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The impact of Australia's measles control programme over the past decade

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SUMMARY

We reviewed measles surveillance data for 1993–2002 to determine the impact of Australia's measles control initiatives. The introduction of a second dose of measles–mumps–rubella (MMR) vaccine for 10- to 16-year-olds in 1993 was followed by marked reductions in measles notifications and hospitalizations, especially in the targeted age group. Further rate reductions were achieved following the Measles Control Campaign (MCC) in 1998, which involved a catch-up campaign for primary-school-aged children and lowering the age for the second dose of MMR vaccine to 4 years. Since the MCC, outbreaks have continued to occur, but most had a source case who was infected overseas, which suggests that indigenous transmission has been interrupted. In addition, a greater proportion of cases have been in adults although infants aged <5 years still had the highest rates. In conclusion, Australia is making good progress towards measles elimination. However, as in other countries, this progress can be sustained only by maintaining high vaccination coverage with the routine childhood vaccination schedule.

INTRODUCTION

Several countries have now succeeded in interrupting measles transmission [1, 2]. Finland has eliminated measles through a prolonged (12-year) period of high coverage (>95%) with two routine doses of measles vaccine [3]. However, most countries have been unable to achieve this. Instead, supplementary 'catch-up' campaigns have proved successful in conjunction with strengthened routine vaccination programmes [1, 2, 4].

In Australia, measles vaccination was recommended for infants in 1971 and a two-dose schedule (one dose at 12 months and another at 10–16 years) was introduced in November 1993 [5]. However, suboptimal vaccination coverage and the gap between the age when the first and second doses were given meant that the number of susceptible individuals increased over time making further outbreaks likely [6]. To address this situation, in 1998 the age for the second dose of the measles–mumps–rubella (MMR) vaccine was lowered to 4–5 years of age (and later to 4 years) and the Australian Measles Control Campaign (MCC) was launched.

The MCC took place in the second half of 1998 and had three components. First, a catch-up campaign involving the mass vaccination of primary-school-aged children was undertaken. Reminder letters were then sent to parents of children overdue for their first dose of MMR vaccine and information packs for secondary school students and their parents to encourage students to obtain a second dose of MMR were produced [6]. An evaluation of the campaign indicated that it achieved an excellent response;

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coverage for children aged 5–12 years was estimated to be 96%, and 90% of children overdue for their first dose were vaccinated [6]. In addition, national sero-surveys conducted before and after the MCC showed a significant increase in immunity in children aged 2–5 years (from 82% to 89%; P value $<0{\cdot}001$) and 6–11 years (from 84% to 94%; P value $<0{\cdot}001$) [6, 7]. The evaluation also reported that, in the 6 months after the campaign, the number of notifications from the 1–12 years age group declined by two-thirds compared with the same time period the previous year.

Since the MCC, a high proportion of cases have been in young adults. This prompted the Australian Government to allocate an additional $20 million in funding to provide free MMR vaccine to 18- to 30-year-olds who visited their general practitioner in 2001 [8]. It may be too early to evaluate the impact of this initiative, however 4 years have now passed since the MCC and a decade since the introduction of a two-dose measles vaccination programme. The aim of this analysis was to review the past 10 years of measles surveillance data to determine the longer-term impact of Australia's control initiatives and progress towards measles elimination.

METHODS

Notifications, hospitalizations and deaths from measles since 1993 were reviewed to determine the impact of the following measles control initiatives: adding a second dose of MMR (MMR2) – given to adolescents during 1994–1998, the MCC, and lowering of the age for MMR2.

Data about measles notifications with onset dates for 1993–2002 were extracted from the National Notifiable Diseases Surveillance System (NNDSS) with supplementary information about confirmation status from each state and territory's notification register (1993–2001). The NNDSS data for 2002 were preliminary (as of 7 March 2003). Measles cases were notifiable if they were clinically compatible, laboratory confirmed or epidemiologically linked to a confirmed case. Laboratory confirmation could be based on blood serology, culture or PCR testing. However, notifications could not be differentiated by method of confirmation.

Hospital discharges for the financial years 1993–1994 to 2000–2001 and deaths recorded during 1993–2001 were obtained from the Australian Institute of Health and Welfare (AIHW) National Hospital Morbidity and Mortality databases respectively. The ICD-10-AM/ICD-10 code B05 (measles) was used to identify those due to measles. For hospitalizations, both principal and other diagnoses (up to 31 can be recorded) of measles were included. For deaths, only those with an underlying cause of death due to measles were counted.

The number, rate and proportion of notifications and hospitalizations by age or age group and median age were calculated by year of disease onset/year of hospitalization. The average number of notifications by single year of age was calculated for three time periods: the outbreak (1993–1994), the period following the outbreak when MMR2 was given to adolescents (1995–1997), and the MCC and subsequent years when MMR2 was given to pre-school children (1998–2002). The mid-year population estimates used to calculate rates were supplied by the Australian Bureau of Statistics. The proportion of notifications that were confirmed (either by laboratory tests or linkage to a chain of transmission that includes a laboratory-confirmed case) was calculated for each year and state/territory.

RESULTS

Impact of adding an adolescent second dose of MMR vaccine

During 1993–1994 Australia experienced an outbreak of measles. During this period annual notification and hospitalization rates peaked at 27 and 6 per 100 000 respectively. The introduction of a two-dose vaccination policy in November 1993 did not appear to have a significant impact on these rates in 1994, but in the following years there were dramatic reductions (Figs 1, 2). By 1995, the notification rate had declined by 76% and the hospitalization rate by 85%, compared with the outbreak years of 1993–1994. Rates continued to decline in all age groups until 1997 when there was an outbreak in the second half of the year. This outbreak was centred in rural south-east Queensland, but subsequently spread across Queensland and to other states [9, 10]. Although rates increased in 1997 they declined to reach a new low in 1998 when notification rates were 94% lower, and hospitalization rates 95% lower, than in 1993–1994. Lower rates have also led to a decline in the number of measles deaths. There have been no deaths recorded since 1995 compared to four deaths during the outbreak in 1993–1994.

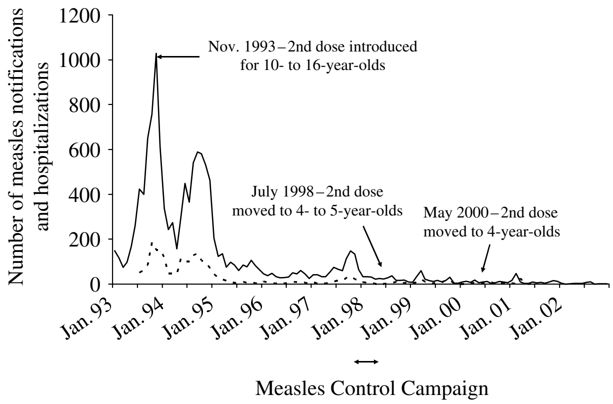

Fig. 1. Measles notifications (——) and hospitalizations (- - - -) by month of onset or admission, including significant changes to measles vaccination practice, 1993–2002.

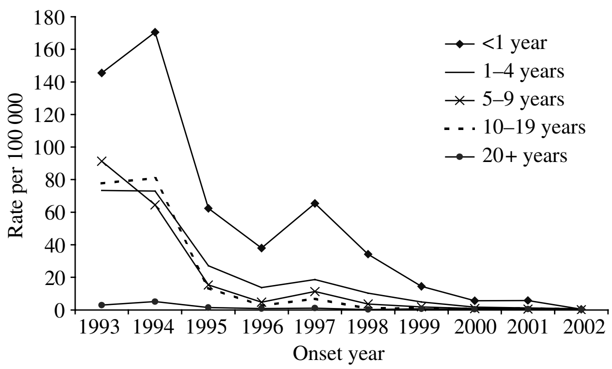

Fig. 2. Measles notification rates by age group and onset year, 1993–2002.

The addition of the adolescent MMR2 dose not only led to lower rates overall, but also had a targeted impact. Notification rates for the 10–19 years age group declined to a greater extent than rates for any other age group. Hence proportionally fewer cases were reported from this age group each year (except in 1997) until 1998, when the age for MMR2 was lowered to 4–5 years (Fig. 3). Hospital figures showed a similar pattern with lower numbers and proportionally fewer hospitalizations from the 10–19 years age group in the years following the introduction of MMR2.

Within the 10–19 years age group, the greatest reductions following the introduction of the adolescent MMR2 were in 13- to 15-year-olds. This led to two notification peaks in the >5-year-olds in 1995–1997 – one predominantly in primary-school-aged children and the other in individuals aged in their late teens and early twenties – whereas there had only been one large peak across all the school-age years in 1993–1994 (Fig. 4).

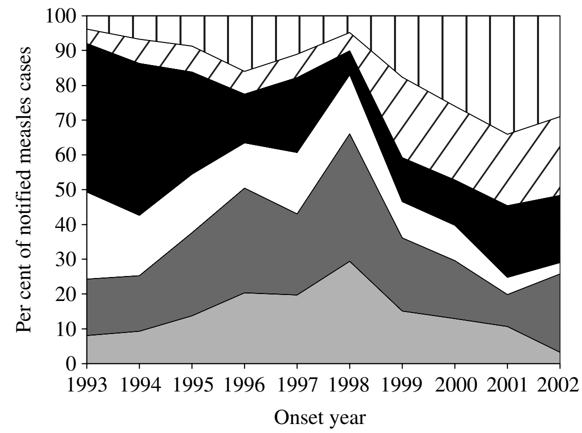

Fig. 3. Percentage of notified measles cases in each age group by year of onset, 1993–2002. ▥, ⩾25 years; ▨, 20–24 years; ■, 10–19 years; □, 5–9 years; ■, 1–4 years; ■, <1 year.

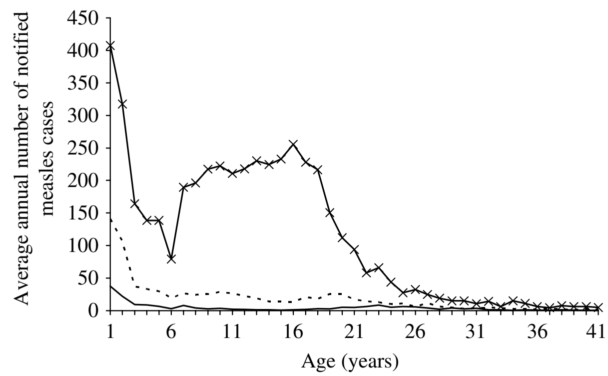

Fig. 4. Average number of measles notifications by single year of age (1–40 years) for three time periods: —×—, the outbreak of 1993–1994; - - - -, the post-outbreak period 1995–1997 – adolescent MMR2; ——, the Measles Control Campaign and subsequent years – pre-school MMR2 (1998–2002). (MMR2 = second dose of measles–mumps–rubella vaccine.)

Impact of the MCC and lowering the age for the second dose of MMR vaccine

Following the MCC, the overall notification and hospitalization rates continued to decline to new record lows (0·2/100 000 for notifications in 2002 and 0·3/100 000 for hospitalizations in 2000–2001).

Impact on children aged <10 years

Hospitalization and notification rates (Fig. 5) for the <1, 1–4 and 5–9 years age groups have all shown a downward trend since 1998, reaching record low levels in 2001 and 2002 respectively. The greatest declines, especially in the first year following the MCC, were in children <1 year old (Fig. 2). Although this age

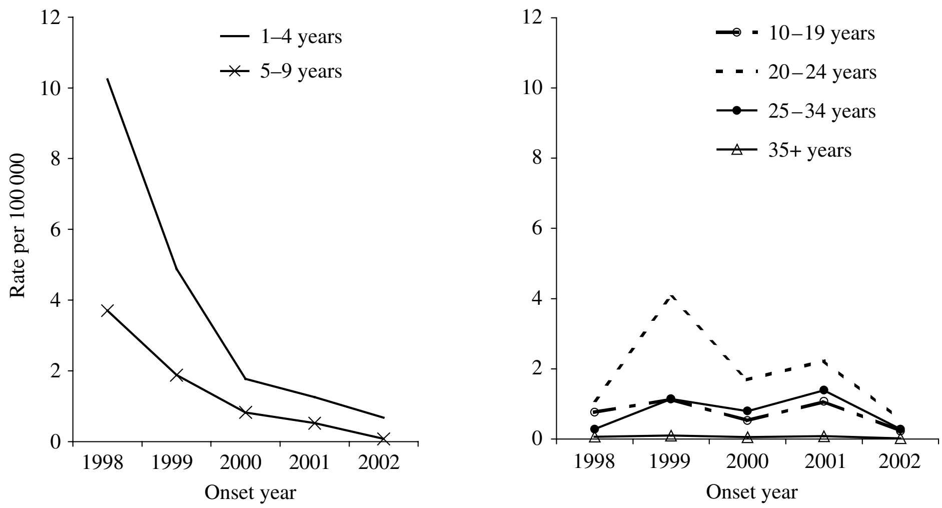

Fig. 5. Measles notification rates by age group and onset year (1998–2002) for ages 1 year and over. (Annual notification rates for <1-year-olds for 1998–2002 were 34·2, 14·5, 5·6, 5·8 and 0·4 per 100 000 respectively.)

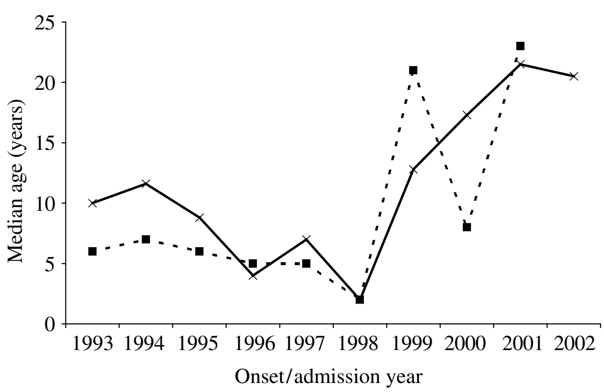

Fig. 6. Median age of notified (—×—) and hospitalized (- - ■ - -) measles cases, 1993–2002. (Notifications 1993–2002 by year of onset, hospitalizations by year of admission July 1993–June 2001.)

group is not targeted by vaccination their rates have declined presumably due to improved herd immunity and lower rates in other ages, especially pre-school and primary-school-aged children. Also of note is the lower number of notifications from primary-school-aged children following the MCC. The peak seen in this age group in 1995–1997 (Fig. 4) decreased progressively each year from 1998 to become non-existent by 2002, initially due to the impact of the MCC and then to additional cohorts being eligible for MMR2 prior to school entry.

Impact on persons aged ⩾10 years

Notification (Fig. 5) and hospitalization rates for those aged 10 years and over have not shown a downward trend since the MCC, unlike rates for children. As with all age groups, record low rates were recorded in the most recent year reviewed, but rates for adults were higher in 1999 (especially for those aged 20–24 years) and 2001 than in 1998. In fact in 2001, for the first time on record, the 20–24 years age group had higher notification and hospitalization rates than any other age group except the <1-year-olds. Adults most affected were aged between 18 and 32 years, in contrast to 1995–1997 when there was a peak in those aged in their late teens and early twenties (Fig. 4).

Higher rates for adults and declining rates for children since 1998 has led to an increasing proportion of notifications and hospitalizations from adults, especially those aged 20–24 years (Fig. 3). This means that the median age of notified and hospitalized cases has also increased over time since the MCC (Fig. 6).

Outbreaks since the MCC

Even though the incidence of measles is at an all time low, outbreaks have continued to occur. The two largest outbreaks since the MCC have been primarily amongst adults aged 20–29 years living in the state of Victoria (Fig. 7). The first was in February–May 1999, when the source case was a returned traveller from Bali [11]. Seventy-five Victorians were infected during this outbreak, and 85% of them were born between 1968 and 1981. Only one (unvaccinated) case was in the age group targeted by the primary school component of the MCC. The second largest outbreak involved 51 Victorians in January–March 2001 [12]. Again, most cases were young adults (90% aged 15–34 years) and the source case was infected in India.

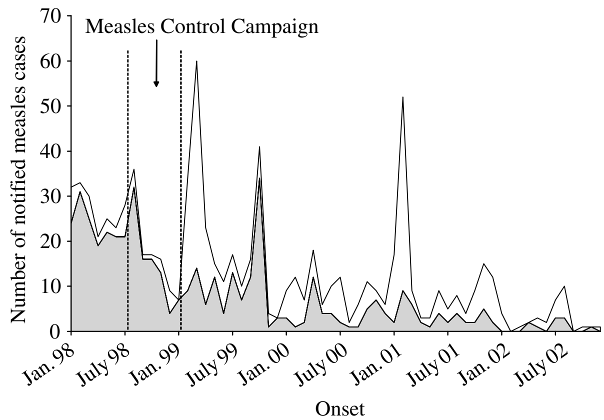

Fig. 7. Outbreaks since the Measles Control Campaign (MCC) by age group. □, ⩾15 years; ▨, 0–14 years.

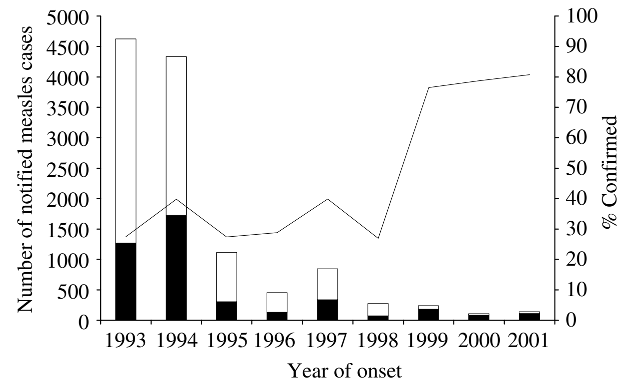

Fig. 8. Measles notifications by year of onset and confirmation status, 1993–2001. ■, Confirmed; □, unconfirmed; ——, % confirmed.

The third largest outbreak, in September–November 1999, was different as it mainly affected children. However, these children were from East Timor where vaccination coverage is likely to be low. They were evacuees staying in safe havens [13, 14] and spread to the wider community was restricted to only three adults and one child, who was too young to be vaccinated. Several other smaller outbreaks have also been reported since the MCC. Most of these involved young adults and a source case who was infected overseas [15].

Confirmation status of notifications since the MCC

To support Australia's measles control efforts during and following the MCC, recommendations were made to enhance measles surveillance [16]. This included a recommendation to seek laboratory confirmation on all sporadic cases. Prior to the MCC (1993–1997), less than one third of notifications were confirmed [17] and the level of confirmation in 1998 was no better. However, in the year following the MCC the level of confirmation, according to state and territory databases, improved markedly (Fig. 8) and in 2001 over 81% of cases were recorded as confirmed. Levels of confirmation increased in all states and territories and in all age groups, especially children, following the MCC. However, there is still room for improvement; one in five notified cases overall are still unconfirmed and this proportion is even higher in the state of New South Wales (42% unconfirmed in 2001).

DISCUSSION

Australia's efforts to control measles by improving coverage with a two-dose schedule and conducting a catch-up campaign have been very successful – notification and hospitalization rates are at an all time low and there have been no deaths from measles since 1995. Although the initial decline following the outbreak of 1993–1994 could be partially explained by the natural cycle of measles incidence, the decline has been sustained. In addition, the reductions have been most noticeable amongst those age groups targeted by the different vaccination strategies.

Our approach to measles control is based on the fundamental strategy recommended by the World Health Organization (WHO); coverage with the first dose of MMR exceeds 90% and all children are offered a second opportunity for vaccination [18]. Australia's policies most resemble those used in the United Kingdom, in that our MCC was also followed by the introduction of a second dose of MMR for pre-school-aged children. However, in Australia the catch-up campaign only involved primary-school-aged children (aged 5–12 years) in contrast to those conducted in the United Kingdom (aged 5–16 years) and the Americas (aged 1–14 years) [4, 19]. The variation occurred because Australia already had an established vaccination programme for infants and, prior to the MCC, provided a second dose of MMR to adolescents. The initial success of Australia's catch-up campaign will only be sustained by ensuring that high coverage with the two-dose childhood schedule is maintained. In the United Kingdom coverage has fallen in recent years and the number and size of measles outbreaks has increased as a result [20].

Now that measles is rare, enhanced surveillance including a high level of confirmation is required and recommended by the WHO [18]. All cases need to be confirmed (either by laboratory tests or linkage to a chain of transmission that includes a laboratory-confirmed case) because a high proportion of clinically diagnosed cases are now unlikely to be measles [21]. Enhanced surveillance for measles during an inter-epidemic period in the state of Victoria (July 1997–December 1998) found that only 7% of the 258 suspected cases tested for measles were laboratory confirmed and the positive predictive value (PPV) of the clinical case definition for notification was only 14% [22]. Because the PPV of a clinical diagnosis is low, many of the notifications in the inter-epidemic years prior to 1999 (when only one third of Australia's notifications were confirmed) are likely to be false-positives. This is especially so for notifications from vaccinated children. In Finland between 1987 and 1993 only 0·8% of vaccinated children with a clinical diagnosis of measles had their infection confirmed serologically [3]. Since the MCC, close to 80% of notifications have been confirmed. This means we can be more confident that notifications represent true cases, even though the level of confirmation in some states and territories still requires improvement.

Enhanced surveillance is also required to detect and investigate the epidemiology of outbreaks. Most outbreaks since the MCC have involved a high proportion of young adults, leading to an increase in the median age of both notified and hospitalized cases. This is due to a higher level of vaccine-induced immunity in those aged <10 years and a residual cohort of susceptible young adults. Adults born in the latter half of the 1970s, are likely to be susceptible because they were not targeted by the MCC, could have missed being vaccinated as infants (when vaccination coverage was lower) and may not have been eligible for, or have received, the adolescent dose given between 1993 and 1998. In addition, they may not have acquired natural immunity from infection, as they were growing up when the incidence of measles was lower than for older cohorts. Serological surveys conducted in the state of Victoria and nationally have also shown this group to be at risk of measles [23, 24]. The young adult MMR vaccination campaign conducted during 2001 to improve immunity in the 18–30 years age group [8] may help to explain the lower rates in young adults in 2002. A more formal evaluation of this campaign will be conducted in 2004 using sero-surveillance data.

Another pattern emerging since the MCC is the high proportion of outbreaks with a source case infected overseas. This suggests that local measles transmission may have been interrupted, with outbreaks only occurring following the re-introduction of the measles virus. Molecular genotyping of circulating isolates supports this conclusion [25]. However, until measles has been eliminated globally (eradicated) it is important to maintain high levels of herd immunity and to ensure that travellers, especially those in the at-risk young adult group, are up-to-date with their vaccinations.

Herd immunity can be maintained by continuing to achieve high coverage with the routine, two-dose, childhood vaccination programme, which is the cornerstone of Australia's elimination strategy. Since the establishment of the Australian Childhood Immunisation Register (ACIR) in 1996, coverage estimates for the first dose of MMR have improved from 83% to 93% [26, 27]. Coverage estimates for the MMR2 dose, which have only been available since 2002, have also increased from 82% to 85% [27, 28]. However, infants aged <5 years still had the highest notification and second highest hospitalization rates of any age group in the latest years reviewed, even though the total number of cases in all age groups has fallen and adults represent a greater proportion of cases than ever before. It is therefore important to maintain and indeed improve the timeliness and completeness of childhood vaccinations in order to have sufficient herd immunity to prevent endemic transmission and protect those too young to be vaccinated. This recommendation is not only appropriate for Australia, but for any country striving to achieve measles elimination.

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