The National Measles Surveillance Strategy

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Background

This surveillance plan has been formulated to help prepare for national measles elimination. It updates and expands upon the surveillance methodology previously outlined in *Measles: Guidelines for the control of outbreaks in Australia* which was developed by the National Health and Medical Research Council (NHMRC).[1] The NHMRC document also contains recommendations about individual case management and outbreak control, which will require revision once the Measles Control Campaign (MCC) has commenced. However, enhanced measles surveillance is needed as soon as possible, as the first phase of the MCC will take place between July and October, 1998.♦ Therefore, all jurisdictions should comply as closely as possible with these guidelines from 1 July 1998.

These guidelines have been developed in collaboration with the Measles Elimination Advisory Committee and The Communicable Diseases Network of Australia and New Zealand. They are intended as best practice guidelines for all those who are likely to contribute towards measles surveillance and elimination in Australia, including: general practitioners, paediatricians and physicians, pathologists, diagnostic and public health laboratories, and disease control officers in State and Territory health departments.

As best practice guidelines, they assume resources that may not yet be available, but are needed for successful measles elimination. In particular, laboratory diagnostic methods and case investigation formats must be standardised, and an agreement made by all States and Territories that they collect the same minimum data set. Measles elimination requires coordinated efforts, perhaps more than any previous health initiative in Australia, and comprehensive surveillance is a critical element for success.

♦ The first phase of the Measles Control Campaign was completed in the second half of 1998, after this article was accepted for publication. The results of the primary schools immunisation campaign have been reported in *CDI*. See for example *Commun Dis Intell* 1998; 22:270. Prior to the campaign, NHMRC endorsed the change in timing of the second dose MMR which is now due prior to school entry at age 4 to 5 years.

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Introduction

In Australia, and worldwide, measles remains the leading cause of vaccine preventable deaths.[2-4] Even with near universal single dose childhood vaccination it seems, with currently available vaccines, measles outbreaks can still occur.[5] However, in the 1990s, major advances have been made in measles control, particularly in the Americas. Indigenous measles transmission has been interrupted in several Latin American countries, the English speaking Carribean, and the United States.[6,7] In Latin America and the United Kingdom, measles control has been achieved through mass vaccination programs, administered regardless of vaccination history, to preschool and school-age children. In Finland and the United States, similar achievements have been attained by maintaining high coverage for a prolonged period with a two dose measles vaccination schedule.[6] Substantial progress has also been achieved in the Western Pacific Region other than Australia.[8] Mass campaigns are able to interrupt endemic transmission quite quickly. However, to prevent the reappearance or reintroduction of measles, very high routine vaccination coverage or smaller follow-up campaigns are needed.

In July 1996, a joint meeting of the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), and the Pan American Health Organisation was convened to consider the feasibility of global measles eradication.[6] This group recommended the goal of global measles eradication, with a target date of 2005-2010. In July 1997, Australia's National Centre for Disease Control established a Measles Elimination Advisory Committee (MEAC). The MEAC provisionally recommended a national, predominantly school-based measles vaccination campaign to commence in the first quarter of 1999. It also recommended that after this campaign: the second dose of measles-mumps-rubella vaccine should be given prior to school entry, and the adolescent MMR program should cease in 1999. In April 1998, the Australian Technical Advisory Group on Immunisation, after considering implications for rubella immunisation, endorsed this change in the Standard Vaccination Schedule. To support these measles control initiatives, substantial enhancements of measles surveillance are required.

Measles elimination objectives

The principal objectives of the Australian measles elimination initiative are:

1. To cease measles related morbidity and mortality, by interrupting indigenous transmission of measles; and
2. To prevent reintroduction of measles until global eradication is achieved, by maintaining uniformly low levels of population susceptibility.

Measles control targets

In order to achieve the elimination objectives outlined above, very high vaccination coverage and low susceptibility levels are needed, especially in closed settings such as schools where contact rates are high. Uniformity of coverage is also important, because pockets of susceptible persons are capable of perpetuating endemic transmission. The following vaccination coverage targets have been set, and should be pursued in all socioeconomic and ethnic groups, and in all regions.

By 2000:

- 95 per cent coverage of school children with an additional dose of vaccine in a school based campaign;
- 80 per cent coverage of children with two doses of measles-containing vaccine by school entry.♦♦

By 2001:

- 95 per cent coverage of children with one dose of measles containing vaccine by their second birthday (10% susceptibility);
- 95 per cent coverage of children with at least one dose, and 90 per cent with two doses of measles containing vaccine by school entry (5% susceptibility).

Subsequent targets will depend upon progress towards measles elimination.

Measles Surveillance Tasks

Surveillance is an essential component of enhanced measles control initiatives. Very high quality active and passive surveillance is now necessary to determine whether measles elimination objectives and coverage targets are being achieved. In this strategy, measles surveillance tasks are described under the following headings:

1. Case definitions, diagnosis, and investigation.
2. Enhancing surveillance.
3. Outbreak investigation.
4. Monitoring measles vaccination coverage and population susceptibility.
5. Monitoring vaccine safety and effectiveness.

1. Case definitions, diagnosis, and investigation

For a measles elimination initiative, disease surveillance must fulfil several functions. In addition to measuring case rates and characterising populations at high risk for infection, we need to be able to:

- Detect cases and the source of infection rapidly so that timely control measures can be implemented;
- Detect interruption or resurgence of indigenous measles transmission;
- Detect importation of measles;
- Monitor serious complications of measles infection (death, encephalitis, seizures, and pneumonia).

1.1. Measles case definitions

1.1.1. Suspected infection

A sensitive clinical definition is needed for the early detection of outbreaks and imported infection, and for timely interventions.

*A **suspected case** is an illness with all of the following features: morbilliform rash, cough, and fever present at the time of rash onset.*[9]

♦♦ This was the target prior to the campaign, although 90 per cent may now be more appropriate

(The Pan American Health Organisation accepts any illness diagnosed as measles by a clinician as a suspected case. This more sensitive definition may need to be adopted as we approach elimination.[6])

1.1.2. Laboratory confirmed infection

As measles becomes well controlled, the positive predictive value of clinical diagnosis becomes poor, especially for young children and sporadic disease, and laboratory based surveillance becomes increasingly important.[10] Laboratory confirmation should be sought on all sporadic clinical notifications, and at least two cases during an outbreak. However, case investigation should not be delayed pending laboratory results (see section 1.3).

Criteria for laboratory confirmation*:*

- *A positive test for measles-specific IgM; or*
- *Isolation of wild measles virus from a clinical specimen; or*
- *A diagnostic rise in measles antibody titres in paired sera.*

A laboratory confirmed case does not need to meet any clinical criteria (except for serologically diagnosed cases who received a measles containing vaccine 6-45 days prior to testing - see section 1.2.4).

1.1.3. Rejected measles infection

*A **rejected case** is an illness which is:*

- *Initially categorised as suspected measles; and*
- *Subsequently found to have negative measles serology, and/or diagnosed as having an alternative cause based on laboratory evidence.*

1.1.4. Epidemiological linkage

This category can provide additional evidence for measles infection in instances where laboratory confirmation is unavailable, or is equivocal (e.g. serodiagnosis following immunisation).

*A measles case is **epidemiologically linked** if:*

- There was exposure to a laboratory confirmed case during their infectious period (4 days before to 4 days after rash onset); and
- This exposure occurred within the expected incubation period of the case under investigation: 7-18 days (mean 14 days) before rash onset.[11]

Exposure must be face-to-face or in a confined setting such as a class room.

1.1.5. Imported infection

Importation of infection poses an ongoing risk during the elimination phase of measles control. An increasingly large proportion of measles notifications in Britain and in the USA are attributable to imported infection.[10,12]

International importation*:*

A confirmed case whose rash onset is within 18 days of arrival in Australia.

The last country visited prior to arrival in Australia should be recorded on the case investigation form (Appendix A).

All other cases are considered ***indigenous***. All indigenous cases are further categorised as either epidemiologically linked to an internationally imported case (see above definition of linkage); or not linked epidemiologically to an internationally imported case.[13]

Interstate importation

A confirmed case whose rash onset is within 18 days of entering the State or Territory. All other cases are considered local to the State or Territory.

These definitions are intended to maximise detection of importation, and therefore will incorrectly label some locally acquired infections as imported.♦♦

1.2. Laboratory diagnosis

1.2.1. Serological diagnosis

Serum anti-measles IgM antibody testing is recommended for diagnosis of acute measles infection. The indirect enzyme immunoassay (EIA) is recommended for routine laboratory diagnosis, because it is relatively quick and convenient to perform. The test characteristics of commercially available indirect IgM EIAs are variable. The sensitivity and specificity of one such assay were estimated to be 86 per cent and 81 per cent respectively.[15] Until further data are available, any of the commercially available kits for measles IgM are considered satisfactory for routine diagnosis.

Timing of specimen collection

Detailed data regarding the optimum timing of specimens for IgM serology has been obtained using a measles capture IgM assay developed by the Centers for Disease Control and Prevention (CDC). This assay was frequently positive at the onset of rash illness, about 80 per cent sensitive within 72 hours of onset, 100 per cent between 4-14 days, falling to 94 per cent at 4 weeks and 64 per cent at 6 weeks.[16] Therefore, a negative EIA test for IgM on serum sampled more than 72 hours after rash onset is very reliable, especially when measles is rare. However, when initial anti-measles IgM antibody is negative, but serum was sampled within the first 72 hours of rash onset, repeat serum sampling for IgM and IgG estimation is recommended after 14 days (range 10-30 days).

Blood collection requirements

Laboratories generally require a minimum of 1mL clotted blood for serology. Blood can be tested from a finger-prick or heel-prick, but venipuncture is less traumatic in the hands of an experienced person. The testing laboratory should be consulted if doubts exist regarding the minimum volume of blood required. It is also possible to test blood which has been collected onto filter paper and air-dried, but this method is not routinely available in Australia.

1.2.2. Confirmatory testing and quality assurance

As the incidence of true measles declines, so too will the positive predictive value of measles serodiagnosis; while the reliability of a negative test improves. Confirmatory testing of IgM positive cases will be needed to achieve

♦♦ A more specific definition for interstate importation is recommended by the Centers for Disease Control: *A confirmed case who was outside the State /Territory for the entire incubation period (7-18 days before rash onset).*[14]

acceptable diagnostic accuracy. In Australia, during inter-epidemic periods, all measles IgM positive and equivocal sera should be forwarded to a reference laboratory for confirmatory testing. During measles outbreaks, when positive tests are more likely to be reliable, a random sample only of IgM positive sera should be forwarded.

In Australia, the recommended reference laboratory confirmatory test for acute measles infection is the IgM capture EIA assay. This assay has been evaluated by the Centers for Disease Control and Prevention (CDC), and its sensitivity and specificity have been estimated to be 97 per cent and 99 per cent respectively.[17,18] This assay has also been used in regional reference laboratories by the Pan American Health Organisation (PAHO) for confirmatory testing of all sera positive or indeterminate by commercial indirect IgM measles assays in screening laboratories, as well as a 10 per cent random sample of negative sera.[6] A reference laboratory network is currently being established in Australia to provide confirmatory measles testing and serological quality assurance.

1.2.3. Alternative methods of diagnosis

Serodiagnosis may also be made by demonstrating IgG seroconversion (change from negative to positive) or rise in measles specific IgG antibodies. Measles specific IgG generally peaks approximately two weeks after onset of rash.[19] Paired sera are collected 10 to 30 days apart, the first of which should be sampled in the week following rash onset, and the sera are tested simultaneously. For reasons of convenience and timeliness, IgG testing is not recommended for routine measles diagnosis, but is necessary for measuring population susceptibility.

A variety of methods are available for detection of measles IgG or total antibody. Plaque reduction neutralisation (PRN) is the gold standard assay for determining protective immunity to measles,[20] although measles specific antibody detectable by any test has been considered to represent immunity.[21] Quantitative assays such as immunofluorescent assays, neutralisation, haemagglutination inhibition (HAI), complement fixation tests (CFT) and PRN, may be used to demonstrate four fold rises in measles antibody, unlike EIA which is a semi-quantitative assay, and cannot be routinely used in this manner.[22] CFT are no longer recommended for measles diagnosis, and HAI is known to have inferior sensitivity compared to more modern assays.[19]

1.2.4. Serodiagnosis following immunisation

Following measles immunisation, seroconversion usually occurs, and measles specific IgM may be detected for one to two months. Serologically diagnosed cases who received a measles containing vaccine 6-45 days prior to testing should be classified as confirmed measles only if they are also linked epidemiologically to another confirmed case.[14] Viral culture and molecular methods can distinguish between vaccine virus and wild strains.[23]

1.2.5. Viral culture and molecular epidemiology

Viral culture is not currently recommended for routine diagnosis of acute measles. However, characterisation of measles isolates will become important in discerning whether future measles outbreaks are caused by strains of domestic origin - which implies failure to interrupt local transmission - or by imported strains of measles.

In the USA, molecular epidemiological analysis based on nucleotide sequencing of either haemagglutinin or nucleoprotein genes has been used together with standard epidemiological techniques to provide this capability. It appears that a single indigenous measles genotype was once prevalent in the USA. Now the situation is more heterogeneous, and an increasing proportion of cases are caused by measles strains previously seen largely in Japan, Europe, and Africa.[24] Currently, eight genotypic groups of measles are known to be circulating worldwide.[25] A global network and a standard system of genotype nomenclature is being developed to help track measles transmission world wide.

Characterisation of a representative sample of current and past Australian isolates is required prior to the vaccination campaign, to enable these powerful molecular epidemiological tools to be employed during the elimination phase.

When to collect specimens for culture

Specimens for culture should be collected from at least one case in every chain of measles transmission (2 or more epidemiologically linked cases), and from at least two cases during an outbreak investigation (Section 3.1.2). The yield from sporadic cases is likely to be low, because clinical diagnosis is unreliable in this setting. A nasopharyngeal aspirate is the specimen of choice for measles culture. Urine, heparinised blood and throat swabs are also suitable specimens. Culture should be performed simultaneously with initial serology, rather than waiting for serological confirmation, as measles virus is rarely shed for more than a few days after onset of rash. The virus may be present in respiratory secretions for up to one to two days after onset of rash,[26] and in the urine for up to 10 days.[27] Contact a reference laboratory regarding the best method of specimen collection and transportation before sending specimens for culture. All positive measles cultures must be referred for molecular typing.

1.2.6. Salivary antibody testing

For diagnosis

It can be difficult to obtain serological confirmation for a large number of suspected measles cases, and considerable interest has been focussed on the possibility of convenient, non-invasive diagnosis of measles using salivary specimens. Saliva has been shown to contain measles specific IgM antibodies in greater than 90 per cent of cases where measles IgM is present in serum.[16,28] Salivary measles IgM testing is now in routine use in measles surveillance in the United Kingdom, but not as yet in the USA.[10] There are technical difficulties with serological tests of saliva, and currently these tests are not available for routine diagnosis of measles in Australia.

For serological surveys

Salivary antibody tests have also been used for seroprevalence studies in paediatric populations. Unfortunately, salivary detection of measles IgG antibodies is very insensitive compared with their detection in serum, and it is unlikely that this method will be useful for population surveys of susceptibility.[29]

1.2.7. Differential diagnosis

Several other infectious diseases can mimic measles, and when measles is well controlled, the majority of suspected cases have alternative aetiologies. The most common of these are: Human herpes virus 6 (exanthem subitum), rubella, enterovirus, and Human parvovirus B19.[10] In cases of suspected measles which are rejected on the basis of serological testing, it is recommended to test for rubella, and other diseases as clinically indicated. Measles reference laboratories will intermittently measure prevalent causes of rash illness by cross-sectionally testing negative sera for a variety of pathogens. This will provide supportive evidence for measles elimination in later stages of the campaign.

1.3. Case investigation

All cases (suspected and confirmed)

Following a report of suspected measles, clinical information needs to be collected to establish whether a notified case meets the clinical case definition described in Section 1.1.1. As soon as possible after notification, collect serum for testing on all suspected cases, and specimens for culture where indicated (see section 1.2.5).

It is important to collect accurate and complete immunisation histories on all cases, including the number of doses and dates when measles-containing vaccines were given. Wherever possible, documentation of vaccination should be sought from written records or registers. This may be difficult for teenagers and adults, for whom self report may be the only available source of information. Document the source of immunisation information on the data collection form (Appendix A).

Collecting demographic data helps characterise cases and detect temporal or geographic clustering of cases. Monitoring disease outcomes, such as death and encephalitis is also important, because the main purpose of measles control is to prevent severe illness and death. Enhanced surveillance is likely to increase notifications of suspected measles, but an increasing proportion of these may be mild or modified by prior vaccination.

Look for the source of infection in all cases of measles. When no apparent history of exposure exists, look for situations where unrecognised exposure may have occurred, such as: day care, school, air travel, indoor sporting events, and contact with overseas visitors.

Appendix A is a sample form which summarises the core data that should be collected during case investigation. These data will be collected and collated at a national level, but additional data will be required for individual case follow up and evaluation of surveillance at a local level, including: the identifying data for reporting authorities, doctors and laboratories, affected institutions, and contacts; dates of laboratory specimen reception and reporting.

Confirmed and epidemiologically linked cases

Identify contacts, establish their immunisation status, and assess the potential for further transmission. Contacts are persons who have been exposed, for any length of time, to a laboratory confirmed or epidemiologically linked case during their infectious period (4 days before to 4 days after rash onset); exposure must be face-to-face or in a confined setting such as a class room. Measles is highly infectious and brief exposure can result in infection. Transmission is most likely to occur in confined settings and institutions, and to those without documented vaccination. Contacts aged 12 months to four years should receive measles-mumps-rubella (MMR) vaccination if they do not have documented evidence of prior vaccination. Contacts aged 5 years and over who are attending primary and secondary schools should be vaccinated with MMR if they are not up to date with the new MMR schedule - that is, have not received two doses of a measles containing vaccine. Contacts should be vaccinated within 72 hours of exposure. Vaccination is not harmful if given later, but it is unlikely to prevent infection.

Refer to the NHMRC document *Measles: guidelines for the control of outbreaks in Australia* for current recommendations regarding: the use of normal human immunoglobulin in contacts who are immunosuppressed or aged less than 12 months; vaccination of high risk populations such as Northern Territory Aboriginals; exclusion of cases and contacts.[1]

1.4. Data flow, analysis and reporting

Notification data should be forwarded weekly to State authorities, and fortnightly to the National Centre for Disease Control. Case investigation data for both suspected and confirmed cases should be forwarded for State and national collation.

Notification data should be reviewed daily at a local level, and fortnightly nationally. Data should be presented by age, sex, vaccination status, and locality at the local government area (by States), and by State and Statistical Division nationally. Data analysis and interpretation should be disseminated at State and national levels at least fortnightly, preferably in a dedicated measles control report.

2. Enhancing surveillance

Existing state-based disease notification systems - which rely primarily upon unsolicited reports from doctors, laboratories, and hospitals - provide a sound basis for enhanced measles surveillance. However, enhancing surveillance through additional case finding is required for successful measles elimination.

2.1. Improving case ascertainment

New cases must be notified by telephone to the local or State/Territory health authority, and an attempt must be made to confirm the diagnosis within 24 hours of notification. Case investigation will help identify source cases and subsequent transmission to other settings. Additional cases must be sought intensively and notified separately. In this way, a chain of measles transmission must be pursued as far as possible. For sporadic cases this will usually involve interviewing: the person who notified the case, the case or one of their family members and the case's school or workplace. As a rule of thumb, seek additional cases with rash onset three weeks before and after that of the index case.

2.2. Active surveillance

Active surveillance is the process of seeking measles cases other than through routine unsolicited reports. It should be used to evaluate, stimulate, and hasten routine

surveillance mechanisms where deficiencies are expected, for example in areas of low vaccination coverage and low measles incidence. Active surveillance can involve contacting schools, doctors, laboratories, and hospitals, seeking cases that have not already been notified. Reviewing additional disease registers or data sets which are not analysed routinely - such as emergency department and laboratory registers - can help determine the magnitude, geographic extent, and beginning and end of outbreaks. Case finding methods need to be tailored to local health services and surveillance objectives. For example, determining the extent of a measles outbreak in a remote community will require a different approach to evaluating the sensitivity of passive surveillance for hospital admissions in an urban health area. In view of the measles vaccination campaign, by July 1998 local health authorities must review mechanisms for quickly instituting active surveillance for measles via local laboratories and health services, and in local communities and institutions at high risk for measles outbreaks.

Alternative data sources

Inpatient statistics and mortality data provide valuable alternatives for examining secular trends in rates of severe disease. These data may be less affected by ascertainment bias than notifications. However, medical and administrative staff of hospitals must ensure that cases admitted for treatment of measles complications, have measles mentioned in the admission and discharge diagnoses. These data sets should be examined and compared to disease notification data at least annually. In addition, where identifying fields are available, cross checking these data against measles notifications can identify deficiencies in the completeness of case ascertainment and outcome monitoring.

2.3. Monitoring surveillance quality

There is no single disease control indicator for measles - such as acute flaccid paralysis for poliomyelitis - which allows an independent means of monitoring measles control. Therefore, quality assurance is operational, rather than validating using an alternative measure for measles incidence. The following will be used as key operational indicators of measles surveillance quality:

1. The proportion of all cases that are subjected to laboratory testing for measles;
2. The median time from rash onset to specimen collection;
3. The median time from specimen collection to notification of the local / State health authority; and
4. Percentage of cases with data on immunisation status.

3. Outbreak investigation

Monitoring and investigating measles outbreaks provides valuable information for control initiatives, and helps strengthen surveillance. Outbreak investigations help characterise populations at risk, and may be used to answer specific research questions. They provide an excellent opportunity to measure vaccine effectiveness, and to evaluate new diagnostic methods.[30,31] A full description of an approach to outbreak investigation is beyond the scope of this document, and only a framework is provided.

3.1.1. Outbreak definition

Two or more laboratory confirmed cases which are related in time and place, or a single laboratory confirmed case in an institution (e.g. school).

As a rule of thumb, cases are considered related in time if the serial interval (time from rash onset in the first to rash onset in the second) is three weeks or less. As we move to towards elimination every confirmed measles case should be considered an outbreak.

3.1.2. Outbreak investigation

When clusters of suspected measles occur, an attempt should be made to obtain serological confirmation, and samples for culture, on at least two cases. For confirmed measles cases, the standard case investigation form can be used, but it may not be possible to complete these data for all suspected cases.

A minimum outbreak investigation would:

- Ascertain age and immunisation status for all suspected cases;
- Assign a unique outbreak name or number to help identify the cases which form part of an outbreak (Appendix A);
- Complete the data collection form for the index case and at least two confirmed cases; and
- Estimate age-specific immunisation coverage for the population/region affected by the outbreak. These data may be extracted from immunisation registers, by examining data from previous surveys, or by performing a new survey.

3.1.3. Monitoring outbreaks

Collecting outbreak investigation data in this way will allow outbreaks to be evaluated in more detail using surveillance data. The regional frequency of outbreaks will be compared - a dot map showing the distribution of outbreaks by health area is a helpful way to present these data. The interval between outbreaks may also be examined by region, and can be used to anticipate the timing of outbreaks.

Performance indicators will also be used to monitor the quality of outbreak investigations. For example, the proportion of outbreak cases with vaccination data; and the proportion of outbreak investigations where at least one specimen was submitted for viral culture.

4. Monitoring vaccination coverage and population susceptibility

Measuring vaccination coverage and population susceptibility determines whether control targets are being reached, and helps predict outbreaks and plan vaccination strategies.

4.1. Vaccination coverage

Vaccination coverage is a key indicator of campaign success and predicts measles control. The following are some important principles regarding vaccination coverage monitoring in the setting of a measles elimination initiative.

4.1.1. Monitoring the routine immunisation schedule

The Australian Childhood Immunisation Register (ACIR) is now yielding quarterly reports for measles coverage on cohorts of 2 year old children who were born since the ACIR commenced in January 1996. These coverage reports are presented by State, but similar tabulations will be used to report data to the level of local government area for use by local immunisation program managers. Routine performance indicators are currently being developed to monitor the quality of ACIR coverage data. In addition, a mechanism is being developed to quickly identify regions or providers that are not achieving coverage targets, so that appropriate improvements can be planned.

At present data are scanty regarding coverage with the second dose of MMR. When the second dose of measles vaccination is brought forward and is given to preschool children instead of adolescents, this dose will also be monitored using the ACIR.

In addition, surrogate measures of coverage, such as vaccine distribution, should be monitored. This will aid interpretation of trends in ACIR data during the initial years of its operation, when apparent improvements in coverage may actually represent improved participation. Intermittent cross-sectional surveys will also be used to validate ACIR coverage data. Coverage should also be measured during outbreak investigations (see section 3.1.2).

4.1.2. Mass vaccination campaign

Vaccination registers are not suitable for measuring coverage during the school based campaign. The ACIR collects data only for children under 7 years of age, so tally sheets will be used by school vaccination teams to count vaccine doses versus students enrolled. Preschool doses, given by the child's usual provider, will be measured using the ACIR.

4.2. Measles susceptibility

As measles is controlled and fewer cases occur, estimates of population susceptibility obtained from serological surveys become an increasingly important source of information regarding the success of the measles elimination program. The National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS) plans to conduct regular serological surveys every two to three years for persons aged 2 to 60 years. These regular serosurveys will be conducted by testing serum residues from blood samples which are referred routinely to major public health laboratories in all States and Territories. These sera will be tested for a range of vaccine preventable diseases including measles and rubella. Blood samples referred from immunosuppressed persons will be excluded.

This serological surveillance will help evaluate the effects of moving the second dose of MMR from adolescence to preschool. It will allow us to monitor changes in measles susceptibility, and confirm that the prevalence of rubella susceptibility remains low in women of child bearing age. Susceptibility data can also be used in conjunction with mathematical modelling to predict the expected timing, size, morbidity, mortality, and age distribution of outbreaks.[32,33] Serological surveillance has been used routinely in Britain for the past 10 years, and using these data it was predicted that a large measles outbreak would occur in Britain in 1994. [34] A mass vaccination campaign of school children was implemented in response to this, and it appears that the expected outbreak has been successfully prevented or delayed.[10,35,36] More recently, it was predicted that a measles outbreak would occur in New Zealand during the years 1997-98, and an outbreak did occur in early 1997.[37]

5. Monitoring vaccine safety and effectiveness

5.1. Vaccine safety

The MMR vaccine licensed in Australia has an excellent safety record. Fever, occurring 6 to11 days after vaccination is the most commonly reported adverse event.[38] However, the majority of persons in catch-up campaigns are already immune to measles, and consequently vaccine virus related adverse event rates (AEs) are usually lower than for vaccination at 12 months of age.[5] Despite this, because catch-up campaigns are necessarily well publicised and a large number of vaccinations are administered over a short period of time, the absolute number of events in any reporting period is increased. As a result, public anxiety regarding AEs is often heightened during mass campaigns.[39]

In order to maintain public confidence, adverse events to vaccines used in mass vaccination campaigns should be given a high priority. It is important to inform doctors and measles campaign staff regarding possible AEs, and remind doctors regarding the importance of AE reporting. A detailed description of the adverse events associated with MMR vaccination is available in the 6th Edition of the *Australian Immunisation Handbook*.[2] Reports of adverse events should be made to the State/Territory health departments, or to measles campaign staff. Providing a 24 hour telephone hot-line may also improve the timeliness of AE reports and public confidence. However, the staff supporting such services must be well briefed on recent controversies regarding MMR vaccine safety, and capable of fielding AE reports or referring them appropriately.

During the mass vaccination campaign, State/Territory AE reports, including outcomes of serious events such as convulsions, should be updated daily and sent to the State or Territory vaccination team. For the routine schedule, AE rates will be calculated using the number of vaccinations reported to the ACIR as the denominator. During mass campaigns, vaccination tallies collected by the vaccination teams will be used for this purpose. Background national rates for some of the diseases which may be confused with vaccine related events - such as encephalitis and Guillain-Barré syndrome - can be estimated using alternative data sources such as inpatient statistics data and surveillance for acute flaccid paralysis. These comparative data will be useful during the vaccination campaign, to evaluate whether reporting rates during the campaign differ from pre-existing rates.

5.2. Vaccine effectiveness

In the future, when more accurate coverage data are available and vaccination status is collected for measles notifications, surveillance data will be used to monitor measles vaccine effectiveness (VE).[40] Accurate coverage statistics are needed, because small changes in coverage

can markedly influence calculations of VE using the 'screening' method. Coverage data, must also reflect the populations and age groups from which notification data originate. Notification biases influence 'screening' estimates of VE, so trends will be more reliable than absolute values. Outbreak investigations can also be used to evaluate measles vaccine effectiveness.[31]

5.3. Cold chain monitoring

Monitoring the cold chain is an important quality control measure which cannot be addressed adequately in this surveillance plan. Guidelines for transport and storage of vaccines are outlined in the Australian Immunisation Handbook.[2] MMR vaccine is distributed as a freeze dried preparation, and prior to reconstitution it is relatively resistant to fluctuations in temperature. Data regarding the adequacy of MMR vaccine storage and transport do not need to be collated and analysed nationally.

Conclusion

This strategy recommends numerous surveillance enhancements that are required to support a measles elimination initiative in Australia. The key elements of this strategy are:

1. Revised control targets both for measles vaccination coverage and population susceptibility (page 42).
2. Uniform, simple, and sensitive measles case definitions; including a definition for imported infection (Section 1.1).
3. Pursuing serological testing (IgM) for all suspected measles cases; and referral of all positive sera from sporadic cases to a reference laboratory for confirmation (Sections 1.2 and 1.3).
4. Collecting specimens for culture from at least two cases in a measles outbreak, and referring all positive cultures for molecular typing (Section 1.2.5).
5. Uniform case investigation, and (minimum) data collection which includes vaccination status for all notifications (Section 1.3).
6. The use of active surveillance to evaluate and enhance routine surveillance mechanisms (Section 2.2).
7. The use of standard indicators to monitor the quality of surveillance data (Section 2.3).
8. Investigation of all measles outbreaks, collecting uniform (minimum) data regarding the outbreak (Section 3).
9. Enhancing surveillance of adverse events following immunisation (Section 5.1).
10. National serological surveys to monitor the effectiveness of the measles immunisation program and the effects of changes to the MMR vaccination schedule.

The surveillance enhancements outlined in this strategy should be instituted as soon as possible, so that they are functioning before the first stage of the elimination campaign commences in July 1998. Undoubtedly, these activities will require considerable additional resources, quite apart form the costs of a mass vaccination campaign. Costing estimates of these surveillance activities are needed. High quality surveillance is integral to successful measles elimination, and should not be considered as a separate cost. It is possible that the Measles Control Campaign will eliminate rubella and mumps. Similar, and integrated surveillance strategies are required for these diseases.

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Appendix A

Measles Data Collection Form

State/Territory

Reporting GP/Clinic/Laboratory/Hospital | Address | Phone

Patient Surname | First Name

Address (No. & Street) | Town/Suburb | Phone

Patient Details

Postcode | State/Territory | Notification date - state (Day Month Year) | State/Territory Identification No.

Date of Birth (Day Month Year) | Date received - national (Day Month Year) | Sex (M=Male, F=Female, U=Unknown)

Age (Unknown=99) | Unit (if DOB unknown) (Y=Years, M=Months (if < 2 years)) | ATSI origin (A=Aboriginal or Torres Strait Islander, N=Not Aboriginal or Torres Strait Islander, U=Unknown)

Clinical data

Morbilliform rash?
Cough?
Fever at time of rash onset?
Y=Yes, N=No, U=Unknown

Date of rash onset (Day Month Year)

Complications

Hospitalised? (Y=Yes, N=No, U=Unknown)

Days hospitalised (Unknown=99)

Date of hospitalisation (Day Month Year)

Pneumonia?
Encephalitis?
Seizures?
Y=Yes, N=No, U=Unknown

Died?

Date of death (Day Month Year)

Cause of death

Laboratory

Was laboratory testing for measles done? (Y=Yes, N=No, U=Unknown)

If laboratory confirmed, date of first postive test report (Day Month Year)

	Date specimen taken (Day Month Year)	Result
Serum IgM		
Serum IgG*		
Culture		

P=Positive, N=Negative, R=Diagnostic rise / seroconversion, I=Intermediate, E=Pending, X=Not done, U=Unknown

Note: positive diagnosis by IgG requires seroconversion or diagnostic rise in paired sera. *For IgG specimen date, only provide the date the **second** serum was taken.

Epidemiological

Date case investigation started (Day Month Year)

Where did this case most likely acquire measles? (1-9)

1=Home, 2=Day care/preschool, 3=Primary school, 4=Secondary school, 5=University / college, 6=Workplace, 7=Health care facility, 8=Remote community, 9=Other, 10=Spread to > 1 setting, 99=Unknown

Epi-linked? Y=Yes, N=No, U=Unknown

Was there further documented spread from this case? Y=Yes, N=No, U=Unknown

If epi-linked, was this case linked to an imported case? Y=Yes, N=No, U=Unknown

If yes, where did it spread to? (1-10)

Outbreak related?

Did this case arrive from overseas less than 18 days before rash onset? Y=Yes, N=No, U=Unknown

If yes, country arriving from

Outbreak name / number

Did this case arrive from interstate less than 18 days before rash onset?

If yes, State/Territory arriving from

Vaccination

Ever had measles containing vaccine?

Number of doses of measles containing vaccine prior to illness onset?

	Date given (Day Month Year)
1st	
2nd	
3rd	

Information source: 1=Parental recall / self report, 2=Parent record, 3=Provider record, 4=ACIR record, 5=State/Local govt. register, 6=Other, 9=Unknown

Final

Final case classification
S=Suspected, C=Laboratory confirmed, X=Lost to follow-up