Measles status in Australia, and outbreaks in the first quarter of 2009

Nicolee Martin, A Ruth Foxwell

Introduction

Measles is an acute, highly communicable viral disease spread by respiratory secretions that may lead to serious complications such as diarrhoea, otitis media, pneumonia or encephalitis.[1] In the past, measles infection was a common childhood illness but as a result of national immunisation campaigns is now rare in Australia.[2] Measles remains endemic wherever vaccination coverage is low and is one of the leading causes of vaccine preventable death in children worldwide.[3]

Historically, measles epidemics occur worldwide every 1 to 5 years with vaccination decreasing the number of cases in an outbreak. However, new birth cohorts or immigration can result in subsequent new epidemics.[4] The critical requirements for epidemics include a community size of approximately 250,000 to 500,000 and approximately 15 to 20 secondary cases arising from every index case.[5] While the measles virus can be divided into a number of genetically different types, and there is molecular evolutionary change, so far this has not resulted in high levels of genetic variation[4] and therefore, all genotypes can be neutralised by antibodies produced from the one strain.[6]

Genotypes are divided by the genetic differences in one small part of the carboxy-terminus of the nucleocapsid (N) gene and the whole length of the haemagglutinin (H) gene (one of the proteins responsible for binding the virus to the host cell).[7] Differences in nucleotide sequence by 2.5% in the N or 2.0% in the H gene will result in the classification of a new genotype.[7] The World Health Organization (WHO) classifies the measles viruses on the basis of clades (letters) and subtypes (numbers) with approximately 8 clades and 23 sub-types. While some of the genotypes are widespread, there are enough that are geographically distinct to make them a useful epidemiologic tool. Communities with lower levels of vaccination coverage and frequent outbreaks have been found to have fewer circulating strains at any one time. However, where endemicity is constant, single genotypes with several lineages tend to co-exist.[6] In Australia, since the early to mid 1990s no one genotype has appeared repeatedly, indicating the absence of an endemic circulating strain.[8]

This report reflects on the current status of measles elimination in Australia and examines a number of measles outbreaks in the 1st quarter of 2009.

Measles elimination

In 2003, the WHO Regional Office for the Western Pacific (WPRO) nominated 2012 as the target date for measles elimination, defined as the absence of transmission of endemic measles virus.[9] It should be noted that even if measles elimination is achieved in a sizeable geographic area such as the WPRO Region, high levels of vaccination would continue to be needed in order to prevent re-introduction of the virus from other areas. Measles cases will continue to occur until measles is eradicated, defined as interruption of measles transmission globally, after which vaccination could be ceased.[10] While global measles eradication is potentially possible, it is difficult to achieve because of the highly infectious nature of the virus and the susceptibility of infants during the period of time between waning maternal antibody resistance and their 1st routine dose of a measles containing vaccine at 12 months of age.[11]

WPRO indicators to track progress towards elimination include: a very low incidence of measles of less than 1 case per million population, not including imported cases; high quality case-based measles surveillance, which includes national reporting of non-measles suspected cases; high population immunity demonstrated by a very high vaccination coverage, defined as greater than or equal to 95% of the population receiving 2 doses of the measles-mumps-rubella (MMR) vaccine; greater than or equal to 80% of outbreaks having transmission of less than 10 cases; and the absence of an endemic measles virus genotype.[12,13]

In 1998, the National Measles Surveillance Strategy (NMSS) was developed in order to prepare for measles elimination in Australia. The main objectives of the measles elimination initiative were to cease measles related morbidity and mortality by interrupting indigenous transmission of measles and to prevent the re-introduction of measles by maintaining uniformly low levels of population susceptibility. High vaccination coverage of greater than 95% for each new birth cohort and low susceptibility levels, particularly in closed environments such as schools,

where rates of contact are high, were needed to achieve these objectives. In particular, the NMSS highlighted the need for coverage to be consistent across the population in order to prevent 'pockets of susceptible persons' from sustaining endemic measles transmission.[14] A widespread school based measles vaccination campaign was started in 1998 and was followed by a change in the routine vaccination schedule which moved the 2nd dose of MMR from between 10 and 16 years to 4 years of age. A second catch up dose for primary school aged children was provided for those between 5 and 12 years of age and born between 1986 and 2003.[14] This strategy significantly reduced the incidence of measles in Australia. The continued high MMR 2-dose coverage under the National Immunisation Program has ensured a high level of population immunity and enabled Australia to move into a measles elimination phase.[15]

Population immunity

Vaccination coverage targets for Australia's measles elimination strategy identified in the NMSS, were 95% for children with at least 1 dose, and 90% with 2 doses of measles containing vaccine (MCV) at school entry by 2001.[14] The latest figures from the 2007 annual immunisation coverage report reveal that 94.1% of 2 year olds (born in 2005) were fully immunised (i.e. received 1 dose of a MCV) and 89.1% of 5 year olds (born in 2001) were fully immunised (i.e. received 2 doses of a MCV).[16] These figures may underestimate the actual coverage of 1 dose of a MCV by 3%–5% and 2 doses by 5%–10% indicating that the NMSS targets may have been met.[8] In addition, incomplete reporting of immunisation encounters and the small proportion of people for which vaccination is medically contraindicated makes it difficult for the coverage estimates to exceed 95%.[15]

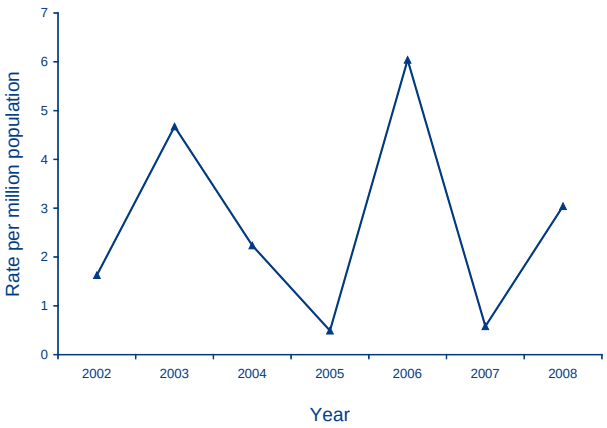
The 2007 annual immunisation coverage report states that up to 3% of Australian parents are not immunising their children for religious or philosophical reasons. However, these levels can be much higher in local areas of some jurisdictions, particularly coastal areas of south-east Queensland, northern New South Wales, the Adelaide Hills and the south-west of Western Australia.[16]

The 2002 measles serosurvey conducted by the National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS) estimated that 94% of the Australian population was immune to measles. However, it also identified susceptible age groups with only 65% of 1 year olds, 88.5% of 2 to 4 year olds, and 87% of 20–24 year olds demonstrating measles immunity at this time.[8] Infants are at high risk until they have had their 1st vaccination at 12 months of age. Young adults born between 1968 and 1982 are a particularly susceptible cohort as many missed being vaccinated as infants when coverage was still low and the risk of exposure and subsequent development of natural immunity was declining. Of this group, those born between 1978 and 1982 (or those who were 20–24 years of age at the time of the 2002 serosurvey) have been identified as at increased risk because during their childhood a 2nd dose was not yet recommended and they were not targeted as part of the catch-up campaign in 1998.[2,9,15] An evaluation of age-specific measles susceptibility in Australia, undertaken as part of a wider evaluation, which included 17 European countries, also identified adolescents and young adults between 10 and 39 years of age as being susceptible to measles outbreaks.[17] This is not the case for those born before 1968, 97% of whom demonstrated measles immunity in the 2002 serosurvey.[8]

Incidence

Measles notification rates in Australia have been progressively decreasing since 1994. Since 2002, measles incidence in Australia has ranged between 0.5 and 6 cases per million population[18] with the WHO target for measles elimination of less than 1 case per million population reached in both 2005 and 2007. For those years in which rates exceeded the WHO target, case-based investigation, including analysis of genotypes, indicate that most were either imported or linked to an imported case.[8] For example, in 2006 there was a large multi-state outbreak that was associated with a travelling spiritual group from a country where measles is endemic.[19] A high proportion of those who attended tour meetings were opposed to vaccination.[8] In 2008, there was another import associated outbreak in New South Wales.[20] Both of these outbreaks led to rates above the WHO target (Figure 1).

Figure 1: Measles notification rates per 1 million population, Australia, 2002 to 2008



High quality surveillance

In Australia, a measles case definition was formally adopted by all states and territories in 2004 as part of the revision and development of standard surveillance case definitions for all nationally notifiable diseases.[21] Public health agencies in each jurisdiction are responsible for the follow-up of all measles and suspected measles cases. While information on measles suspected cases are not collected at the national level, and therefore do not meet this WHO elimination indicator,[9] it is collected and notified on suspicion at the jurisdictional level. National measles guidelines for public health units outline requirements that include the recording of all suspected, probable and confirmed measles cases on the notifiable diseases data base in each jurisdiction.[22] Confirmed measles cases are all notified to the National Notifiable Diseases Surveillance System (NNDSS). Researchers at NCIRS concluded in a paper published in November 2008 that despite not reporting non-measles suspected cases at the national level, Australia has satisfied multiple criteria that justify the formal declaration of measles elimination.[8]

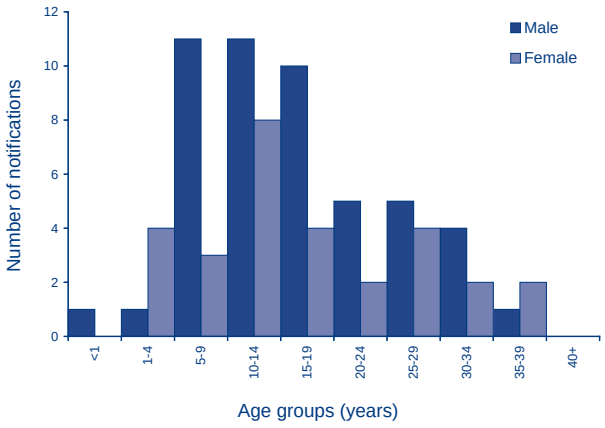
Measles cases in Australia, 1st quarter 2009

Measles outbreaks still occur in Australia when susceptible populations are exposed to the measles virus. These outbreaks are usually associated with a case imported from overseas, as has occurred in the 1st quarter of 2009 when separate importations of measles led to large outbreaks in Queensland and Victoria. Based on information provided by the Victorian Department of Human Services and Queensland Health and to the NNDSS as at 31 March 2009, both Queensland and Victoria had one and 2 outbreaks respectively in which local transmission exceeded 10 cases. However, approximately 84% (16/19) of outbreaks in this quarter had less than 10 cases, which meets the WHO elimination criteria of greater than or equal to 80% of outbreaks having transmission of less than 10 cases.

Between 1 January and 31 March 2009, 78 cases of measles were reported in Australia, 5.5 times the quarterly 5-year rolling mean (n=14.2). This compared with 65 cases notified for all of 2008. The majority of cases were from Victoria (n=33) and Queensland (n=31), with lower numbers reported from New South Wales (n=7), Tasmania (n=2), Western Australia (n=2), South Australia (n=1), the Australian Capital Territory (n=1) and the Northern Territory (n=1). Of the 78 cases, 49 (63%) were male and 29 (37%) were female with ages ranging from less than 1 year to 38 years (Figure 2).

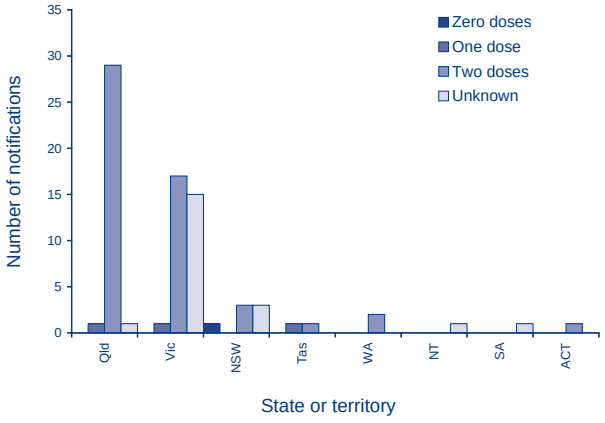
The number of vaccine doses was known for 57 of the 78 cases, of which none had received 2 doses of

Figure 2: Notifications of measles, Australia, 1 January to 31 March 2009, by age and sex



a MCV, four (7%) had received 1 dose and 53 (93%) had received no doses: the remaining 21 cases were of unknown vaccination status (Figure 3). Of the 4 cases who had received 1 dose of a MCV, two were adults born in 1971 and 1983 respectively and as such part of the susceptible cohort mentioned above; and one was a 3-year-old child, not yet due their second dose.

Figure 3: Notifications of measles, Australia, 1 January to 31 March 2009, by state or territory and number of vaccine doses



Recent travel, resulting in the acquisition of measles overseas, accounted for 22% (17/78) of the cases. Importation of cases occurred from India (n=6), Vietnam (n=4), Thailand (n=2) and one each from the Philippines, France, the United States of America, New Zealand (related to an outbreak cluster where the index case was imported from Vietnam) and Iran. Of the 17 imported cases, 13 (76%) were young adults between 17 and 34 years of age. Sixty-one of the cases were locally acquired resulting in an annualised rate of 1.14 cases per 100,000 popula-

tion (or 11.4 cases per million population) in 2009 compared with 0.23 cases per 100,000 population (or 2.3 cases per million) for all of 2008.

While measles cases were reported from all states and territories during the 1st quarter of 2009, imported cases only led to locally acquired cases in Queensland, Victoria and New South Wales with only Queensland and Victoria reporting outbreaks of greater than 10 cases. Importantly, isolated imported cases into Western Australia, South Australia, the Australian Capital Territory and the Northern Territory did not result in any ongoing transmission in those states and territories.

Outbreaks of less than 10 cases during the 1st quarter of 2009

A Tasmanian case imported from India and identified as genotype D4 was epidemiologically linked to 2 locally acquired cases, both 31-year-old males, one each from Victoria and Queensland. The measles virus in this cluster of three was 6 base pairs different from the D4 identified in the larger Queensland outbreak described below. Of 4 imported cases in New South Wales, three resulted in local secondary transmission to 1 case as at 31 March 2009.

Outbreaks of more than 10 cases during the first quarter of 2009

Queensland had a total of 31 cases of measles notified in the 1st quarter of 2009. Of these, 25 cases in a Sunshine Coast high school were linked to an imported case from India diagnosed on 12 January 2009, and were of genotype D4. None of the 25 cases were vaccinated at the time of exposure. In this case an outbreak occurred amongst a cohort of unvaccinated children despite the vaccination coverage in the overall geographical area being estimated at greater than 90% (assessed at 24 months of age for the birth cohort 1/10/05 to 30/9/06)(Map). This highlights the risk of imported disease resulting in a localised outbreak with the potential for sustained transmission when uniform MMR coverage is not achieved. An additional 6 cases were notified from Queensland during this period, of which three were imported and the remaining three were locally acquired, including the case linked to the imported Tasmanian case described above.

In Victoria, 4 outbreaks of measles were identified and were linked to 4 separate imported cases. The 1st Victorian outbreak involved 11 cases and began with an imported case from Iran diagnosed on 2 January 2009 and resulted in 3 generations of locally acquired transmission. The measles virus identified was genotype H1. Five cases were epidemiologically linked to the index case from Iran however, an additional two and 3 separately linked cases, all H1, could not be definitively linked to each other or the imported case. Of the H1 cases, six were unvaccinated, four were of unknown vaccination status and 1 case was partially vaccinated with 1 dose of a MCV.

A 2nd cluster of 20 cases, identified as genotype D8, began in Victoria with an imported case from India diagnosed on 5 February 2009. This outbreak resulted in 5 generations of local transmission by the end of March. In this cluster, 9 cases were unvaccinated and 11 were of unknown vaccination status.

The additional 2 clusters included 1 imported case in an 11-month-old baby (too young for vaccination) from Thailand, identified as genotype D9, which had no ongoing local transmission, and a 31-year-old man epidemiologically linked to the imported case in Tasmania described above.

A timeline of measles notifications by state and outbreak is presented in Figure 4 for the main Queensland and Victorian outbreaks. A clear chain of transmission in the 3 main clusters (the D4 school based outbreak in Queensland, H1 and D8 clusters in Victoria) can be seen with exposure periods, onset date and infectious periods outlined for each case based on information provided to NNDSS.

Public health measures by the relevant jurisdictions, including media releases, contact tracing, case isolation and offering prophylactic vaccination and normal human immunoglobulin for contacts with confirmed or suspected measles where indicated, minimised the spread of local transmission in the affected areas.

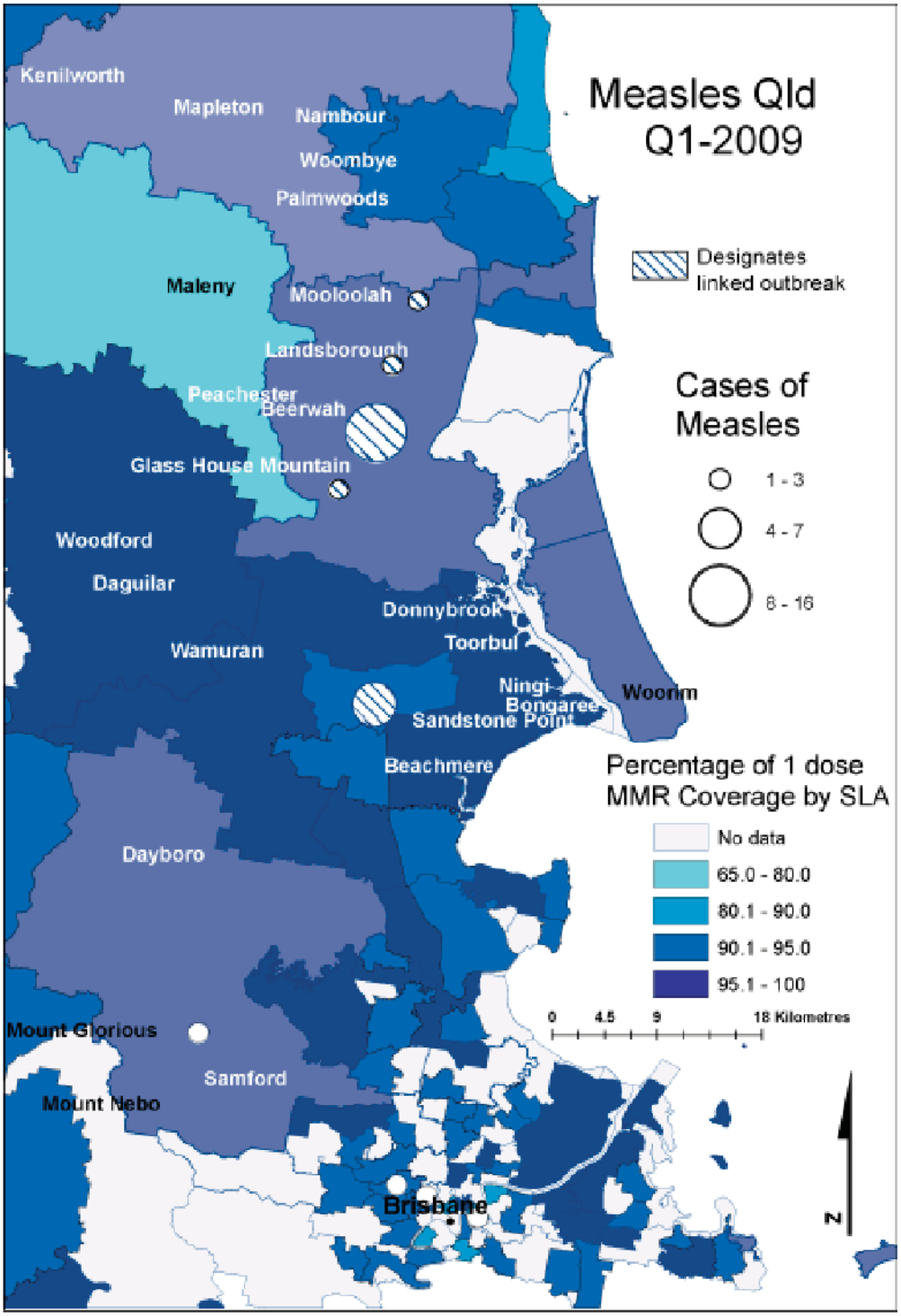
Conclusion

The rapid public health response in each jurisdiction to 17 separate measles importations during the 1st quarter of 2009 has prevented sustained measles virus transmission and highlights the capability of Australia's disease surveillance systems.

Adolescents and young adults have been identified as a susceptible cohort with young adult travellers a major source of imported infection during the 1st quarter of 2009. It has been suggested that prevention of outbreaks in this susceptible age group may require strategies such as one-off targeted mass vaccination campaigns, requirements for up-to-date vaccination records for entry to further education or overseas travel.[9,15,17]

It will also continue to be critical during this elimination phase of measles control that molecular analysis occurs in routine and outbreak investigations to identify the genotype of each new cluster and the

Map: Percentage of 1 dose measles-mumps-rubella coverage* assessed at 24 months of age (birth cohort 1/10/05 to 30/9/06), by Queensland Statistical Local Area and postcode of residence



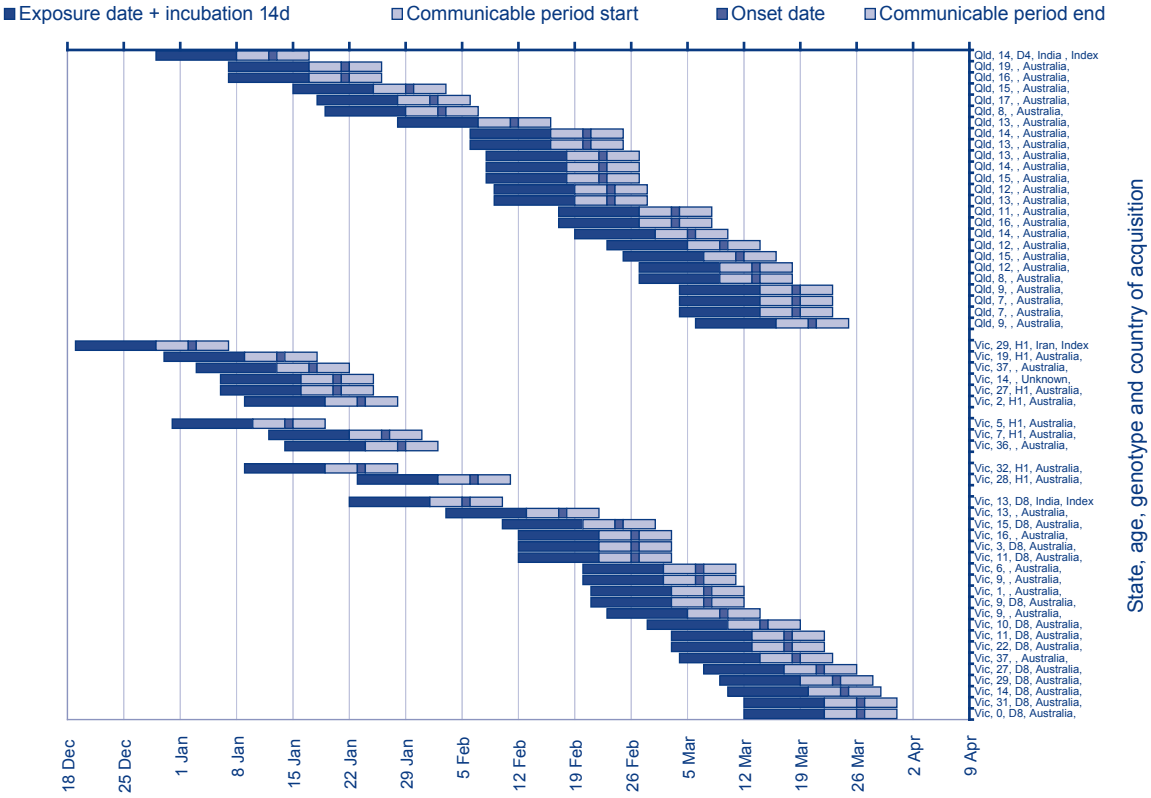
* Some Statistical Local Area 100% coverage figures are imprecise estimates as they are based on small numbers of children.

Source: B. Hull, Australian Centre for Immunisation Research unpublished data, July 2009.

origin of the measles virus in order to demonstrate the absence of sustained transmission of 1 genotype in Australia.[8]

In summary, although evidence suggests that endemic measles has been eliminated from Australia with the absence of an endemic circulating genotype, we will continue to be at risk of outbreaks among susceptible populations associated with imported cases from time to time. Ongoing efforts to maintain uniformly high levels of immunisation coverage across all regions of Australia are therefore

Figure 4: Timeline of measles outbreaks greater than 10 cases, National Notifiable Diseases Surveillance System, Victoria and Queensland (n=56), 1 January to 31 March 2009, by infectious period



required. Enhanced surveillance to identify every new case of measles and track genotypes continues to be essential in order to move Australia from the current phase of elimination to measles eradication by 2012.

Acknowledgements

The authors would like to thank the following people from the Department of Health and Ageing: Dougald Knuckey for his time and skill in producing the Queensland MMR coverage map; Kate Robinson for her comments and editorial input; and Conan Liu for comments and demonstrating the use of the modified Gantt chart. In addition we would like to thank Brynley Hull from NCIRS, Lisa Hall from Queensland Health and the following staff from the Victorian Department of Human Services: James Fielding, Margaret Hill, Pauline Lynch, Marion Moloney, Anne Murphy and Kleete Simpson and from the Victorian Infectious Diseases Reference Laboratory: Jennie Leydon, Thomas Tran and staff from the Serology and Viral Identification laboratories for their invaluable input.

The Master of Applied Epidemiology Program is funded by the Australian Government Department of Health and Ageing.

Author details

Nicolee Martin[1]

A Ruth Foxwell[1,2]

1. Vaccine Preventable Disease Surveillance, Department of Health and Ageing, Canberra, Australian Capital Territory
2. Master of Applied Epidemiology scholar, National Centre for Epidemiology and Public Health, Australian National University, Canberra, Australian Capital Territory

References

1. Heymann DL. Ed. *Control of Communicable Diseases Manual* 19th Edn. Washington DC: American Public Health Association; 2008.
2. National Health and Medical Research Council. *The Australian Immunisation Handbook*. 9th Edn. Canberra: Commonwealth of Australia; 2008. Available from: http://www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/5335A7AB925D3E39CA25742100194409/$File/handbook-9.pdf
3. The Measles Initiative [online]. Available from: http://www.measlesinitiative.org/index3.asp Accessed 18 May 2009.
4. Pomeroy LW, Bjornstad ON, Holmes EC. The evolutionary and epidemiological dynamics of the paramyxoviridae. *J Mol Evol* 2008;66:98–106.
5. Griffin DE. Measles virus. In Fields BN, Knipe DM, Howley PM, Eds. *Virology*. Philidelphia: Lippincott Williams and Wilkons; 2001. p.1401–1441.

6. Riddell MA, Rota JS, Rota PA. Review of the temporal and geographical distribution of measles virus genotypes in the prevaccine and postvaccine eras. *J Virology.*2005;2:87–95.
7. World Health Organization. Nomenclature for describing the genetic characteristics of wild-type measles virus (update, Part 1). *Wkly Epidemiol Rec* 2001;76:242–247.
8. Heywood AE, Gidding HF, Riddell MA, McIntyre PB, MacIntyre CR, Kelly HA. Elimination of endemic measles transmission in Australia. *Bull World Health Organ* 2009;87:64–71.
9. World Health Organization. Progress towards the 2012 measles elimination goal in WHO's Western Pacific Region, 1990–2008. *Wkly Epidemiol Rec* 2009;27(84):269–280.
10. Measles eradication: Recommendations from a meeting cosponsored by the World Health Organization, the Pan American Health Organization, and CDC. *MMWR Morbid Mortal Wkly Rep* 1997;46(RR11):1-20.
11. Fenner, F. Candidate viral diseases for elimination or eradication. *MMWR Morbid Mortal Wkly Rep* 1999;48(SU01):86-90.
12. World Health Organization Regional Office for the Western Pacific. Monitoring measles surveillance and progress towards measles elimination. *Measles Bulletin*. 2007;13:1–6. Available from: http://www.wpro.who.int/NR/rdonlyres/7BE6353C-7D82-4368-A300-57-DB3F38148D/0/MeasBulletinIssue13.pdf
13. World Health Organization Regional Office for the Western Pacific. Field guidelines for measles elimination. Geneva: 2004. Available from: http://www.wpro.who.int/publications/pub_929061126x.htm
14. Heath T, Burgess M, McIntyre P, Catton M. The national measles surveillance strategy. *Commun Dis Intell*1999;23:41–50.
15. Gidding H, Wood J, MacIntyre CR, Kelly H, Lambert SB, Gilbert GL, et al. Sustained measles elimination in Australia and priorities for long-term maintenance. *Vaccine* 2007;25:3574–3580.
16. Hull B, Deeks SL, Menzies R, McIntyre P. National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases. Annual Immunisation Coverage Report, 2007. *Commun Dis Intell* 2009;32 (2): 169–186.
17. Andrews N, Tischer A, Siedler A, Pebody RG, Barbara C, Cotter S, et al. Towards elimination: measles susceptibility in Australia and 17 European countries. *Bull World Health Organ* 2008;86(3):197–204.
18. Department of Health and Ageing. National Notifiable Disease Surveillance System. Available from www.health.gov.au/nndss Accessed 14 April 2009.
19. Sheppeard V, Forssman B, Ferson MJ, Moreira C, Campbell-Lloyd S, Dwyer DE, McAnulty J. Vaccine failures and vaccine effectiveness in children during measles outbreaks in New South Wales, March-May 2006. *Commun Dis Intell*. 2009;33(1):21-26.
20. Australian Government Department of Health and Ageing. Communicable Diseases Surveillance. Highlights for 1st quarter, 2008. *Commun Dis Intell* 2008;32(2):274–276.
21. National Surveillance Case Definitions for the Australian National Notifiable Diseases Surveillance System Canberra: Department of Health and Ageing. Available from: http://www.health.gov.au/casedefinitions Accessed on 27 July 2009.
22. Australian Government Department of Health and Ageing. Series of National Guidelines. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/cdnasongs.htm Accessed on 18 August 2009.