1 case per million population twice during the study period, a previous indicator of low incidence set by the World Health Organization, required to reach elimination.[19] More recently, however, this indicator was updated to not include a threshold. The revised indicator states countries where measles has been eliminated should have a very low incidence of confirmed cases and absence of seasonality, a situation which our study support.

It has previously been accepted that measles is predominantly a childhood disease. During the period reported, despite overall low incidence, the

Table 1: Selected indicators of severe morbidity for hospitalised cases of measles, Australia, 2007 to 2011,* by age group

Age group (years)	Measles complicated by pneumonia		Measles with complications other than pneumonia, otitis media, encephalitis or meningitis		Measles without complications	
	n	% total†	n	% total†	n	% total†
<1	1	6.7	2	13.3	12	80.0
1–4	0	–	0	–	28	100.0
5–9	0	–	0	–	2	100.0
10–19	1	3.8	1	3.8	24	92.3
20–34	3	4.2	7	9.9	60	84.5
35+	5	16.1	6	19.4	20	64.5
All ages	10	5.8	16	9.2	146	84.4

* Hospitalisations by principal diagnosis only.

† Per cent of total in the age group.

Table 2: Length of stay per admission of measles hospitalisation, 2007 to 2011,* by age group

Age group (years)	Hospital admissions		Length of stay (days)	
	n	Rate per 100,000†	Median number of days	Range
< 1	15	1.03	1	1–6
1–4	28	0.50	1.5	1–5
5–9	2	0.03	1	1–1
10–19	26	0.18	2	1–6
20–34	71	0.31	3	1–8
35+	31	0.05	3	1–10
Total	173	0.16	3	1–10

* Hospitalisations by principal diagnosis only.

† Average annual age-specific rate per 100,000 population.

0–4 years age group remain a vulnerable population for measles infection and hospitalisations and infants younger than 12 months of age had the highest incidence in most years, highlighting their susceptibility. One possible explanation for this could be the decline in maternal antibodies in women with vaccine-acquired immunity, reaching a lower nadir at 7–9 months of age than those with infection-acquired immunity.[20,21] It has been postulated that because measles is becoming rare, the lack of natural boosting through exposure to wild virus in both vaccinated women and women with past infection has consequently resulted in infants becoming more susceptible. It is thus important, to avert preventable cases, that timely vaccine uptake among infants occurs at the recommended 12 months of age. During outbreaks, the 1st dose of measles can be administered early, for example at 9 months of age, with 2 subsequent doses required after 12 months of age due to concerns of interference with maternal antibodies. Previously under the NIP, the 2nd MMR dose (MMR2) was administered at 4 years of age. In 2008, it was recommended that MMR2 should be brought forward to 18 months given the number of notifications in the 1–4 years age group and the potential to improve vaccine uptake.[13] This recommendation was implemented under the NIP in July 2013 and aims to protect children against measles at an earlier age.[13]

Between 2009 and 2010, it was notable that individuals aged 10–19 years had high notification rates that further increased in 2011. It is likely that a proportion of this age group were too young to have been eligible for MMR2 given at 10–14 years between 1995 and 1998 and too old for MMR2 when the dose was brought forward to 4–5 years of age in 1998, and thus missed out on MMR altogether. This was highlighted during a recent high-school based outbreak (10 cases in a single high-school).[22] Additionally, collection and analysis of detailed demographic information on the 10–19 years age group may assist in considering risk factors that may be associated with infection such as ethnicity (8 of the 10 cases were of Pacific Islander origin[22]). This would allow for more targeted interventions to be piloted, promoting vaccination uptake in this age group.

Our study supports previous literature that identified young adults as a susceptible cohort. [23] The authors from the serosurveillance study reported highest immunity (98.3%) in subjects born before 1968 reflecting greater exposure to the wild type measles virus in older adults. Those born between 1968 and 1982 are particularly susceptible as low vaccine coverage existed when they were infants and circulation of wild virus was becoming less common.[23] Furthermore, many in this cohort were ineligible for MMR2 as they exceeded the 10–16 year eligibility age when it was offered between 1994 and 1998. Young adults are increasingly well-travelled and a number of more recent outbreaks have occurred following the importation of measles by a young adult traveller from an endemic country.[24–26] Although a targeted young adult measles campaign was conducted in 2001, it did not achieve high uptake.[27]

In Aboriginal and Torres Strait Islander people, notification and hospitalisation rates for measles have remained low across all age groups.[28] The highest notification and hospitalisation rate among Aboriginal and Torres Strait Islander people occurred in children less than 5 years of age.[28] With respect to hospitalisations, there were no hospitalisations recorded for Aboriginal and Torres Strait Islander people ≥15 years of age.[28] Vaccination status of all reported measles cases should be checked and validated.[30] As most outbreaks in Australia begin with an importation of measles from an endemic country, it is essential that measles immunity status be assessed when patients attend clinics to receive vaccinations for international travel. Currently, all individuals born during or after 1966 who have not acquired natural immunity or received 2 doses of MMR are recommended to be vaccinated before travelling overseas.[13] Of further concern is whether travellers present to a healthcare provider for pre-travel advice. In a study of 17,353 ill returned travellers who presented to one of the 30 participating travel or tropical medicine clinic around the globe, 50% had documented pre-travel health advice.[29] An Australian-based study found that 4% of 917 recently returned travellers who presented to 2 hospitals over a 6-year period (1998–2004) were vaccinated against MMR.[30] Hence, it is necessary to raise awareness of the risk of measles in under- or unvaccinated individuals travelling to measles endemic countries as part of pre-travel health advice. Currently, comprehensive information is provided on the Department of Foreign Affairs and Trade Smartraveller web site.[31]

Clearly, age-specific vulnerability (derived from interpretation of age-specific seropositivity to measles antibodies) of populations exist, even though measles is so rare in Australia and consequently this may lead to outbreaks in these populations. To determine whether cases are linked, it is important that genotyping of specimens occurs. Additionally, genotyping indicates the origins of the virus and gives information as to whether there are particular strains circulating in a country– especially important for ensuring measles elimination status.[32]

A number of limitations in the analysis warrant caution in interpreting the results. In general, notification data are considered not representative of all cases in the community as not all cases may present to a medical practitioner or be recognised. However, this is unlikely to occur for measles as it is assumed most cases would attend a medical practitioner due to the severity of the symptoms of the disease.

Hospitalisations for measles should be interpreted with caution due to possible coding errors. A Victorian based study found that the discrepancy rate in coding fields among hospital morbidity data increased the rarer the condition.[33] Our data also highlighted these discrepancies, as in some instances the number of hospitalisations exceeded the number of notifications suggesting either the under-reporting of measles notifications and/or the miscoding of hospitalisations as measles.

There were reporting issues with mortality data too and paucity of information on complications, pre-existing co-morbidities and/or extremes of age.[34]

Lastly, the case definition for measles was amended in 2004. Prior to 2004, a confirmed case of measles could include a diagnosis based on an illness clinically consistent with measles. As many conditions may present with similar symptoms to measles, the specificity of this earlier case definition is likely to have been low and subsequently led to an overestimation of true measles cases. [35]

Conclusions

Measles is rare in Australia. The incidence of measles has fluctuated over the last 12 years, with presence of age-specific vulnerability in populations, even though measles incidence is so low in Australia. Children less than 5 years of age, and more recently, adolescents and young adults have been susceptible and hence, there is an ongoing need to improve vaccine uptake in vulnerable populations to prevent outbreaks. Overall, in this period, measles incidence has remained low with cases being mainly imported or imported-related, whilst only limited secondary spread has been documented, which together provide evidence consistent with elimination of indigenous measles in the country.

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