Recent increases in mumps incidence in Australia: the "forgotten" age group in the 1998 Australian Measles Control Campaign

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ABSTRACT

Objectives: To describe the epidemiology of mumps and examine potential factors underlying the recent increase in the incidence of mumps in Australia.

Design, setting and participants: Analytical descriptive study, for all Australian states and territories, of mumps notifications (1994–2007); hospitalisations for mumps (1994–2005); and mumps seroprevalence in a nationally representative sample of 2787 subjects (1997).

Main outcome measures: Incidence of notifications and hospitalisations for mumps; seropositivity by birth cohort.

Results: Notified mumps cases increased from 60 in 2002 to 231 in 2005 and 512 in 2007. Between 1994 and 2005, there were 605 hospitalisations for mumps. Mumps seropositivity in all states and territories in 1997 was high (range, 87.1%–94.3%). The predominant age group affected by mumps shifted to adults over time: between 2005 and 2007, 41% of cases occurred among people aged 20–29 years. Cases were concentrated among the birth cohort of 1978 to 1982, who had higher rates of notifications and hospitalisations for mumps and a lower seropositivity rate (92% [95% CI, 89%–94%]) than other birth cohorts.

Conclusions: The birth cohort of 1978 to 1982 was too old to reliably receive a second dose of measles–mumps–rubella (MMR) vaccine in the 1998 Australian Measles Control Campaign and too young to have had mumps infection. Renewed efforts to maximise two-dose MMR coverage are important for prevention of mumps and measles in young adults.

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Mumps is an acute disease caused by infection with an RNA virus belonging to the family *Paramyxoviridae* and characterised by fever, swelling and tenderness of one or more salivary glands, most commonly the parotid glands.[1] Orchitis is a common complication in adult males, occurring in about 20% of cases. Before the introduction of vaccination, mumps was a common cause of viral meningitis and an important cause of hearing loss in children and sterility in some men.[1,2] Death from mumps is rare: in Australia, 10 deaths were reported between 1978 and 1997 and two between 1998 and 2005.[3,4]

The disease is highly infectious, being transmitted rapidly through droplet spread in susceptible people living in close proximity. For mumps, the basic reproduction number, R_0 (ie, the number of secondary cases expected to result from an index case in a fully susceptible population) is estimated to be 10–12. This is only slightly less than the R_0 for measles (15–17), another disease recognised to be highly infectious. Before the introduction of vaccination, mumps epidemics occurred every 2–5 years.[5]

Mumps vaccine was first available in Australia from 1981, and in combination as measles–mumps vaccine from 1983, for children at 12 months of age. From 1989, measles–mumps–rubella (MMR) vaccine was used in the national childhood immunisation schedule. A second dose of MMR vaccine was introduced for children aged 10–16 years in 1994, replacing the rubella vaccine previously given only to girls in this age group. Then, as part of the Australian Measles Control Campaign (MCC) in 1998, the second dose of MMR was moved from 10–16 years to 4 years of age, with catch-up vaccination offered to those aged between 4 and 16 years. However, school-based delivery was limited to primary schools.[6] Thus, people born from 1981 onwards were eligible to receive two doses of mumps vaccine, either in high school, from 1994, or in the MCC.

After the introduction of mumps vaccination, annual reported cases of mumps declined in Australia from an estimated 59 000 in 1969[7] to 60 in 2002,[4] but increased again recently.[4,8] The aim of our study was to examine patterns of mumps epidemiology in Australia over the past decade, in the context of 1997 serosurveillance data as a proxy for vaccine coverage and the recent experience of mumps outbreaks in other developed countries.[5,9-12]

METHODS

Seroprevalence survey

The seroprevalence survey was based on sera collected in 1997. The methodology of population-based serosurveillance in Australia has been previously described.[13] All 52 major public and private diagnostic laboratories in Australia were invited to contribute sera, and 45 agreed to participate in 1997. The samples used for our survey had been submitted for various diagnostic tests and would otherwise have been discarded. Sera from people who were immunosuppressed, had received multiple or recent blood transfusions (within 3 months prior to our survey), or were known to be infected with HIV were excluded. Information available for each sample included a unique code number, the patient's age and sex, and the state or territory of collection.

The antibody assay was performed using the Microimmune Mumps IgG Screen ELISA (enzyme-linked immunosorbent assay) (Microimmune Ltd, Brentford, United Kingdom) according to the manufacturer's guidelines, as described previously.[14] For analysis of antibody test results, serum samples were stratified into the age groups 2–6, 7–14, 15–19, 20–29, 30–39 and ⩾ 40 years. The basis for this stratification was to understand the immunity profile of the population in relation to vaccination against mumps. In each age group, the sample size was calculated to achieve a point estimate of seroprevalence with 95% confidence intervals of about ±5% based on the expected level of seroprevalence. The sample size was calcu-

1 Mumps IgG ELISA results, by state and territory, 1997

Jurisdiction	Number positive/ total tested	Proportion positive (% [95% CI])
Tas	61/70	87.1 (79.3–95.0)
ACT	43/49	87.8 (78.6–96.9)
NT	29/33	87.9 (76.8–99.0)
NSW	866/958	90.4 (88.5–92.3)
SA	197/214	92.1 (88.4–95.7)
Qld	465/500	93.0 (90.8–95.2)
WA	258/277	93.1 (90.2–96.1)
Vic	647/686	94.3 (92.6–96.0)
Total	*2566/2787*	*92.1 (91.1–93.1)**

ACT = Australian Capital Territory. ELISA = enzyme-linked immunosorbent assay. NSW = New South Wales. NT = Northern Territory. Qld = Queensland. SA = South Australia. Tas = Tasmania. Vic = Victoria. WA = Western Australia.
* Weighted according to the 1997 population. ◆

lated to be representative by age, sex and jurisdiction. Data were analysed using SAS software, version 9.1 (SAS Institute, Cary, NC, USA). The χ^2 test was used to compare proportions and for trend analysis.

Notification data

In assessing disease notification rates we included all cases with onset between 1 January 1994 and 31 December 2007. Data were obtained from the National Notifiable Diseases Surveillance System. All rates were calculated using Australian Bureau of Statistics mid-year estimated resident populations, and are presented as annual rates per 100 000 population, or population in age or geographical subgroups, as appropriate.

Hospitalisation data

Hospitalisation rates for mumps were assessed for the period 1 January 1994 to 31 December 2005. Data were obtained from the Australian Institute of Health and Welfare's National Hospital Morbidity Database, which contains data on patients admitted to all public and private hospitals in Australia since 1993. Cases included in our analysis were those with separation dates between 1 January 1994 and 30 June 1998 having the ICD-9 (International classification of diseases, ninth revision) code 072 and those with separation dates between 1 July 1998 and 31 December 2005 having the ICD-10 (10th revision) code B26.

Ethics approval

Our study was approved by the State-wide Health Confidentiality and Ethics Committee of NSW Health and the Human Research Ethics Committee of the Sydney West Area Health Service.

RESULTS

Seroprevalence survey

We analysed 2787 sera. The age distribution in the sample corresponded to the age distribution in the general population. The proportion of mumps-positive sera in all states and territories was high, ranging from 87.1% to 94.3%. The overall proportion of the population estimated to be seropositive for mumps was 92.1% (95% CI, 91.1%–93.1%) (Box 1).

Further analysis by geographical region showed that, among people born between 1978 and 1995 (who were aged 2–19 years in 1997), mumps seropositivity in Victoria (94.2% [308/327]) was significantly higher than for the rest of Australia (88.2% [902/1023]) ($P = 0.001$).

The seropositivity rate among people born before 1978 (95.9% [1549/1615]) was significantly higher than the rate in those born in 1978 or later (86.8% [1017/1172]) ($P < 0.001$). Children aged 2–6 years in 1997 had the lowest proportion of seropositive results (82.9% [515/621]) (Box 2).

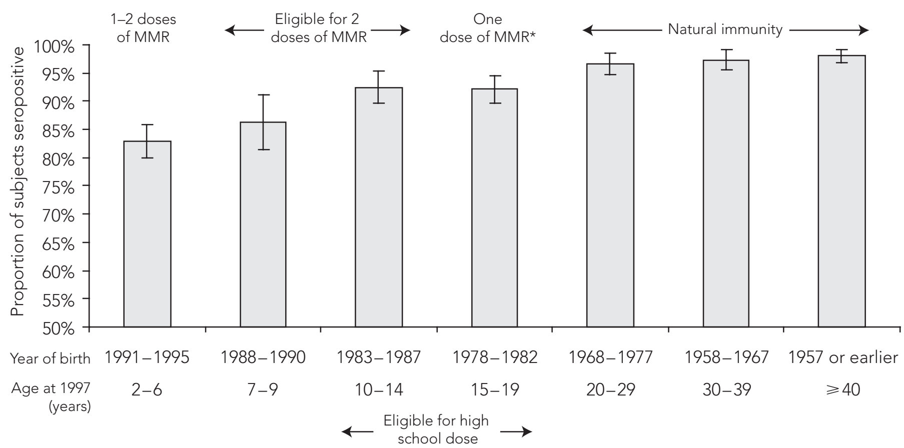
Younger age groups had more negative or equivocal test results than older age groups, leading to a skewed distribution. The median age of those with negative results was 8 years, which did not differ significantly from the median age of 7 years for equivocal results. The median age of people with positive results (17 years) was significantly higher ($P = 0.001$). Overall, there was no significant difference in seropositivity rates between males (92.3%) and females (91.9%) ($P = 0.816$), and seropositivity did not differ significantly between males and females by age group.

Notifications

Mumps cases were reported in all states and territories during the study period, but notification requirements varied between jurisdictions and over time, making comparisons difficult until 2004, when criteria for notifications became uniform. Between 2005 and 2007, New South Wales, Queensland, South Australia, Western Australia and the Northern Territory all had notification rates above the average for those years, while Victoria had a significantly lower notification rate than other jurisdictions ($P = 0.041$).

Notified mumps cases increased from 60 in 2002 to 231 in 2005 and 512 in 2007. Analysis of the age distribution of notified cases for the period 1994–2007 showed that the predominant age group affected shifted to adults over time, while notification rates declined significantly for children aged 2–14 years. In the age group 20–29 years, notification rates increased significantly from 2004, with 41% of cases occurring in this age group between 2005 and 2007.

2 Proportion of an Australia-wide population sample ($n = 2787$) seropositive for mumps in 1997, by birth cohort, age group and immunisation program history*†



MMR = measles–mumps–rubella vaccine. * The mumps vaccine was introduced in 1981 for children aged over 1 year, then replaced by a measles–mumps vaccine in 1983 and an MMR vaccine in 1989. A second dose of MMR vaccine was introduced for 10–16-year-olds in 1994. In 1998, the age group for the second dose was moved to 4 years. † 2566/2787 sera (92.1%) were positive for mumps. ◆

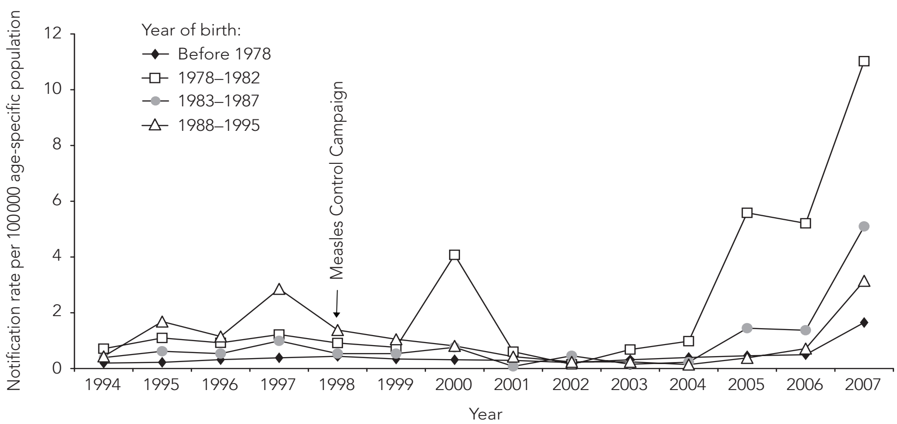
When notified cases were analysed by year of birth using broad groups corresponding to different pre-vaccination and post-vaccination eras (Box 3), the cohort born before 1978 was found to have very low and steady infection rates over the study period. In contrast, people born between 1978 and 1982 had increased notification rates, in 2000 and after 2004, while there was a progressive decline in notification rates among younger birth cohorts, particularly those born after 1987. During the period 1999–2007, the mean notification rate for the 1978–1982 birth cohort was more than threefold higher than for other birth cohorts ($P < 0.001$), with a significant upward trend compared with the other birth cohorts ($P = 0.001$).

Overall, there was no significant difference between males (50.5%) and females (49.5%) in the notified cases during the study period, while there was a slight male preponderance (53.5% males v 46.5% females) in the age group 20–29 years. The reported vaccination status overall was 17% vaccinated, 29% not vaccinated, and 54% unknown. In the age groups 0–9 years, 10–19 years and over 19 years, the proportions reported as vaccinated were 36%, 28% and 9%, respectively. About 53% of people in these age groups had unknown vaccination status.

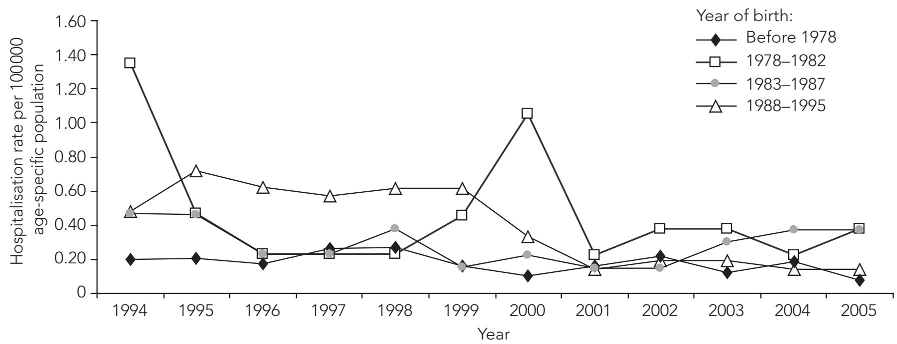
Hospitalisations

Between 1994 and 2005, 605 recorded hospitalisations were coded for mumps, including 464 (77%) with mumps as the principal diagnosis. Hospital admissions occurred in all age groups and in both sexes, with a male : female ratio of 1.2 : 1 ($P = 0.03$). The age distribution of hospitalised cases, using the same birth cohorts as for notifications, is shown in Box 4. Notably, for the period 1994–2005, the birth cohort of 1978–1982 had a significantly higher mean annual hospitalisation rate than pre-1978 and post-1982 birth cohorts ($P = 0.04$). Hospitalisation rates for cohorts born both before 1978 and after 1982 were low, and declined over time.

3 Distribution of notified cases of mumps in Australia, by selected birth cohorts, 1994–2007



4 Distribution of hospital admissions for mumps in Australia, by selected birth cohorts, 1994–2005



DISCUSSION

Our analysis shows patterns of age-specific disease notification and hospitalisation rates consistent with the prevalence of mumps immunity in the relevant age cohorts in Australia in 1997.

The cohort born before the 1970s represent the pre-vaccination era, when mumps virus transmission was widespread and seropositivity was highest (96%–98%). This is consistent with investigations of recent mumps outbreaks in other Western countries, in which age cohorts born before the vaccination era were not affected.[9-12] Among those born in the 1980s, coverage with a single dose of mumps vaccine was increasing, but estimated to be only 68% among children under 5 years of age, so continuing exposure to wild virus was likely.[15,16] The 1998 MCC did not target this age group as effectively as those attending primary school, and their immune profile is consistent with partial vaccination during a period of reduced exposure to wild virus transmission. It is this age cohort that has had the most noticeable recent increase in notifications, as well as hospital admissions in 2000.

Among those born after 1990, estimated coverage for at least one dose of mumps vaccine increased from 80% in 1990 to 90% in 1995,[17,18] reflected by a sharp reduction in notified and hospitalised cases. Children born in the early 1990s (aged 2–6 years at the time of sampling) had the highest proportion susceptible in 1997 (17%), but would, at most, have received one dose of MMR vaccine at that time. Although seroconversion rates after a first dose of mumps vaccine under clinical trial conditions are as high as 97%,[15] under field conditions vaccine effectiveness after one dose is about 88% and approaches 95% after two doses.[10]

In Europe, serological surveys have shown that high mumps incidence is related to low levels of population immunity in affected countries.[9] However, even in countries with relatively high vaccine coverage, such as the United States[11] and the United Kingdom,[12] recent outbreaks have occurred, predominantly affecting young adults who have had less exposure to natural infection, as described here for Australia. Cases have also occurred among vaccinated children who had received only a single dose of MMR vaccine.[10]

Higher seropositivity rates in younger age groups (eligible for two doses of MMR) in Victoria compared with the rest of Australia probably reflect past high rates of MMR vaccination coverage[3,18] in this state. This is consistent with higher levels of protective immunity against measles found in Victoria,[19,20] which, together with lower notification rates for mumps than in the rest of Australia, suggests that higher historical MMR vaccination coverage reduced the number of cases in that state.

Our study had some limitations. First, the case definition for mumps notifications and the number of jurisdictions in which mumps was notifiable varied until 1996, when it became notifiable in all states and territories. It was recognised that a more specific case definition was needed in the context of low disease incidence,[7] so the surveillance case definition for mumps was modified in 2004 to include only those with laboratory evidence of mumps or epidemiological linkage to a confirmed case.[3] While changes in case definition may have affected the rates presented, notifications from 2005 to 2007 should be relatively specific, although false-positive serological results cannot be ruled out. Second, opportunistic collection of sera has the potential for bias. However, the same sample has been used to assess immunity to measles and rubella,[21] and comparison between the opportunistic collection method and randomised cluster sampling found comparable estimates for measles immunity.[13]

Transmission of mumps virus has been considerably reduced since the introduction of vaccination. Both the waning of vaccine-acquired immunity and the accumulation of unvaccinated cohorts over time appear to have contributed to an increased susceptibility among young adults. The increased two-dose MMR coverage achieved since the 1998 MCC will reduce the risk of outbreaks among those born since 1982, although recent outbreaks have been described among two-dose recipients in the US,[22] and this may have implications for Australia in later years. For now, the priority should be to target young adults, particularly those born during the late 1970s and early 1980s and now aged 25–30 years, for a second dose of MMR. In this well travelled age group, an important opportunity for giving a second dose of MMR is at the time before overseas travel. MMR vaccine is provided free of charge for all age groups in many Australian jurisdictions.

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COMPETING INTERESTS

None identified.

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REFERENCES

1 Chin J. Control of communicable diseases manual. 17th ed. Washington, DC: American Public Health Association, 2000.
2 Leinikki P. Mumps. In: Zuckerman AJ, Banatvala JE, Pattison JR, et al, editors. Principles and practice of clinical virology. 5th ed. Chichester: Wiley, 2004: 459-466.
3 McIntyre PB, Gidding HF, Gilmour R, et al; National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases. Vaccine preventable diseases and vaccination coverage in Australia, 1999 to 2000. *Commun Dis Intell* 2002; 26 Suppl: i-xi, 1-111.
4 Australian Department of Health and Ageing. National Notifiable Diseases Surveillance System (NNDSS). Introduction to the National Notifiable Diseases Surveillance System. http://www.health.gov.au/internet/main/publishing.nsf/Content/cda-surveil-nndss-nndssintro.htm (accessed Apr 2008).
5 Anderson RM, May RM. Immunisation and herd immunity. *Lancet* 1990; 335: 641-645.
6 National Health and Medical Research Council. The Australian immunisation handbook. 9th ed. Canberra: NHMRC, 2008.
7 Guy RJ, Andrews RM, Kelly HA, et al. Mumps and rubella: a year of enhanced surveillance and laboratory testing. *Epidemiol Infect* 2004; 132: 391-398.
8 Brotherton J, Wang H, Schaffer A, et al. Vaccine preventable diseases and vaccination coverage in Australia, 2003 to 2005. *Commun Dis Intell* 2007; 31 Suppl: S1-S152.
9 Nardone A, Pebody RG, van den Hof S, et al. Sero-epidemiology of mumps in western Europe. *Epidemiol Infect* 2003; 131(1): 691-701.
10 Cohen C, White JM, Savage EJ, et al. Vaccine effectiveness estimates, 2004–2005 mumps outbreak, England. *Emerg Infect Dis* 2007; 13: 12-17.
11 Centers for Disease Control (CDC). Update: multistate outbreak of mumps — United States, January 1–May 2, 2006. *MMWR Morb Mortal Wkly Rep* 2006; 55: 559-563.
12 Gupta RK, Best J, MacMahon E. Mumps and the UK epidemic 2005. *BMJ* 2005; 330: 1132-1135.
13 Kelly H, Riddell MA, Gidding HF, et al. A random cluster survey and a convenience sample give comparable estimates of immunity to vaccine preventable diseases in children of school age in Victoria, Australia. *Vaccine* 2002; 20: 3130-3136.
14 Backhouse JL, Gidding HF, McIntyre PB, Gilbert GL. Evaluation of two enzyme immunoassays for detection of immunoglobulin G antibodies to mumps virus. *Clin Vaccine Immunol* 2006; 13: 764-767.
15 Kakakios AM, Burgess MA, Bransby RD, et al. Optimal age for measles and mumps vaccination in Australia. *Med J Aust* 1990; 152: 472-474.
16 Australian Bureau of Statistics. Children's immunisation survey, Australia, November 1983. Canberra: ABS, 1984. (ABS Cat. No. 4351.0.)
17 Lister S, McIntyre PB, Burgess MA, O'Brien ED. Immunisation coverage in Australian children: a systematic review 1990–1998. *Commun Dis Intell* 1999; 23: 145-170.
18 Australian Bureau of Statistics. Children's immunisation, Australia, April 1995. Canberra: AGPS, 1995. (ABS Cat. No. 4352.0.)
19 Gidding HF, Gilbert GL. Measles immunity in young Australian adults. *Commun Dis Intell* 2001; 25: 133-136.
20 Kelly HA, Gidding HF, Karapanagiotidis T, et al. Residual susceptibility to measles among young adults in Victoria, Australia following a national targeted measles-mumps-rubella vaccination campaign. *BMC Public Health* 2007; 7: 99.
21 Gilbert GL, Escott RG, Gidding HF, et al. Impact of the Australian Measles Control Campaign on immunity to measles and rubella. *Epidemiol Infect* 2001; 127: 297-303.
22 Dayan GH, Quinlisk MP, Parker AA, et al. Recent resurgence of mumps in the United States. *N Engl J Med* 2008; 358: 1580-1589.

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