Immunisation coverage in Australian children: a systematic review 1990-1998

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Abstract

The Australian Childhood Immunisation Register (ACIR) commenced operation in January 1996 and provides a comprehensive database of children's immunisations in Australia. The ACIR enables implementation of an immunisation recall and reminder system and improved surveillance and reporting of immunisation coverage. Before the introduction of the ACIR, the methods used in assessing coverage varied widely in design and quality, with few studies measuring coverage at national or statewide level. This is a systematic review of the scope and reliability of estimates of immunisation coverage available in Australia from 1990 to 1998. A total of 108 studies were identified of which 51 were classified as higher quality based on a range of criteria including whether they had a response rate of 50% or better. ***Commun Dis Intell*** **1999;23:145-170.**

Summary

Introduction

Accurate information on the proportion of children immunised in Australia is essential for the planning of effective immunisation programs. Before the introduction of the Australian Childhood Immunisation Register (ACIR) in January 1996, the methods used in assessing coverage varied widely in design and quality, with few studies measuring coverage at national or statewide level.

This systematic review of the scope and reliability of estimates of immunisation coverage from 1990 to 1998 was initiated by the National Centre for Immunisation Research and Surveillance of

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Vaccine Preventable Diseases (NCIRS) to evaluate the available Australian estimates of immunisation status against data from the ACIR.

Methods

Studies were identified and included in the review, using all available sources, if they examined Australian data and were published or produced between January 1990 and June 1998. Eligible studies were abstracted with a standard proforma including type of publication, sample characteristics, validation and outcome measures. Studies were classified as higher quality using a range of criteria, including if they had response rates of 50% or higher. The term 'fully immunised' was defined as coverage of the full course of vaccines scheduled at the time of each study. Data were also tabulated by individual vaccine and age strata (12-23 months, 24-35 months and 4-6 years) where available.

Results

A total of 108 eligible studies were identified and 51 higher quality studies tabulated by location, design, sample size, response rate, strategy and method of validation (Tables 1-7). Studies investigating immunisation procedures and processes, and letters and editorials that did not report original data on immunisation coverage were excluded.

The most common assessment age was from 24 to 35 months and the proportion of children fully immunised ranged from 51% to 88% (excluding *Haemophilus influenzae* type b (Hib)). The 1995 Australian Bureau of Statistics (ABS) estimates for 24 to 35 months were lower (51.3%) than most other comparable population-based studies (range 60.3% - 88%). Details of the immunisation status of children by age strata are shown in Tables 8-10.

Immunisation coverage in child-care settings for children aged 0-5 years ranged from 60.3% to 70% (excluding Hib) in studies using provider documentation. Coverage in schools for children aged 4-6 years was higher (range 67% to 89% excluding Hib) but likely to be overestimated. While studies in remote Aboriginal communities suggested coverage was much higher than the general population, studies in less remote areas found much lower levels of coverage in Aboriginal children than in the general population.

Comprehensiveness and validity at a national population level were key criteria for data quality, fulfilled only by the ABS surveys. Statewide population databases using provider-held records to assemble a prospective birth cohort had the next highest validity, followed by cross-sectional studies with appropriate sampling and high response rates. Many studies based on retrospective birth cohorts had low response rates with potential selection bias. These more geographically restricted studies have generally produced higher estimates of immunisation coverage than the ABS survey. The first 12 month cohort from the ACIR gave lower coverage estimates for diphtheria-tetanus-pertussis (DTP) and poliomyelitis (OPV), but higher for Hib than the ABS survey. ACIR data are currently incomplete and should be viewed as minimum estimates, but can detect large changes over time such as has occurred with Hib vaccine coverage.

Conclusions

This review showed that methodology strongly influences the final estimates of coverage and supports the need for a nationally consistent methodology, which would make comparisons much easier. The best national estimate of immunisation status in Australian children prior to the ACIR is the 1995 ABS survey. The ACIR should give increasingly accurate estimates as reporting improves. This can be expected due to current incentive initiatives, but specific surveys of coverage in small populations such as urban Aboriginal communities may still be required. The available data from comparable industrialised countries still indicate suboptimal performance by Australia, with coverage for three doses of pertussis-containing vaccines at around 80% compared with estimates of over 90% in the United Kingdom (UK) and the United States of America (USA).

Introduction

Accurate information on the proportion of children immunised for each vaccine on the recommended schedule is essential for the planning of effective immunisation programs. In Australia, there have been few studies measuring national or statewide immunisation coverage and the methods of data collection have varied in quality. The Australian Childhood Immunisation Register (ACIR) was introduced in 1996 in part to provide more consistent and comparable information about immunisation coverage, but all immunisations for children less than 7 years of age will not be included until after 2001.

This systematic review of the scope and reliability of estimates of immunisation coverage in Australia since 1990 was initiated by the NCIRS to provide the background against which coverage estimates from the ACIR could be judged. The available literature was examined with reference to the following research questions:

1. With the exception of the ACIR:
   (a) What is the best overall estimate of the current immunisation status of Australian children?
   (b) What is the best estimate of immunisation status for each scheduled vaccine by age?
2. How do the estimates from other studies compare with those from the ACIR?
3. How does the immunisation status of Australian children compare with overseas estimates?

Background

Australia has had childhood immunisation programs since the 1920s, with enormous advances in eliminating or reducing the impact of vaccine preventable diseases (VPDs) such as poliomyelitis, tetanus and diphtheria.[1] However, outbreaks of measles and rubella continued to occur in the 1990's and pertussis is endemic, with nine deaths in infants occurring in 1996-97.[2,3] This disease activity is occurring because immunisation coverage remains below the level of 90%-95% required to interrupt transmission of these highly contagious infections.[4]

Concern about Australia's poor record for immunisation coverage prompted a series of national initiatives, beginning with the National Health and Medical Research

Council (NHMRC) convening a panel to review services in 1993. The resulting National Immunisation Strategy set targets for immunisation coverage and control of vaccine preventable diseases (VPDs) and recommended initiatives to achieve these targets. [4]

The recommendations of the National Immunisation Strategy were addressed in several ways. The establishment of the National Notifiable Diseases Surveillance Scheme (NNDSS) in 1991 had already begun the process of national surveillance and reporting of VPDs using common case definitions. From 1996 the ACIR provided both an immunisation recall and reminder system for parents and improved surveillance and reporting of immunisation coverage.

In 1997, the Minister for Health and Family Services initiated the 'Seven Point Plan' to increase the proportion of fully immunised children in Australia. This Plan included monetary incentives, commencing in mid 1998, for parents whose children receive child-care assistance payments and incentives for general practitioners whose practices include a high proportion of fully immunised children. The Plan outlined the measles elimination strategy, a range of educational initiatives, a proposal to introduce uniform school entry legislation relating to immunisation status, and enhancement of research activities which led to the establishment of the NCIRS.

The only national immunisation coverage data, prior to the ACIR, came from national surveys by the Australian Bureau of Statistics (ABS). The most recent survey in 1995 found that 52.1% of children aged 0-6 years were fully immunised for age, excluding Hib. The level of full immunisation for the same age group in the previous ABS survey in 1989-90 was similar (54.1%), although these estimates are not directly comparable due to changes in the standard immunisation schedule and the format of the questionnaire.[5] The ABS survey showed that coverage levels varied between States and Territories, vaccines, age groups and socioeconomic and ethnic groups.[5]

Other than the ABS surveys, data on coverage were statewide or regional and predominantly from ad hoc surveys. Meaningful comparisons between these studies are difficult because methodology and outcome measures were not uniform. Several States and Territories also developed their own population-based vaccination registers (Australian Capital Territory,[6] Victoria[7], Queensland[8,9] and Northern Territory[10,11]) to obtain more consistent data for analysis of trends. Comprehensiveness of the data from some of these registers can be questioned due to incomplete reporting by providers and because some children receive their immunisations in both the private and public sectors. Other estimates of coverage have come from a variety of sources including outbreak investigations, serological surveys and field vaccine studies, but this was incidental to their main objective and applied only to particular settings.

This review includes both published and unpublished literature from 1990 to 1998 and focuses on studies in which the primary purpose was to estimate immunisation coverage. These data on childhood immunisation coverage in the 1990s provide the background against which the initiatives begun in 1997 may be compared.

Methods

Search strategy

Studies were included in the review if they gave Australian data and were published or produced between January 1990 and June 1998. University theses and treatises were included, as were conference abstracts and proceedings although efforts were made to identify resulting publications wherever possible. Publication was defined as a peer-reviewed journal, government bulletin or report in the public domain. All other studies were classified as unpublished. Letters and editorials containing relevant data were also included.

While the review focuses on coverage of the primary immunisation schedule in children aged 6 years and under (the age group used in the ACIR and ABS immunisation surveys) studies were also included for young people up to the end of high school. The eligible vaccines were those recommended for use in children during the study period: diphtheria-tetanus-pertussis (DTP), poliomyelitis (OPV), measles, mumps and rubella (MMR), Hib and hepatitis B.

The following sources were searched for studies and reviews on childhood immunisation status in Australia since 1990:

- Medline from 1990 to 1998 using the search terms 'immunisation', 'immunisation programs', 'immunisation status', 'Australia' (in MeSH) and the text words 'immunisation status or cover(age) or rate(s)' and 'vaccination status or cover(age) or rate(s)' for all headings. The term 'vaccination' was coded under 'immunisation'.
- Published and unpublished departmental reports, studies and newsletters from the States and Territories. These were identified by direct contact with immunisation co-ordinators, members of the Communicable Disease Network of Australia and New Zealand (CDNANZ) and the authors themselves.
- Manual and electronic searching of the *Communicable Diseases Intelligence* journal from 1990-1998.
- University theses and treatises in public health located by personal contact with authors and supervisors.
- Follow-up of references from key reports and publications.
- Abstracts and conference proceedings from the Public Health Association (PHA) National Immunisation Conferences of 1991, 1993, 1995 and 1996 and other relevant conferences in Australia, for example the NSW Public Health Network Conference. The authors of these studies were contacted and full reports obtained wherever possible.

Criteria for eligibility

The following study designs were included in the review:

- cross-sectional or cohort studies directly measuring immunisation coverage, both in the entire population and in specific settings, such as child care centres and schools;
- state immunisation databases and data from vaccine distribution systems;
- immunisation coverage measured as part of outbreak investigations;
- serological surveys; and

- studies were excluded if they were surveys primarily measuring attitudes, knowledge and behaviour of providers and consumers, studies of vaccine adverse events or studies monitoring the vaccine cold chain.

Data abstraction

After assessment of eligibility, identified studies were abstracted using a standard proforma, which included:

- type of publication (published / unpublished);
- study design (population based / non-population based and including sub-sets such as schools, child-care services);
- sample characteristics - design, size and response rates;
- vaccines included;
- measures of immunisation status; and
- validation of immunisation status.

These data were entered into a Reference Manager database.

Quality assessment

A group of higher quality studies from a range of designs and settings were selected for tabulation and comparison with the ACIR. Studies were classified as higher quality using criteria including study design, study population, response rates, sample size and validity. Generalisability was a particularly important criterion. For example, population-based cross-sectional studies using large sample sizes and with high response rates were rated more highly than retrospective birth cohorts with sample sizes of less than 50% and evidence of selection bias. Moreover, studies with validated coverage data were rated more highly than those relying on parental recall.

The peer-reviewed published studies in this review were given greater weight than the unpublished studies. However, several State Health Departments routinely used data from non-peer reviewed publications to estimate and monitor immunisation coverage in their regions. Peer-reviewed publication was therefore not the only important measure of data quality.

Age strata for coverage assessment

The National Immunisation Strategy in 1993 identified 2 year old children as the primary group for estimates of full immunisation[4] and this is reflected in the outcomes of many of the studies in this review. More recently, the NHMRC described immunisation outcomes in terms of 'milestones' set at 6 months, 12 months and 18 months.[12] However, the outcomes from the majority of the studies in the review were not classified according to these categories (other than 12 months) and therefore the assessment ages outlined above were used. The Appendix outlines the 1994 NHMRC immunisation schedule current for the 1995 ABS survey and describes the major changes made since the previous survey in 1989-90. The 1996 immunisation schedule is also outlined in the Appendix, including the immunisation 'milestones'.[12]

The outcome measures from the higher quality studies, including data on full immunisation and for individual vaccines, were grouped into the following age strata for comparability with each other and data from the 1995 ABS survey:

- 12-23 months
- 24-35 months; this was the most common assessment age used in the studies
- 4-6 years; to determine school entry immunisation

Definitions of immunisation coverage

Immunisation coverage is normally expressed as the proportion or prevalence (%) of complete immunisation by particular assessment ages or 'milestones'. Most studies in this review have allowed for a 'grace period' of around 1 to 3 months in assessing coverage, which is up to 6 months for the ACIR cohort.[13] The definition 'fully immunised' used in this review is receipt of the full course of vaccines scheduled at the time of the study for the assessment age. This definition includes using various outcomes such as 'age appropriately immunised' and 'immunised up to date' but only if separate questions have been asked about each vaccine.[14] The full course of vaccines included are those defined in the standard vaccination schedule at the time of the study (Appendix) but it is noted that a small number of studies in this review have accepted the combined diphtheria and tetanus (CDT) vaccine as a substitute for DTP.[8,15]

The ABS immunisation surveys

The ABS has conducted national immunisation surveys on a regular basis since 1983, which until the advent of the ACIR, provided the only Australia-wide population, based data on immunisation status. The ABS surveys have been considered a reference standard for estimating immunisation coverage because of their high quality sampling methods.

The most recent survey in 1995 was conducted as part of the regular monthly Labour Force survey, which derives a probability population sample using a stratified, multistage and clustered design.[5] Each State or Territory was divided into strata, and sampling of Census Collection Districts then undertaken. Around 30,000 private dwellings in total were included, with interviews conducted by trained interviewers over a two week period in April 1995. High response rates, complete population ascertainment and large sample size are notable features of this survey.

Information on children's immunisation and health screening was obtained by parental report for 6,768 children aged 0-6 years from approximately 5,000 households. Of these children, 870 were aged under 1 year, 960 were 12-23 months, 1,021 were 24-35 months, 907 were 36-47 months and 3,010 were aged 4-6 years. Parent Held Records (PHRs) were consulted for 60.6% of children aged 3 months to 6 years. Just over half (52.1%) of the 1995 sample were found to be fully immunised (excluding Hib), and 46% were classified as partially immunised as they had not completed the full course of each vaccine. The remaining children had either an unknown immunisation status (1.1%) or were totally unimmunised (0.4%).[5]

Although the same sample selection procedure is used for all the ABS immunisation surveys, comparability between the 1995 and earlier surveys is limited by changes in the NHMRC schedule and the questions asked.[5,16] These changes are summarised in the Appendix.

The Australian Childhood Immunisation Register

The ACIR began on January 1, 1996 as part of the 1993 National Immunisation Strategy.[4] The aim of the register was to provide more accurate and comprehensive information about immunisation coverage and to be a key component of an initiative to improve the immunisation status of Australian children.[13] The register is administered by the Health Insurance Commission (HIC), which is responsible for both routine reports and a recall-reminder system. The database holds immunisation details on all children under the age of 7 years who are registered for Medicare (approximately 98% of children by 12 months of age) and also for any notification of immunisation to the ACIR for children not registered with Medicare.

Immunisation information may be transferred to the ACIR by all providers in both the public and private sectors. Under-reporting is estimated to reduce immunisation coverage by approximately 10%,[17,18] especially in States with a higher proportion of general practitioner (GP) providers such as New South Wales (NSW) and Western Australia (WA). Difficulties have also occurred in the transfer of data to the HIC from some regions.[18]

Coverage reports from the ACIR are based on 3 month birth cohorts measured at two 'milestones': 12 months (DTP, OPV and Hib vaccines) and 24 months (MMR, DTP, Hib and OPV vaccines).[13]

Results

Studies reviewed

A total of 108 out of 448 studies reporting published and unpublished data on immunisation coverage in Australian children from 1990 to 1998 were eligible for inclusion.

Fifty-one higher quality studies were selected from a range of designs and settings shown in Tables 1-7. These tables summarise the location, design, sample size and age, response rate, strategy and method of validation for each study. Several studies, which indirectly reported coverage data, were included in this review. For example, some evaluated the implementation of immunisation reminder systems[19-21] others evaluated the effectiveness of the Parent Held Record (PHR),[22] or the accuracy of parental report[23] or described an immunisation campaign.[24] A preliminary evaluation of the ACIR was also included.[25]

Excluded studies[26-29] were primarily those investigating immunisation procedures and processes rather than coverage. Seventeen letters and editorials[14,30-46] and a review document on the role of parents and service providers[47] were also excluded as they did not contain original data on immunisation coverage.

Type of publication

The majority (72%) of the coverage studies included in the review were published in either peer-reviewed journals or State/Territory communicable diseases bulletins. Of the remainder, five were Master of Public Health treatises or PhD theses[48-52] and 12 studies were either published as government reports or were included in State government annual reports.[7,53-64]

Methodology

Study populations

Most studies were either population-based (52%) or from specific settings such as child-care (9%), schools (29 %) or population sub-groups such as Aborigines or persons of non-English speaking background (6%). Six studies which were based in clinical or related settings were included in the review, five of which are shown in Table 7.[23,65-68] Many of the population based studies, including the ABS, used appropriate random sampling methods but the findings may not be generalisable beyond the population from which they were drawn. Thirty school-based studies[50,62,69-96] including all measles outbreak investigations were identified, with some overlap between primary and high schools in some studies. Nine of these are presented in Table 5 and five outbreak investigations are outlined in Table 6. Ten child-care studies were included,[55,97-108] six of which are presented in Table 4.

Study design

Cross-sectional study designs accounted for 66% of the total, followed by birth cohorts (28%), of which three were retrospective[51,109,110] and two prospective.[104,111] All other prospective cohort studies used data from registers in Victoria (Victorian Maternal and Child Health Nurses (VMCHN) database),[7] the Australian Capital Territory (ACT) (ACT Central Vaccination Register),[6] Queensland[8,9] and the Northern Territory (NT).[10,11]

Sample size and response rates

The sample size in the studies varied widely, from a final sample of 69 two year old children in child-care[102] to over 6,700 children in the 1995 ABS immunisation survey,[5] shown in Tables 1-5. In many studies, particularly those using birth cohort methods, low response rates reduced power and generalisability. Furthermore, some studies reported significant differences in the characteristics of respondents and non-respondents, further reducing their representativeness.[109,110] However, several studies using random sampling achieved response rates of above 90%.[5,16,112-114] Two studies used the World Health Organization (WHO) method[115] of cluster random sampling, one in a sparsely populated rural region[58] and one in metropolitan Melbourne.[116]

Vaccines studied

The majority of studies measured all age-appropriate vaccines with a small number measuring individual vaccines only (Table 3). Studies evaluating individual vaccines were primarily focused on recently introduced vaccines such as Hib[6,61,117] and hepatitis B[118,119] or were part of outbreak investigations for measles[72,79,91] rubella,[49,120] or pertussis.[15,103]

Validation of immunisation status

The majority of studies in the Tables 1-7 validated at least a subset of their data by sighting Parent Held Records (PHRs) or by contacting the vaccination provider. A small number of serological surveys were conducted[23,54,68,118,121] while immunisation databases used only data transmitted from providers.

Validation of parental recall

Validation by Parent Held Record (PHR)

Most parents use the PHR when it is available and refer to it as their primary source of information. Hall et al found that 80.1% of parents of children 2-4 years used the PHR which was completed correctly in most cases.[58] With some exceptions,[121,122] most studies in this review investigating the validity of parental report found significant differences between reported and validated levels of vaccination. For example, a study in Northern Sydney found only 60% agreement between parental report of vaccination status and provider records.[110]

The 1995 ABS immunisation survey used both parental recall and viewing of PHRs (60.6%) for children aged 3 months to 6 years. Forty-seven per cent of children with records available were fully immunised compared with 33.1% of all children in the survey. The ABS study classified children as unimmunised if the parent could not recall the exact number of doses for each vaccine, which is likely to have underestimated true immunisation coverage.[5]

A study of children attending child-care facilities in Queensland also found that those with a PHR were more likely to be fully immunised at 2 years of age.[97] The PHR is less likely to be useful among disadvantaged groups, as illustrated by a study of Aboriginal families which found that there was no documentation of vaccinations for 52% of children.[114]

Serologic validation of parental recall

A serosurvey in Western Sydney medical centres found only 74% of the children in the total sample had protective levels of measles antibody, compared with 84% from parentally reported vaccination, a positive predictive value of 84%.[23] A population-based serologic survey in NSW found a non-significant difference in measles immunity between parents with written records (84% immunity) and those using parental report (76% immunity).[121]

Serological surveys

The small number of serological surveys largely focused on specific diseases, for example measles and rubella,[23,49,54,121] including two studies[54,121] that were opportunistically added to larger studies, for example the National Survey of Lead in Children. These studies gave valuable data on age-specific seroprevalence but were unable to differentiate between acquired and vaccine induced antibody (Causer et al, 1998; personal communication).

Regional immunisation registers

Coverage estimates from population immunisation databases are more likely to be accurate than parental recall, but underestimates coverage if providers do not report all immunisations given. The VMCHN database[7] calculates age-specific coverage rates using all births in Victoria as the denominator and all children attending Maternal and Child Health (MCH) clinics as the numerator. The data are likely to be accurate for children up to 1 year of age, as approximately 90% of all children in this age group attend the clinics,[7] but as attendance progressively falls and children may be immunised by more than one provider, ascertainment through MCH clinics is less complete over this age.

Other regional databases include the NT immunisation database,[10,11] the ACT Central Vaccination Register[6] and the Vaccination Information Vaccination Administration System (VIVAS) in Queensland.[9,21] The VIVAS system includes a vaccine distribution scheme which increases reporting of immunisation encounters. The VIVAS and ACT databases have been modified to transmit data for the ACIR on a centralised reporting basis since early 1996, but the other separate databases have been discontinued.

School entry immunisation certificates

School entry immunisation certificates were made compulsory in NSW, Victoria and the ACT during the period covered in this review. A number of studies have assessed the quality of these data and estimated coverage for children entering school. Many schools do not have a completed certificate for all children in kindergarten or Year 1[81,96] and those certificates which are completed substantially overestimate immunisation.[71]

Acceptance of non-statutory evidence of immunisation was identified as the major factor leading to over-estimation of compliance with the legislation.[71,93,95] Two studies evaluating the effectiveness of the new legislation in Victoria and NSW found inconsistencies in the issuing and administration of certificates and evidence of schools. To reduce the impact of over-reporting, some studies excluded incomplete certificates from their analysis[75,78] and one study concluded that school certificates should not be used for assessing coverage.[83]

Child-care immunisation certificates

Immunisation certificates at entry into licensed child-care services have recently been introduced in many Australian states, some on a compulsory basis (NSW, Victoria, ACT). In 1995 in NSW, the Statewide Sentinel Immunisation Surveillance System (SSISS) database for child-care was established, containing a systematic random sample of child-care immunisation records.[101] Among 745 children aged 2 years of age, 70% of children were recorded fully immunised (excluding Hib). Prior to the introduction of legislation in the ACT in 1994, 34% of records in a child-care centre were found to be incomplete during an outbreak investigation for pertussis.[103]

A survey in the NT following the introduction of a voluntary program in 1995, found that centres had documentation for only 66% of children.[106] Similarly, a study reviewing documentation of immunisation records in Family Day Care and child-care centres in NSW in 1995 found that many parents in Family Day Care had not submitted their certificates to the provider.[102] Overall it seems likely that similar problems to school immunisation certificates (poor quality and low levels of compliance) are prevalent with child-care immunisation certificates.

Measures of immunisation status

Full immunisation, partial immunisation and timeliness

The outcome measure used in the majority of studies was 'fully immunised' and the ages most commonly used in the assessments were 24-35 months and school entry (aged 4-6 years). A summary of outcome measures for age groups of 1 year, 2 years and school entry are shown in Tables 8-10. A small number of studies did report both the coverage and timeliness of the vaccinations, with only 21% of vaccinations given on time in a Northern Sydney study

(within 1-2 weeks for the infant doses and 4-6 weeks for the 12 and 18 month doses).[110] In child-care, although 66% of 2 year old children were completely immunised, only 24% had been immunised on time.[99,100] Several studies measured the level of partial immunisation where one or more doses of vaccine were given but others had been missed. The proportion of partially immunised children ranged from 11% to 33.5%.[58,69,99,100,106,110,123]

Age of assessment

Many studies showed a drop in the proportion of children immunised after the age of 12 to 18 months. In the ABS 1995 survey, 88.5% of children were fully immunised against D/T at 1 year falling to 63% at 2 years. These data indicate that while many children received the 12 month single dose of MMR, they did not receive the fourth doses of DTP and Hib at the age of 18 months. A child-care coverage survey found that coverage for the primary series of DTP and Hib was over 95%, falling at 18 months by 22%-26%.[106] Similarly, coverage of only 65% for the fourth doses of DTP and Hib was found in a regional Queensland database, where coverage for the first three doses had been 81%-84%.[8]

Vaccines assessed

Many studies reviewed reported coverage for separate vaccines, which while providing more information, made comparisons by age more complex. Moreover, while most studies reported the levels of the combined vaccine DTP, a small number reported levels of the combined diphtheria and tetanus (CDT) vaccine, which excludes pertussis, in their definition of 'fully immunised'.[8,15]

The major change to the Immunisation Schedule during the review period was the introduction of Hib in April 1993, with free vaccine available from July 1993. As a result, several studies[5,50,113] undertaken around this time give estimates of full immunisation coverage including and excluding Hib, with large differences between the estimates. For example, a school entry study using PHRs in 1996 found that full immunisation was 47% if Hib was included but that this increased to 74.5% if Hib was excluded.[50] Similarly, the ABS survey estimated that full immunisation for children aged 0-6 years was 33.1% with Hib and 52.1% without Hib.[5]

Immunisation status of 1 year old children

Only a small number of studies reported immunisation status for children at approximately 12 months of age (Table 8). There is some variation in the estimates for full immunisation as some include MMR and others exclude these antigens. Estimates from the ABS 1995 survey were 51.4% including Hib and 70.8% excluding Hib. Estimates of full immunisation from other studies were generally higher, for example the NT database reported levels of 75% including Hib.[11] Where rates for DTP are reported, however, these are similar to the ABS 1995 estimates. Assessment of immunisation status in a cohort of children in Melbourne suggested that 92%-93% of children aged either 9 or 16 months were fully immunised, much higher than both the 1995 ABS estimate and estimates from the VMCHN database. However, a serosurvey assessing the prevalence of measles immunity in NSW found that 77% of children aged 12-23 months were immune, which is 10% lower than the levels reported in the 1995 ABS survey but consistent with a measles vaccine efficacy of around 90%.[121]

Immunisation status of 2 year old children

Table 9 illustrates the range of outcome measures used for children of around 2 years of age in several studies dated from 1994, including the 1995 ABS survey. Most of these studies included 4 doses of DTP and OPV in their definition of 'fully immunised', but at least one of these studies[116] included only 3 doses of DTP and OPV in their assessment. Estimates for both full immunisation and DTP showed a very wide range (51%-88% and 58%-93% respectively).

The ABS 1995 rate of full immunisation for 2 year old children is much lower than any other reported estimate for this age group. The other studies that estimated full immunisation, including Hib, ranged from 51.1% - 66.5% compared to 34.3% for the ABS survey. Estimates excluding Hib ranged from 60.3%-87.8%, compared to 51% for the ABS survey. A cross-sectional, population-based, cluster sample survey in Newcastle, NSW,[113] reported estimates both with and without Hib of 51.1% and 77% respectively. While the reported immunisation coverage for DTP and OPV in the two Victorian studies were similar,[7,116] estimates for the same vaccines differed in the NT, although one of these was a child-care centre based study.[10,106]

There were also major variations in coverage reported for studies using the same method of data collection. For example, the Victorian immunisation database[7] showed that 85.3% of children aged 18 months to 3 years in 1996-97 were immunised for DTP while the urban Darwin database in the NT reported that only 60% of children had been immunised for DTP in 1996.[10] The pattern for all other vaccines in these databases was similar with the exception of Hib and it is unclear whether these are caused by technical problems with the database or due to actual differences in coverage between the States.

Immunisation status at school entry

Table 10 shows estimates from school entry and other school surveys, which as discussed above, show a higher level of full immunisation coverage than for younger children. In WA between 80% and 86.5% of children were fully immunised (excluding Hib).[81,125] In NSW, 89% of children were classified as fully immunised at school entry, based on parental reports.[69] Overall, the estimates shown in Table 10 are higher than those from the ABS 1995 survey but are likely to be overestimates (see Methods).

Child-care settings

Studies based in child-care centres using provider held documentation, show estimates of full immunisation for 2 year olds ranging from 60.3%-85%.[97,99,100,106-108] One study in the NT found that 67% of 2 year old children with child-care immunisation certificates were fully immunised and that this rate was higher than in the general population of 2 year olds in Darwin,[10] although estimates in Darwin were lower than those using data from all seven NT databases.[11] A prospective cohort study in Perth found higher rates of full immunisation (excluding Hib) than other comparable studies, with levels ranging from 86% at 12 months to 85% at 24 months.[104,105] However, these data were based on parental report only and are likely to be overestimates.

Immunisation status in States and Territories

State by State coverage results from population-based studies and for children aged 2 years are reported in Table 11 and are compared with the ABS 1995 results. In all regions, with the exception of Tasmania and one study in the NT, the fully immunised coverage estimates from studies other than the ABS are much higher. This appears to be largely due to low proportions of DTP in the ABS data, (48%-66%). Rates for OPV and MMR, however, are largely comparable with the ABS estimates and as expected, Hib rates are lower in the ABS than the other studies. Interestingly, the ABS estimates vary considerably between States, with Tasmania showing full coverage of only 23.9% (including Hib) compared to 42.5% in WA. Estimates without Hib for these two States were 37.3% and 58.3% respectively.

Hib

Two studies in the review assessed the pre and post uptake of Hib after its introduction in 1993 and one of these also compared the age-specific incidence of Hib with changes in uptake of Hib.[6,61,122] In Sydney, uptake of Hib was estimated at 9% in May 1993 rising to 48% in August 1993 for children under 18 months of age and rising from 31% to 45% in the same period for children aged 19-60 months.[61,122] The ACT immunisation register estimated that 68% of 9 month old children and 34% of 2 year old children had received Hib vaccine by March 1995.[6]

Hepatitis B

Three studies assessing the level of coverage of hepatitis B in specific populations, including Aboriginal and non-English speaking groups were involved in the review.[68,118,119] Coverage was generally low, with only 54% of Aboriginal children (median age of 24.5 months) in North Queensland immune to hepatitis B.[118] In one study however, 81.6% of infants from 'at risk' groups in Victoria received one or more doses of hepatitis B vaccine.[119]

Aboriginal communities

Some studies assessing coverage in Aboriginal children from remote communities in the NT and WA suggested a higher than average rate of immunisation.[112,125] For example, the NT study estimated that over 97% of 2 year old children had been immunised for all vaccines other than fourth doses of DTP and polio.[112] Conversely, studies in urban and less remote rural areas found a much lower level of coverage in Aboriginal children compared to non-Aboriginal children from the same populations.[57,114] For example, a study in western NSW estimated that only 60% of Aboriginal children aged between 2 and 4 years of age were fully immunised compared to 84.1% of the non-Aboriginal children.[57] Furthermore, a study in the North Coast region of NSW reported ABS estimates which showed the immunisation status for Aboriginal children was only half that of the overall population.[114]

Evaluating Australian coverage studies

The 51 higher quality studies summarised in Tables 1-7 included 38 published in peer-reviewed journals, the two ABS surveys (1989-90 and 1995)[5,16] and 12 government reports, treatises and abstracts. Attempts to evaluate all these studies were difficult for reasons previously outlined in this review due largely to variations in age groups, vaccines studied and definitions of immunisation status, in addition to study design and other criteria used for assessing quality. Generalisability and reliability at a national population level were key determinants of quality and in this review only the ABS surveys fulfilled these criteria.

The studies with highest validity at a State level were databases using provider-held records and calculating coverage from a prospective birth cohort, such as the VMCHN database,[7] the ACT vaccination database[6] and the NT database.[10,11] The NT database was also sensitive enough to give data on specific small populations such as remote Aboriginal communities.[112]

The second category of coverage studies was cross-sectional studies with appropriate sampling and high response rates that are likely to have high validity for the specific populations included. These included a cluster sample from metropolitan Melbourne,[116] a cluster sample from Newcastle, NSW[113] and a cross-sectional study of Hib vaccine coverage in Sydney.[61,122] A household study in central Sydney investigating coverage of measles and rubella used serology to validate parental report and while this provided optimum validation it was only generalisable to the local area.[53] All these surveys had positive features but generalisability of the findings was limited by the differences in vaccine delivery and uptake between regions in Australia.

The third category of coverage surveys was retrospective birth cohorts, which shared the problem of low response rates and selection bias. Response rates in Sydney,[110] Western Australia[51] and Queensland[109] were 49%-58%. It is likely that respondents have higher immunisation coverage than non-respondents and that this study design will overestimate coverage.

The ABS immunisation survey remains the reference standard in this review for generalisability and reliability. This is followed by State immunisation databases and then a small number of coverage surveys. However, all these designs exhibit different biases and comparisons are difficult. A national, prospective birth cohort design in which data is complete is clearly the ideal method, complemented by ad hoc coverage surveys to assess coverage in small populations with special needs such as urban Aboriginal communities.

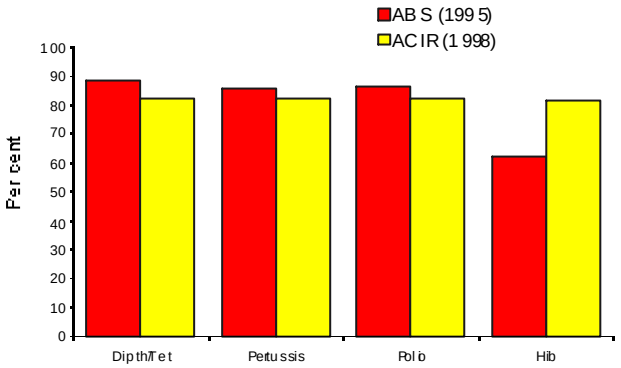
Comparison of data from the ACIR with the ABS

Table 12 compares the proportion of children fully immunised with DTP, OPV and Hib in each State and Territory using the ABS 1995 survey and the ACIR coverage estimates.[18] The estimates for DTP and OPV from the ABS are much higher than those for the ACIR for all States/Territories with the exception of Queensland, probably reflecting the more complete data available from the VIVAS reporting system which is linked to the vaccine supply.

It is important to note that ABS estimates for full immunisation at 1 year were derived from a cross-sectional sample at 12-23 months of age whereas the ACIR reports the status of a birth cohort at 12 months of age. This means that children who received the third dose of a vaccine scheduled in the first year of life after 12 months of age are deemed immunised by the ABS but not by the ACIR, which may slightly increase the ABS estimates.

As expected, Hib coverage is lower in the ABS estimates than in those from the ACIR because the ABS survey was conducted soon after the introduction of Hib vaccine, while ACIR data refer to a 1996 birth cohort (Figure 1). The comparison shows how rapidly uptake of Hib vaccine occurred, with an average increase of 17% for all of Australia. The only region with similar Hib vaccine estimates in both the ACIR and the1995 ABS survey is the NT, where the two dose primary course and widespread publicity may have promoted early Hib uptake.

Figure 1. Immunisation coverage for one year olds: ABS 1995 and ACIR 1998



Overall, ACIR estimates should be viewed as preliminary minimum estimates consistent with the estimates from the ABS survey. Coverage as measured by the ACIR is likely to improve dramatically with the introduction of a range of incentives for parents and providers to immunise and to report to the ACIR.

Comparisons with overseas studies

Immunisation coverage estimates overseas in comparable industrialised countries such as the UK and the USA are higher than in Australia. Estimates for five other English speaking countries are shown in Table 13. The vaccination coverage statistics for children at 12 months of age in the UK for three doses of DTP, OPV and Hib are between 91.7% and 92.8%, compared with estimates from the ABS 1995 survey of 83%-86% for DTP and OPV (Figure 2).[126]

Coverage for children aged 2 years in the UK is higher than at 12 months, contrasting with the situation in Australia in which a reduction in coverage occurs after 12 months of age. However, the UK immunisation schedule does not include a fourth dose of DTP or Hib at 18 months, in contrast to Australia. In the UK, regional databases submit immunisation data to a centralised register from which quarterly reports are prepared. This system commenced in 1987 and uses the birth cohort method to analyse data, which is similar to the ACIR. It also incorporates a financial incentives scheme for GPs to encourage high immunisation levels and the British national target now exceeds 90% coverage for each antigen.[127]

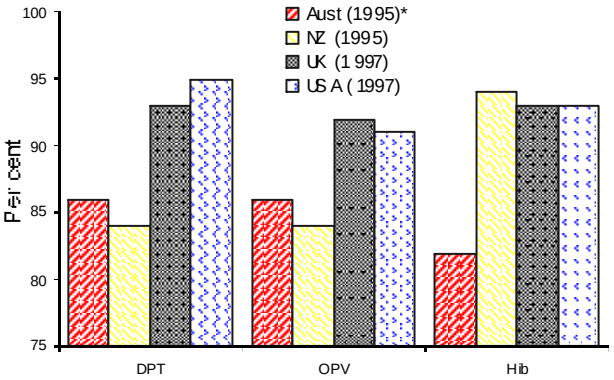
In the USA, the National Immunisation Survey (NIS)[128] was initiated in 1994 as the main method to estimate coverage for children aged 19-35 months. In this quarterly random telephone survey, response rates are around 67% and providers are also contacted for verification of immunisation status. The 12 month estimate for the period January to December 1997 was 95% for three doses of DTP or CDT, 91% for OPV and 93% for Hib and 91% for a measles-containing vaccine (MCV).[128] The equivalent proportions for the 1995 ABS survey are comparable for measles but much lower for DTP (at only 63% for diphtheria /tetanus and 58% for pertussis) and also for OPV (87%). Estimates of full immunisation at around 24 months of age show that 78% of children in the USA were fully immunised in comparison to 51.3% of children in Australia.[128]

Prior to the implementation of the NIS, coverage was measured by ad hoc surveys and it was found that while most children (87%) were fully immunised at school entry because of legislation requiring compulsory immunisation, the proportions for children aged 2 years old were much lower at 44%.[129] Coverage for very young children in the USA has therefore increased substantially since 1994.

The Canadian experience mirrors that of the USA in that immunisation estimates were not collected in a standardised manner until 1994, when a system which collects data by mailed questionnaire for four cohorts of children turning 2 years of age during 1994-96 was implemented.[130] Coverage for this period ranged from 85%-87% for four doses of DTP, and was 90% for polio. Coverage for MMR was high at 97% and has remained fairly constant while the lower rates for Hib vaccine reflect its introduction during the period of data collection. Vaccine specific estimates increased by 1% -3% above baseline in the period from 1994 to 1996.[130]

New Zealand immunisation estimates were obtained by coverage surveys and by health benefit claim data. Immunisation estimates in the 1990s show a progressive increase in coverage from a relatively low level. For example, a cohort study of children born in 1990-1991 found a complete immunisation rate of 75% by 6 months of age[131] while a more recent cohort study in Christchurch in 1995 estimated that 93% of children had been fully immunised by 8 months of age.[133] Health Benefit data from 1994 are shown in Table 13, with an estimated a range of 79%-87% for most vaccinations for children aged

Figure 2. Immunisation coverage at age one year: international comparisons



12-18 months.[133] Recent New Zealand coverage data for the same age group indicates that coverage levels of DTP/Hib in 1997 dropped slightly to 87.3% after an overall increase to 90.6% in 1996.[134] This may be due to changes in processing claims rather than a real decrease. Coverage for Maori and Pacific Islander children was lower in northern New Zealand than for all other children, reflecting a similar pattern similar to Aboriginal children in Australia.[58,114,135]

While there is some variation with the immunisation schedules in some overseas countries, the available data suggest that the UK, USA and Canada out-perform both Australia and New Zealand particularly for immunisation with pertussis containing vaccines. The differentials are especially large when comparing coverage for the fourth dose of DTP, with estimates in Australia falling well behind those of the other countries in Table 13. The UK appears to have the highest coverage levels of all the countries surveyed, with estimates of between 90%-95% for all antigens shown in this table. While the Australian data are not as recent as all the other estimates in Table 13, they remain the only population-based estimate available for comparison, while the ACIR is still in the developmental stage.

Coverage levels in most other countries in the world are reported on the WHO Internet site.[136] These data are obtained from routine national reports without details of methodology and are therefore difficult to compare with those outlined above.

Discussion

The best estimate of immunisation status in Australian children, or reference standard, in 1998 is the 1995 ABS survey. It is the only national coverage study that is generalisable to the whole population, despite concerns about reliance on unvalidated parental report for almost half of the responses. However, it is likely that the ACIR will take over this role when it becomes fully established.

The estimate for full immunisation in the ABS study for children aged 2 years (51%), even when Hib was excluded from the analysis, was substantially lower than those in other coverage studies in this review (range 60% to 88%). This appears to be due largely to lower reported levels of DTP rather than the levels of OPV and MMR. With the exception of serological surveys which tend to focus on assessing coverage for single vaccines in specific populations, the ABS was also the best estimate of coverage for specific vaccines and 'milestones'.

When estimates from the ABS 1995 survey were compared with the first 'milestone' data from the ACIR (Table 12), the ABS estimates were higher than the ACIR for most vaccines and some statewide differences did emerge in this comparison. However, any meaningful interpretation is complicated by technical difficulties with the ACIR resulting in underestimates of coverage at present. This may improve with the introduction of financial incentives to GPs based on their performance as recorded by the ACIR, from July 1998. The exception was the difference between the low levels of Hib in the ABS 1995 survey (during the phasing-in of the vaccine) and the higher estimates of the ACIR. This comparison is useful as it shows how quickly the uptake of Hib has occurred in younger Australian children.

This review included both published and unpublished literature, reducing the possibility of publication bias resulting in an overly optimistic view of immunisation coverage. The extent to which the large variation in coverage estimates was attributable to methodological problems in study design and analysis was often impossible to assess, as very few publications provided adequate data. It was difficult to determine whether the net effect of a particular study had been to underestimate or overestimate vaccine coverage.

The higher quality studies were larger and population based. Retrospective cohorts suffered from low response rates and selection bias, leading to an overestimate in coverage. Cross-sectional studies, although largely free of bias, provided only a snapshot at one point in time and could not monitor trends. Most of the immunisation databases cited in the review were derived from prospective birth cohorts, as was the ACIR and the well established COVER database in the UK. This method is clearly the best design if reporting is complete, and provided there has been adequate time for the operation of the database to become established.

Serological surveys, while the most accurate method for validating coverage, have sample sizes that are necessarily limited and therefore differences between population subgroups cannot be examined. At the whole population level, serological surveys have been shown to be very useful in demonstrating trends in susceptibility to vaccine preventable diseases, as in the UK.[136] The first population-based serological surveys using opportunistically collected sera are currently underway in Australia sponsored by the National Centre for Disease Control and conducted by the NCIRS. These surveys will be repeated on a two or three-yearly basis.

In contrast, parental recall is the simplest means of estimating immunisation status, but frequently overestimates coverage. The PHR is more accurate than parental recall, but is dependant on the quality of the information added to the record and the book being kept up-to-date. Well maintained provider-held records overcome these problems but must be adequately linked for children who have multiple providers and/or high mobility. Providers are the source of data for the State/Territory immunisation databases in this review, for the ACIR and for coverage in the UK[126] and the USA.[128]

As methodology strongly influences the final estimates, this review supports the need for a nationally consistent methodology, facilitating comparisons between regions. A national, prospective birth cohort design in which data are complete is clearly the ideal method, complemented by ad hoc surveys to assess coverage in small and specific populations, for example urban Aboriginal communities.

Immunisation coverage in developed countries overseas, particularly the UK, is reportedly higher than in Australia (over 90% for all antigens at 24 months). Both the USA and Canada collect national data regularly using national surveys. The USA has recorded increased uptake in infants and very young children since the implementation of their quarterly surveys. The UK has a well established centralised immunisation database which reports coverage data on a quarterly basis. The use of 1995 data from Australia, however, meant that it was not as up to date as the other overseas estimates. A fundamental requirement

in comparing such estimates is the need for timely, accurate Australian data which should be achievable through the ACIR.

Failure to develop a regular system of measuring immunisation coverage which is high quality and generalisable at a national population level will result in continued confusion about the true levels and trends of coverage in Australia. It is only by having a sensitive and timely system that interventions to improve and maintain coverage can be assessed and gaps identified. Only when true coverage rates regularly exceed 90% can we hope to achieve and maintain the levels of herd immunity needed to interrupt transmission of vaccine preventable diseases in Australia. We will then be able to eliminate diseases such as measles and take a responsible role in the world-wide eradication efforts planned by the World Health Organization.

Tables

Table 1. Immunisation coverage : Population-based studies (national and regional) with high response rates

Study	Location	Design	Final sample size and age	Response rate* (%)	Strategy and date	Validation
ABS (1989) [6]	Australia (national)	Cross-sectional population survey	Multistage, random sample of 12,732 children aged 0-14 years	96%	Household interviews with data for children 0-14 years collected by parental report	Parent Held Record (PHR) consulted in 45% cases
ABS (1995) [5]	Australia (national)	Cross-sectional population survey	14,591 children aged 0-14 years (6,768 aged 0-6 years)	>95%	Household interviews. Parental report	PHR consulted in 61% cases
Australian Childhood Immunisation Register (ACIR)[18]	Australia (national)	Birth cohort, Immunisation Register	All Australian children aged 0-6 years (birth cohort 259,167 children in 1996)	>76% NSW >86%Victoria	Providers submit immunisation data to national database	Provider held records used
Victorian Maternal and Child Health database [7]	Victoria (statewide)	Birth cohort using MCH records	All children age 0-6 years attending maternal & child health clinics (birth cohort 62,857 children in 1996)	90% of all births, decreasing with increased age	MCH nurses collect data and this is collated annually	Use verified records
Carnie J et al 1995 [116]	Three areas of metropolitan Melbourne	Cross-sectional population survey	Cluster sample (WHO method) of 630 children aged 18 months to 3 years	N/A	Household interviews in 1991. Parental report	PHR or provider held records used
Thorman et al (1997) [11]	Northern Territory (NT) (statewide)	Birth cohort, Immunisation Register	All children born after January 1996 (part of ACIR) (birth cohort 35,000 in 1996)	87%	Providers submit immunisation data to NT database	Provider held records used
Mitchell et al (1997) [10]	Darwin urban area	Birth cohort, Immunisation Register	All children immunised in Darwin urban area (approx birth cohort 2,500 in 1995)	91%	Providers submit immunisation data to database	Provider held records used
Skinner et al (1995) [110]	Northern Sydney Health region	Birth cohort (retrospective)	1,004 children aged 2 years from a 3 month birth cohort	58%	Parent questionnaire (sent by mail) in 1994	Providers contacted. 60% agreement with parents
Herceg et al (1995) [113]	Newcastle, NSW	Cross-sectional population survey	Cluster sample of 187 children aged 2 years	97%	Household interviews in 1994. Parental report	PHR or provider held record

Table 1. Immunisation coverage : Population-based studies (national and regional) with high response rates, continued

Study	Location	Design	Final sample size and age	Response rate* (%)	Strategy and date	Validation
Sullivan et al (1998) [124]	NSW	Cross-sectional population survey	Multistage, random sample of 322 children aged 3-24 months	100%	Household interviews undertaken in 1992	PHR only (produced in 84% of cases)
Bond et al (1998) [17]	NW Melbourne Victoria	Randomised controlled trial	405 children 9 months or 16 months	100%	Children on the ACIR who were late for their vaccinations were randomised with 2 arms to evaluate a home vaccination service	PHR and provider held records used
Parker et al (1996) [8]	Darling Downs, SW Queensland	Birth cohort, Immunisation Register	50,000 vaccination events for children born 1994 onwards	N/A	Vaccination rates calculated from vaccination events	Provider held records used
Guthridge et al (1993) [112]	NT (remote Aboriginal communities in 3 districts)	Birth cohort, Immunisation Register	461 Aboriginal children born in 1990, and aged between 12-24 months	90%	Data analysed on all vaccinations received by cohort until December 1992	Provider held records used
Young et al (1994) [114]	North Coast Health Region of NSW	Cross-sectional survey	1,094 Aboriginal children aged from 0-11 years	93% of study population	Review of provider held immunisation records from 10 areas in Region in 1991	Provider held records used
Hall et al (1994) [58]	Western NSW (4 rural health districts)	Cross-sectional survey	Cluster sample of 211 children (WHO method) aged 2-4 years	>98%	Survey by telephone and household interview using modified WHO method in 1993	PHR cited in most cases
McCall et al (1995) [109]	West Moreton, Queensland	Birth cohort (retrospective)	108 children aged 18 months	55%	Household interviews. Significant difference between respondents and non-respondents	Provider held records used
Hanna et al (1995) [118]	Queensland (10 Aboriginal and Torres Strait Islander communities)	Cross sectional serological survey (HBV, OPV, measles)	101 Aboriginal children median age 24.5 months (non-random)	N/A	Serosurvey of fully vaccinated children to assess immunity to HBV, OPV, measles	Provider held records and serosurvey
Kilmartin et al (1998) [111]	Southern Tasmania	Prospective birth cohort	242 mothers of infants born between June1994 and February 1995	75% at 1 week and 61% at 12 months	Mothers completed questionnaires by interview (1 week) and mail (12 months) post-partum	PHR used
Andrews et al (1995) [30] Part 1 of study, see Table 4	Victoria (Upper Yarra)	Retrospective review of immunisation records	845 children aged 2-4 years	N/A	Review of immunisation records from Shire of Upper Yarra's Shire database in 1995	Provider held records used

* Response rate shows % of original sample in the final sample

Table 2. Immunisation coverage: Studies (population and settings based) with less than 50% response rates

Study	Location	Design	Final sample size and age	Response rate* (%)	Strategy and date	Validation
Edwards BM et al (1995)[51]	Western Australia (WA) (statewide)	Birth cohort (retrospective)	487 children born in April 1993 (and aged 2 years at time of survey)	49%	Questionnaire mailed to mothers across WA, randomly selected from midwives database	96.5% mothers referred to PHR (not validated by researchers)
Conaty et al (1996) [57]	Western Sydney, NSW	Cross-sectional telephone survey	483 children aged 2 years	36%	Telephone household survey conducted in 1995 in Western Sydney and Wentworth Health Areas	86% respondents cited PHR
Ferson MJ et al (1995)[74]	NSW (Eastern Sydney)	Randomised controlled trial of primary school intervention	103 in final sample (249 randomised) from kindergarten in 1991	43% of randomised children	Kindergarten children screened and non-fully immunised children randomised into 2 intervention arms	Screening cards completed by school nurses
Miles et al (1996) [102]	Hunter Health Area, NSW	Cross-sectional survey	69 children aged 2 years attending formal child-care	29%	Review of immunisation records held by child-care services in 1995	Provider held record used

* Response rate shows % of original sample in the final sample

Table 3. Immunisation Coverage: Population-based studies (national and regional) single vaccine studies

Study	Location	Design	Sample size and age	Response rate* (%)	Strategy and date	Validation
Causer et al (1998) [54]	Central and Southern Sydney, NSW	Cross-sectional serological survey (measles & rubella only)	580 children aged 18 months to 5 years	75% approx.	Household interviews and venous blood samples	PHR and serosurvey
McIntyre et al (1995)[122]	Sydney Statistical Division	Cross-sectional population survey (Hib only)	549 children aged 0-4 years from 412 households	82%	Random telephone sample to households in August 1993	50% sub-sample had records verified from providers
McIntyre et al (1994) [61]	Sydney Statistical Division	Cross-sectional population survey (Hib only)	551 children aged 0-4 years from 394 households	74%	Random telephone sample to households in August 1994 (repeat of 1993 survey)	50% sub-sample had records verified from providers
O'Brien et al (1997) [6]	ACT (statewide)	Birth cohort using immunisation register (Hib only)	9,790 children aged either 9 or 24 months	N/A	Providers submitted immunisation data to ACT central database	Provider held records used
Oman et al (1997) [119]	Victoria (statewide)	Birth cohort using MCH records (Hepatitis B only)	3,611 children at risk of HBV aged 12-24 months	63% of infants at increased risk of HBV	MCH nurses collected data on 'targeted' infants born between July 1992 - June 1993	Provider held records used
Ferson et al (1998) [121]	NSW	Population-based serosurvey using data from National Survey of Lead in Children	347 children aged 1-4 years in 1995 who provided adequate blood sample for two assays	50% provided adequate blood sample	Blood samples collected from National Lead survey were tested for measles and compared with parental report and PHRs	Serosurvey

* Response rate shows % of original sample in the final sample

Table 4. Immunisation coverage in child-care settings

Study	Location	Design	Final sample size and age	Response rate* (%)	Strategy	Validation
Hanna et al (1994) [97]	Northern Queensland (Cairns area)	Cross-sectional survey	Cluster sample of 613 children aged 0-5 years attending formal child-care	94%	Review of immunisation status using PHR and provider held records	PHR and provider held records used
Lloyd et al (1996) [99]	Illawarra region, NSW	Cross-sectional survey	1,109 children aged 0-2 years attending 80 child-care centres	94% of child-care centres	Review of immunisation records held at child-care centres in 1995	Provider held records used
Menzies et al (1996) [101]	NSW (statewide)	SSISS Immunisation register‡	745 children aged 2 years attending child-care centres	N/A	Review of sample of records in SSISS register in 1995	Provider held records used
Chow et al (1995) [55]	Western Sydney, NSW	Cross-sectional survey	1,092 children aged 2-3 years attending 95 long day care centres	83% of child-care centres	Review of immunisation records held by centres in Western Sydney and Wentworth Health Areas	Provider held records used
Mitchell et al (1997) [106]	NT (Territory-wide)	Cross-sectional survey	269 children aged 2 years in 39 child-care centres	66% of children from 87% of centres	Review of immunisation records held at child-care centres in 1995	Provider held records used
Andrews et al (1995) [48] Part 2 of study (see Table 1)	Victoria (Upper Yarra)	Cross-sectional survey	250 children randomly selected from 700 Family Day Care and pre-school records in 1995 (2-4 years old)	75%	Parent questionnaire (mailed)	Immunisation Register used to validate responses

* Response rate shows % of original sample in the final sample

‡ Statewide Sentinel Immunisation Surveillance System

Table 5. Immunisation coverage in schools

Study	Location	Design	Final sample size and age	Response rate* (%)	Strategy	Validation
Watt et al (1996)[96]	NSW Central Coast	Cross-sectional survey (school entry)	3,741 children from 68 schools, enrolled in kindergarten in 1994	97% of total kindergarten enrolments	Review of immunisation certificates in all North Coast schools including non-government schools	School entry certificates used (90% completed)
Kelly et al (1993)[126]	WA (Midwest & Gasgoyne regions)	Cross-sectional survey (school entry)	1,008 children from 49 schools, enrolled in Grade 1 in 1992	N/A	Review of immunisation status by school nurse using a range of documentation and maternal report	86.7% of children had 'adequate' documentation
Kelly et al (1994)[81]	WA (Great Southern Region)	Cross-sectional survey (school entry)	1,220 children enrolled in Grade 1 in 1994	N/A	Review of immunisation status by school nurse using documentation and maternal report	84% had immunisation cards or school records
Gilchrist et al (1993)[76]	NSW (South West Health Area)	Cross-sectional survey (school entry)	3,666 kindergarten children attending schools in 1992	86%	Questionnaire mailed to parents by school nurses	Most parents consulted PHR - not validated by researchers

Table 5. Immunisation coverage in schools, continued

Study	Location	Design	Final sample size and age	Response rate* (%)	Strategy	Validation
Bell et al (1993) [69]	NSW (western Sydney)	Cross-sectional survey in primary schools	966 kindergarten children in 1992	91% sample	Questionnaire mailed to parents, including non-government schools	No - parental report only
Kempe et al (1995) [82]	ACT (Territory-wide)	Cross-sectional survey (school entry)	Random sample of 350 immunisation records from 3,398 kindergarten records	85% parents returned child's record to school (N= 3,398)	Review of a sample of school immunisation records for kindergarten children in 1994	Providers authorised the records
Leckie et al (1996) [83]	NSW (Auburn LGA)	Cross-sectional survey (school entry)	737 kindergarten children in all primary schools in 1994	100%	Review of all school immunisation records by school nurses	Most had provider authorised records
Watson (1997) [95]	WA (Swan Health Service)	Cross-sectional survey (school entry)	405 kindergarten children from 9 primary schools	100%	Review of all school immunisation records by school nurses and follow-up as required	Provider authorised records used
Duffield (1997) [50]	WA (Southern Region)	Cross-sectional survey (school entry)	2,203 kindergarten children from 158 schools in 1995-6	55%	Review of immunisation records by school nurses with follow-up if no record produced at enrolment	Provider authorised records only used

Table 6. Immunisation coverage: Outbreak studies

Study	Location	Design	Final sample size and age	Response rate* (%)	Strategy	Validation
Herceg et al (1994) [79]	ACT (one primary school)	Cross-sectional survey (outbreak investigation for measles)	384 children attending a primary school aged 4-12 years	78%	Questionnaire mailed to parents and cases identified in 1993	Parents asked to consult PHR
Miles et al (1992) [88]	Port Stevens Shire, NSW	Cross-sectional survey (outbreak investigation for measles)	158 cases including 116 school pupils (average age 7 years, 7 months) 73% school children	N/A	Data was collected on all cases in a measles outbreak by active surveillance and contact tracing in 1990	Record of clinical or serological diagnosis
Donnelly et al (1994) [72]	Bunbury, WA	Cross-sectional survey (outbreak investigation for measles)	53 cases from high and primary schools	N/A	All cases notified received a telephone questionnaire and contacts were identified	Serological confirmation in 40% of cases
Lush et al (1994) [84]	Alice Springs, NT	Review of measles notifications (outbreak investigation for measles)	258 cases notified aged from <1 year to over 30 years (55% Aboriginal)	N/A	Review of notifications and hospital records of measles cases	Serosurvey and clinical diagnosis
McDonnell et al (1995) [85]	NSW (Western Sydney)	Matched case-control study (measles vaccine)	79 children aged 5-9 years in 5 primary schools in 1993	91% response from initial screening survey	Screening for measles by parent questionnaire (mailed). Cases and controls selected, parents interviewed at home	PHR / provider held records used

* Response rate shows % of original sample in the final sample

Table 7. Immunisation coverage in other settings

Study	Location	Design	Final sample size and age	Response rates*	Strategy	Validation
Burgess et al (1996) [65]	NSW (Central Sydney)	Cross-sectional survey in Early Childhood Centres (ECCs), GP surgeries and hospital A&E	5,162 children age 0-15 years during an 8 week period in 1993	N/A	Questionnaire completed by all parents prior to their child receiving service (ECC, GP or A&E). 'On the Spot' vaccination given if required	Provider records used where possible (or parental recall)
Jones et al (1992) [67]	NSW (Camperdown, Sydney)	Cross-sectional survey (hospital based)	All children (N=520) attending casualty over a 10 day period in 1989	100%	Parents of all children attending a paediatric casualty dept. were interviewed	PHR and provider held records where possible
Thompson et al (1998)[68]	Melbourne Juvenile Justice Centre (MJJC)	Cross-sectional serological survey	90 adolescents participated and 85 agreed to venipuncture	69% participated	Questionnaire completed and blood sample taken from trainees at the MJJC	Serosurvey
Hawe et al (1991) [23]	NSW (Western Sydney)	Cross-sectional serological survey (measles only)	128 children in final sample in 1986-87	80%	Parents were approached in four 24 hour medical centres waiting rooms and interviewed. Blood sample also taken	Serosurvey
Ewald et al (1998) [66]	Alice Springs, NT	Cross-sectional study of PHRs in three General Practices	146 children aged 0-6 years attending GPs in Alice Springs in 1997	100%	Parent interviews at the GP surgeries. PHRs viewed and results checked against ACIR database	PHRs, providers records and ACIR

* Response rate shows % of original sample in the final sample

Table 8. Summary of immunisation status for children aged 12-23 months (using studies dated from 1995)

Study State	Age	DTP (3 doses) (%)	OPV (%)	MMR (%)	Hib (%)	Fully immunised (%)
ABS (1995) (Australia) [5]	12-23 months	88.5% (D/T) 86.2% (P)	86.3%	86.8% measles 86.0% mumps 81.4% rubella	62.3%	51.4% (incl. Hib) 70.8% (exc. Hib)
Bond et al (1998) (Vic) [17]	9-16 months	N/A	N/A	N/A	N/A	9 months: 93.1% (includes Hib) 16 months: 92%
Victorian Maternal & Child Health nurses (1995-6) (Vic) [7]	1-2 years	85.2%	85.4%	77%	N/A	N/A
Thorman et al (1997) (NT) [11]	12-14 months	89%	87%	91%	79%	75%
Parker et al (1995) (Qld) [8]	12-18months	85-86% (DTP/OPV/Hib)		81%	N/A	N/A
Kilmartin et al (1998) (Tas) [111]	12 months (54 weeks)	N/A	N/A	N/A	N/A	94%
Skinner et al (1995) (NSW)[110]	12 months	N/A	N/A	N/A	N/A	21% (on time)

Table 9. Summary of immunisation status for children aged 2 years (using studies dated from 1994)

Study State	Age range	DTP (%)	OPV (%)	MMR (%)	Hib (%)	Fully immunised (%)
ABS (1995) (Australia) [5]	24-35 months	63% (D/T) 57.5% (P)	86.9%	91.5% measles 90.1% mumps 81.1% rubella	52%	34.3% (inc. Hib) 51.3% (exc. Hib)
Skinner et al (1995) (NSW) [110]	21-24 months	N/A	N/A	N/A	N/A	86% (exc. Hib)
Herceg et al (1995) (NSW) [113]	24-35 months	80.9%	95.5%	93%	59.2%	51.1% (inc. Hib) 77% (exc. Hib)
Lloyd et al (1996) (NSW) [99]	24-35 months	69.9%	79.8%	86.5%	N/A	63.8% (exc. Hib)
Hall et al (1994) (NSW) [58]	2-4 years	84%	89.6%	90.6%	N/A	80.2% (exc. Hib)
Sullivan et al (1998) (NSW) [124]	3-24 months	N/A	N/A	N/A	N/A	66% (exc. Hib)
Hanna et al (1994) (QLD) [97]	24-35 months	63.8%	82.4%	81.9%	N/A	60.3% (exc. Hib)
Victorian Maternal and Child Health Nurses (1996-7) (VIC) [7]	24-35 months	85.3%	86.7%	76%	85.2%	N/A
Carnie et al (1995) (VIC) [116]	18-36 months	93.1% (DTP/ OPV)		89.9%	N/A	87.8% (exc. Hib)
Mitchell et al 1996 NT child-care services (NT) [106]	24-35 months	77%	73%	92%	76-81%	66.5% (inc. Hib)
Mitchell et al 1996 Urban Darwin area (NT) [10]	24-35 months	60%	60%	76%	50%	N/A

Table 10. Summary of immunisation status for children at school entry, aged 4-6 years, using selected studies from the review

Study State	Location	Age	Fully immunised (%)*†
ABS (1995) (Australia) [5]	National	6 years	21.5%
Bell et al (1993) (NSW) [69]	NSW (Western Sydney)	4-6 years	89%
Watt et al (1996) (NSW) [96]	NSW (Central Coast)	5 years	79%
Roden et al (1992) (NSW) [90]	NSW (Western Sydney)	5 years	84%
Kempe (1995) (ACT) [82]	ACT	4-5 years	67%
Kelly et al (1994) (WA) [81]	Western Australia	4-6 years	80%
Watson et al 1997 (WA) [95]	Western Australia	4-5 years	80%

* These children were not be eligible for Hib

† 5th dose PT only came in early 1994 and would exclude many of these children

Table 11. Regional studies by vaccine: Population studies only

Study and date	Age coverage estimated	DTP (%)	OPV (%)	MMR (%)	Hib (%)	Fully immunised (%)
New South Wales						
NSW [5]	24-35 months	63% (D/T) 59.7% (P)	85.9%	89.2% measles 86.9% mumps 76.3% rubella	48.7%	33.6% inc. Hib 54.2% exc. Hib
Newcastle [113]	24-35 months	80.9%	95.5%	93%	59.2%	51.1% inc. Hib 77% exc. Hib
Northern Sydney [110]	21-24 months	N/A	N/A	N/A	N/A	86% exc. Hib
Western NSW [58]	2-4 years	84%	89.6%	90.6%	N/A	80.2% exc. Hib
Central Sydney [54]	18-60 months	N/A	N/A	88.8% measles 91.9% rubella	N/A	N/A
Victoria						
Victoria [5]	24-35 months	58.4% (D/T) 52.4% (P)	88.2%	92.5% measles 92.0% mumps 85.2% rubella	55.6%	34.4% inc. Hib 47.6% exc. Hib
Victoria [7]	24-35 months	85.3% (DTP)	86.7%	76.0%	85.2%	N/A
Melbourne [116]	18-36 months	93.1% (DTP/OPV)	see rate for DTP	89.9%	N/A	87.8%
Queensland						
Queensland [5]	24-35 months	58.2% (D/T) 59.5% (P)	86.9%	93.2% measles 92.4% mumps 79.0% rubella	53.6%	33.1% inc. Hib 50.4% exc. Hib
West Moreton [109]	18 months	95% (12 months)	N/A	N/A	N/A	74% inc. Hib 85% exc. Hib
Darling Downs [8]	12-18 months	85-96% (DTP/OPV/Hib)	see DTP	81%	See DTP	N/A
Australian Capital Territory						
ACT [5]	24-35 months	62.2% (D/T) 60.0% (P)	84.4%	93.3% measles 93.3% mumps 93.3% rubella	55.6%	42.2% inc. Hib 57.8% exc. Hib
ACT [13]	9 and 24 months	N/A	N/A	N/A	(9m) 68% (24m) 34%	N/A N/A
Western Australia						
WA [5]	24-35 months	70.4% (D/T) 66.0% (P)	90.3%	91.5% measles 91.1% mumps 91.8% rubella	58.3%	42.5% inc. Hib 58.3% exc. Hib
Northern Territory						
NT [5]	24-35 months	65.4% (D/T) 65.4% (P)	61.5%	99.9% measles 99.9% mumps 99.9% rubella	46.2%	38.5% inc. Hib 53.8% exc. Hib
NT [11]	12-14 months	89%	87%	91%	79%	75% inc Hib
Darwin [10]	24-35 months	60%	60%	76%	50%	N/A
Remote NT [112]	12-24 months	91 (4th dose)	91% (4th dose)	97%	N/A	N/A

Table 11. Regional studies by vaccine: Population studies only, continued

Study and date	Age coverage estimated	DTP (%)	OPV (%)	MMR (%)	Hib (%)	Fully immunised (%)
South Australia						
SA[5]	24-35 months	57.9% (D/T) 50.8% (P)	89.3%	91.9% measles 90.9% mumps 97.8% rubella	52.8%	31.0% inc. Hib 47.2% exc. Hib
Tasmania						
Tasmania[5]	24-36 months	52.2% (D/T) 47.8% (P)	77.6%	89.6% measles 86.6% mumps 79.1% rubella	40.3%	23.9% inc. Hib 37.3% exc. Hib
Southern Tasmania[111]	12 months	N/A	N/A	N/A	N/A	94% inc. Hib

Table 12. Percentage of children fully immunised with Diphtheria, Tetanus, Pertussis (DTP), Oral Polio (OPV) and *Haemophilus influenzae* type b (Hib) vaccines by State and Territory assessed at 12 months of age ‡

	Vaccine						Fully Immunised		
	DTP (%)		OPV (%)		HIB (%)		(%)		
State	ACIR*	ABS†	ACIR*	ABS†	ACIR*	ABS†	ACIR*	ABS§	ABS**
New South Wales	78%	87%	78%	88%	78%	63%	76%	54%	74%
Victoria	83%	90%	83%	88%	83%	66%	82%	54%	77%
Queensland	84%	79%	85%	83%	85%	52%	83%	41%	62%
South Australia	81%	86%	81%	85%	81%	57%	79%	45%	69%
Western Australia	77%	87%	77%	84%	77%	71%	75%	50%	69%
Tasmania	83%	87%	83%	91%	83%	63%	82%	44%	62%
Australian Capital Territory	86%	87%	85%	87%	82%	69%	82%	57%	71%
Northern Territory	67%	85%	67%	70%	71%	70%	62%	59%	63%
AUSTRALIA‡	81%	83%-86%	81%	83%-86%	81%	55%-62%	79%	51%	71%

‡ Totals from ABS 1995 range from children aged 7-12 months to children 12-23 months

* ACIR: Assessment date 31/12/97 for cohort of children born between 1/7/96-30/9/96

† Australian Bureau of Statistics: Children's Immunisation Survey, April 1995. Data for children aged 12-23 months.

§ 1994 schedule including Hib

** 1994 schedule excluding Hib

Table 13. Comparison of ABS immunisation coverage data with overseas studies

Study	Age	DTP (%)*	OPV (%)*	MMR (%) (1 dose)	Hib 3 (3 doses)	Fully immunised (%) (exc. Hib)
ABS (1995)[5]	12-23 months	85.5% (D/T) 86.2% (P)	86.3%	86.8% measles 86.0% mumps 81.4% rubella	62.3%	51.4% inc. Hib 70.8% exc. Hib
	24-35 months	63% (D/T) 57.5% (P)	86.9%	91.5% measles 90.1% mumps 81.1% rubella	52%	34.3% inc. Hib 51.3% exc. Hib
UK (1998) [126] (1997 data)	12 months	92.8%	91.7%	N/A	92.6%	
	24 months	95.8%	94.3%	90.5%	95.5%	N/A
USA (1998)[127] (1997 data)	19 months	95%	91%	91%†	93%	N/A
	35 months	81% (4 doses)	91%	91%		76% (4DTP/3 OPV/ 1MCV/3Hib)
New Zealand (1995)[133] (1994 data)	12 months- 18 months	84.1%	84.4%	86.6%	94.1% (Monovalent Hib)	N/A
Canada (1996)[130] (1994-96 data)	2 years	87.1% (D) (4 doses) 84.8% (T) (4 doses) 85.9% (P) (4 doses)	89.9% (3-4 doses)	97.0%	69.3%	N/A

*3 doses unless stated

† Measles containing vaccine

Appendix

Appendix 1. Australian Standard Vaccination Schedule, August 1994

Age	Disease	Vaccine
2 months	Diphtheria, tetanus, pertussis, poliomyelitis, Hib	DTPw* OPV-Sabin vaccine, Hib vaccine (HbOC or PRP-OMP)**
4 months	Diphtheria, tetanus, pertussis, poliomyelitis, Hib	DTPw* OPV-Sabin Vaccine, Hib vaccine (HbOC or PRP-OMP)**
6 months	Diphtheria, tetanus, pertussis, poliomyelitis, Hib (HbOC schedule only)	DTPw* OPV-Sabin Vaccine, Hib vaccine (HbOC)
12 months	Measles, mumps, rubella, Hib (PRP-OMP schedule only)	MMR, Hib vaccine (PRP-OMP)
18 months	Diphtheria, tetanus, pertussis, Hib (HbOC schedule only)	DTPw, Hib vaccine (HbOC)
Prior to school entry: 4-5 years	Diphtheria, tetanus, pertussis, poliomyelitis	DTPw, OPV-Sabin vaccine
10-16 years	Measles, mumps, rubella	MMR
Prior to leaving school:15-19 years	Diphtheria, tetanus, poliomyelitis	Td (ADT)*** OPV-Sabin Vaccine

* DTPw is the abbreviation for Diphtheria-Tetanus-Pertussis vaccine (whole cell).

** Abbreviations for Hib vaccines - HbOC is 'HibTITER'; PRP-OMP is 'PedvaxHIB'. HbOC is given at 2, 4, 6 and 18 months. PRP-OMP is given at 2, 4 and 12 months.

*** Td is combined Diphtheria-Tetanus vaccine. The DT formulation for children is often referred to by the trade name 'CDT'. The Td formulation for adults is often referred to by the trade name 'ADT'.

Appendix 2. Changes to Australian Standard Vaccination Schedule between 1989 and 1994*

The following changes have been made to the schedule since the ABS last collected information on immunisation status in the 1989-90 NHS (which used the 1986 version of the schedule):

- The introduction of a DTP vaccination to replace the CDT vaccination at 5 years or prior to school entry
- Introduction of vaccination against Hib, not previously included in the schedule. This vaccine was recommended for inclusion in 1993. For the purpose of measuring uptake of the vaccine and its effect on the overall immunisation status of the child, the Hib vaccine was excluded in the derivation of overall status against the previous schedule; and
- Introduction of a combined Measles, Mumps and Rubella vaccination at one year of age.

* Taken from ABS 1995 [5]

Appendix 3. Australian Standard Vaccination Schedule,[111] November 1996

Age	Disease	Vaccine	Milestones
2 months	Diphtheria, tetanus, pertussis poliomyelitis Hib	DTPw* OPV-Sabin vaccine Hib vaccine (HbOC or PRP-OMP)**	
4 months	Diphtheria, tetanus, pertussis poliomyelitis Hib	DTPw* OPV-Sabin Vaccine Hib vaccine (HbOC or PRP-OMP)**	
6 months	Diphtheria, tetanus, pertussis poliomyelitis Hib (HbOC schedule only)	DTPw* OPV-Sabin Vaccine Hib vaccine (HbOC)	First (6 months)
12 months	Measles, mumps, rubella Hib (PRP-OMP schedule only)	MMR Hib vaccine (PRP-OMP)	Second (12 months)
18 months	Diphtheria, tetanus, pertussis Hib (HbOC schedule only)	DTPa* or DTPw* Hib vaccine (HbOC)	Third (18 months)
Prior to school entry : 4-5 years	Diphtheria, tetanus, pertussis poliomyelitis	DTPa* or DTPw* OPV-Sabin vaccine	
10-16 years	Measles, mumps, rubella Hepatitis B (1st dose)	MMR HBV	
1 month later	Hepatitis B (2nd dose)	HBV	
6 months after 1st dose	Hepatitis B (3rd dose)	HBV	
Prior to leaving school:15-19 years	Diphtheria, tetanus poliomyelitis	Td (ADT)*** OPV-Sabin Vaccine	

* DTPw is the abbreviation for Diphtheria-Tetanus-Pertussis vaccine (whole cell); DTPa is the abbreviation for Diphtheria-Tetanus-Pertussis vaccine (acellular).

** Abbreviations for Hib Vaccines - HbOC is 'HibTITER'; PRP-OMP is 'PedvaxHIB'. HbOC is given at 2, 4, 6 and 18 months. PRP-OMP is given at 2, 4 and 12 months.

*** Td is combined Diphtheria-Tetanus vaccine. The DT formulation for children is often referred to by the trade name 'CDT'. The Td formulation for adults is often referred to by the trade name 'ADT'.
Hepatitis B schedule for adolescents - give the 1st dose at the same time as MMR (10-16 years), the 2nd dose about 1 month later, and the 3rd dose 6 months after the 1st dose.

Interim hepatitis B schedule for infants

The NHMRC has endorsed the use of hepatitis B vaccine (HBV) for all infants. HBV should be administered at birth, 1 month, and 6-12 months of age. Hepatitis B vaccine has not yet been included in the standard infant schedule because it is only available as an additional injection. Parents who express an interest in infant HBV should be encouraged to have their children vaccinated, as long as compliance with schedule vaccines is not jeopardised.

The NHMRC strongly recommends that HBV be offered to all infants born to HBsAg+ mothers and to all infants and young children from groups with hepatitis B carrier rates of over 2%.

Editorial Note:

This historical article describes the Australian Standard Vaccination Schedule in 1994 and 1996. The current schedule at May 1999 includes DTPa vaccine as an Alternative to DTPw for infants and has the second dose of measles, mumps and rubella vaccine at age 4-5 years (rather than at 10-16 years).

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Cryptosporidium in Water

Report of the consensus conference on Cryptosporidium in Water, Melbourne, October 1998

Robert Douglas [1] *and Martha Sinclair* [2]

Introduction

The *Cryptosporidium* in Water conference, held in Melbourne in October 1998, provided an overview of the current scientific knowledge on *Cryptosporidium* , and an opportunity to discuss the needs for future research, public health strategy, and risk assessment and management for water supplies.

More than 290 delegates from diverse backgrounds in water supply and management, parasitology, general microbiology, epidemiology and public health attended the conference.

The conference was divided into three themes, each with its own objective:

- Parasitology and genetic typing, to introduce genetic typing to assist in locating the source of the parasite;
- Epidemiology, to improve epidemiological surveillance, outbreak management and public health response; and
- Risk assessment and management, to understand and manage the health risks implied by *Cryptosporidium* monitoring results.

During the opening session, five speakers presented an overview of the latest *Cryptosporidium* research. The conference was then divided into the three parallel workshops for more specialised presentations on each of the themes. The conference closed with a plenary session in which the discussions on each theme were summarised by expert reporters, and questions were invited from the audience.

On the day following the general conference, small groups of experts continued discussions on each theme, with the aim of arriving at consensus positions on parasitology research needs, public health strategy and risk management principles. The deliberations and conclusions of the Epidemiology workshop group are summarised in the following Consensus Statement.

Consensus Statement: Epidemiology workshop group

Discussions led to the identification of a number of areas of research priority as well as the need to develop rational public health policies despite the current limitations in our understanding. The group agreed that the primary aims of public health in relation to *Cryptosporidium* in water supplies are to:

- control disease;
- only intervene when needed; and
- use public funds as efficiently as possible.

Research priorities

The research priorities agreed by the group highlighted the current inadequate understanding of the natural history of the disease in humans, the nature and role of the immune response and the determinants of disease.

It was agreed that in this current state of uncertainty, there is a need to invest in well-targeted research that:

- will help us to understand the natural history of the disease and its immunology;
- explores the factors which enhance transmission of the infection in humans and the risk factors which predispose to that infection; and
- explores the effect of prior serological experience on infection outcomes.

Phenotyping or genotyping of strains

It was agreed that considerable effort should go into developing methods for routine phenotyping or genotyping of strains isolated from humans and from water. Such techniques would represent a significant advance in epidemiology by allowing us to trace the origins of

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Conference Proceedings can be obtained from the CRC for Water Quality and Treatment, PMB 3, Salisbury, South Australia 5108. Fax: 08 8259 0228
Sponsored by the Cooperative Research Centre for Water Quality and Treatment, the Water Services Association of Australia, the Australian Water and Wastewater Association,with additional support from the Department of Human Services Victoria

individual strains, and determine the importance of drinking water relative to other routes of transmission.

Viability and pathogenicity

There is also a great need for improved tests to determine the viability and pathogenicity of oocysts isolated from the environment so that we can better assess the degree of health risk posed by oocysts detected in drinking water.

Methods of treatment

There is also a need for continuing efforts to develop effective methods of treatment of people with known infection. The availability of such treatment would markedly reduce the risks associated with infection in immunocompromised individuals, and would significantly change the public health perspective on this organism.

Community education

There is clearly a need for better community education to improve the understanding of the disease, and to permit the effective protection of the community without promoting panic. It is important that we make efforts to explain our current limited knowledge of these issues, and the difficulties in predicting health risks from water testing results. We must also endeavour to use scarce public health resources as efficiently as possible.

Protocol for surveillance

It is believed there is a need to develop a national best practice protocol for surveillance that is based on standard advice to laboratories regarding which stool specimens to examine, which methods to use, and the minimum notification data that should be passed on to public health agencies when the organism is identified. General practitioners around Australia should be advised by public health agencies on which cases to request stools for, and the most common risk factors, as they are currently understood, in this condition. At present there are considerable variations in testing practices and reporting procedures between different States and Territories which makes it difficult to establish a comprehensive picture. There is also a need for a validated system of multiplier values to relate the number of laboratory defined cases to the number of cases in the community.

Surveillance will only work effectively if improved partnerships are developed between public health units and water authorities, and if there are agreed triggers for enhanced surveillance. It is believed that increased water turbidity events and the presence of contamination with other pathogens may be appropriate triggers for enhanced surveillance for Cryptosporidial infection. Enhanced surveillance should include a systematic approach to elevated rates of diarrhoeal illness in nursing homes and other institutions, a follow-up of individual cases of cryptosporidosis, active contact with laboratories, and possible activation of other sentinel systems, including school absenteeism, general practice systems and oncology units. Geographic Information Systems mapping of such data may be useful as an adjunct to identify and track outbreaks. The National Communicable Diseases Network is seen as the appropriate forum to progress these improvements in surveillance mechanisms for *Cryptosporidium*.

Outbreak investigations

On the issue of investigation of suspected waterborne outbreaks, the group was not convinced that case control methodology is always the best approach to conducting investigations. A clear specification of the relevant investigative questions requires input from both public health as well as water authorities, and this may require brainstorming and application of cutting-edge technology. It is emphasised that while outbreaks of illness are undesirable, they nevertheless represent opportunities to improve our knowledge. The opportunity should be taken to store faecal and blood specimens, and it should be expected that each outbreak will help us further to understand the natural history of the disease. Finally, there is a need for national and international collaboration in outbreak investigations, including the standardisation of questionnaires used.

Monitoring *Cryptosporidium* in finished water

In the review of Sydney events, it became evident that the workshop group and others have been puzzled by the huge oocyst counts reported in finished water, with no detectable evidence of increased disease despite substantial enhancment of surveillance. It is noted that the availability of the technical capacity to detect *Cryptosporidium* in finished water makes it difficult for water authorities to avoid monitoring, but it is emphasised that the Sydney episode underlines our inability to interpret such findings. This is perhaps due to technology being ahead of medical science.

Multiple ‘boil water’ alerts can have hazardous results both in terms of injury risks to the community, loss of credibility for water and health authorities, and community outrage. The workshop group emphasised the view that, at present, public health is not a reason for monitoring *Cryptosporidium* numbers in finished water. Given the current state of testing technology, the viability or infectivity of oocysts cannot be determined, and therefore such counts cannot be used as a basis for public health action. However, it is recognised that such monitoring may serve a purpose for the water industry in assessing the effectiveness of water treatment processes for the removal of *Cryptosporidium* oocysts, and in identifying environmental factors which lead to elevations in oocyst numbers.

The group believed that a better approach to the monitoring of treated water would be careful investigation of all turbidity events. Changes in turbidity of treated water requires collaborative discussions with health personnel, review of water treatment procedures, and possibly introduction of enhanced surveillance when raw water *Cryptosporidium* counts are raised. When *Cryptosporidium* counts on treated water are elevated, it cannot be assumed that they necessarily consitute a significant public health hazard without extensive accompanying data and advice from a range of experts. Thus the detection of such events should not automatically trigger a ‘boil water’ alert, but instead trigger investigations by water and health officials to determine the causes and consider the need for such an alert to be issued.

The available evidence on natural history indicates that several oocysts are needed to infect people with normal immune function, but it is not clear whether people with significantly impaired immune function might be infected

with lower numbers, perhaps even with one oocyst. Few (if any) water authorities can guarantee complete freedom from such a risk from using finished water, given the current state of technology.

Swimming pools

Finally, it was agreed that *Cryptosporidium* constitutes a substantial public health hazard in swimming pools, and that this risk will continue while parents take young children to pools in the summer. The only approaches identified as being available were public education to minimise contamination of pools, improved engineering of pool filters, and overnight hyperchlorination of affected filters and pools. Pool closures are as undesirable for the recreational water industry as 'boil water' alerts are for the drinking water industry, and may create similar public responses. While there is some scope for reducing the problem by better design and operation of pools, it is clear that the major need is for better public understanding of the issue.

Public health strategy for drinking water

There was further discussion of the consensus public health strategy for drinking water in the final plenary session, with the following points being agreed:

- Relevant health and water industry personnel should have frequent routine contact so that rapid and effective consultation can take place whenever unusual water quality events occur.
- A stepwise response protocol should be established depending on the degree of health concern associated with different circumstances.
- It is important that the response protocol agreed between health and water authorities is subject to public comment during its development.
- The final response protocol must be made available to the public and the media. The protocol should set out the circumstances that would trigger a response, the investigative and corrective measures to be implemented for various levels of response, and the time period required to carry them out. Placing this information in the public domain in advance of any water quality events helps to address industry concerns over 'duty of care' with respect to the time taken for confirmatory testing and investigations.

It is preferable that one person in each State or Territory is responsible for dealing with the media during the investigation of water quality events. The media should be kept informed on the progress of investigations being undertaken to ascertain the degree of health risk to the community.

Errata

Amin, J. Heath, T. and Morrell, S. Hepatitis A in Australia in the 1990s: future directions in surveillance and control. *Commun Dis Intell* 1999; 23:113-120.

The organisation with which the first author is affiliated is the National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS).

A sentence towards the end of the Methods section (paragraph 1, page 115) should read 'The outbreak level is defined as the number of notifications occurring in a month for which the probability of that number occurring is less than 0.05, based on the expected number of notifications per month being the average number of notifications per month'.

Typhoid fever - urgent health alert

A health warning has been issued to all passengers who travelled on the P&O *Fair Princess*, cruise No.76 that departed Cairns, Australia on 12 May 1999 and travelled to Port Moresby, Samarai Island, Milne Bay, Honiara, Champagne Bay and Vila to see a doctor immediately if they are feeling unwell or have been recently sick.

The Communicable Diseases Network of Australia New Zealand (CDNANZ) advises that at least three passengers on this cruise have been infected with typhoid fever and there may be more passengers who are affected.

There are two confirmed cases of typhoid fever in Victoria and one in NSW. All of the cases notified so far appear to have taken a Kokoda Trail tour on 14 May.

Typhoid is an infection caused by bacteria of the Salmonella group. It occurs world-wide but is more common in developing countries such as Asia, including the Pacific Islands, the Middle East, Africa and Latin America.

Typhoid is transmitted by contaminated food, water or ice. The symptoms of typhoid are fever, diarrhoea or constipation, abdominal pain or tenderness, nausea, vomiting and headache, malaise and cough. Diagnosis is usually made by blood test or faeces examination. Symptoms can occur within three days and up to three months after consumption of contaminated food or water, but usually in one to three weeks. Antibiotic treatment is extremely effective and results in complete recovery.

Passengers who travelled on this cruise and who have the above symptoms are advised to seek medical attention urgently.

P&O Cruises are cooperating fully with the investigation now under way and they point out that the evidence so far points to the Kokoda tour as the source of the problem.

Communicable Diseases Surveillance

Highlights

Communicable Diseases Surveillance consists of data from various sources. The National Notifiable Diseases Surveillance System (NNDSS) is conducted under the auspices of the Communicable Diseases Network Australia New Zealand. The *CDI* Virology and Serology Laboratory Reporting Scheme (LabVISE) is a sentinel surveillance scheme. The Australian Sentinel Practice Research Network (ASPREN) is a general practitioner-based sentinel surveillance scheme. In this report, data from the NNDSS are referred to as 'notifications' or 'cases', whereas those from ASPREN are referred to as 'consultations' or 'encounters' while data from the LabVISE scheme are referred to as 'laboratory reports'.

Prolonged outbreak of leptospirosis in Queensland

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In Queensland between 50 and 120 notifications of leptospirosis are typically reported annually. In the period 1 January to 18 May this year 153 notifications have been reported to Queensland Health (Figure 1). This is in comparison to 34 notifications for the same period in 1998. Of the notifications, 80% have been reported from Far North Queensland (Figure 2), with the likely cause being the prolonged wet season in this region. The infecting serovars for Queensland are shown in Table 1.

Epidemiological investigations show that the banana (agriculture), meatworker and farming industries account for over 30% of the notifications. Clinical symptoms most commonly reported by respondents are headache (87%), chills (83%), severe fever (78%), sweats (72%), myalgia (71%) and arthralgia (59%) (Table 2). Pulmonary haemorrhage was reported in 9% of cases and was associated with the serovars australis and zanoni

Most notifications (75%) are in the 20-49 years age groups while school aged children (5-16 years of age) represent approximately 5% of the notifications. A 50%

Figure 1. Notifications of leptospirosis by month, 1 January to 18 May 1999

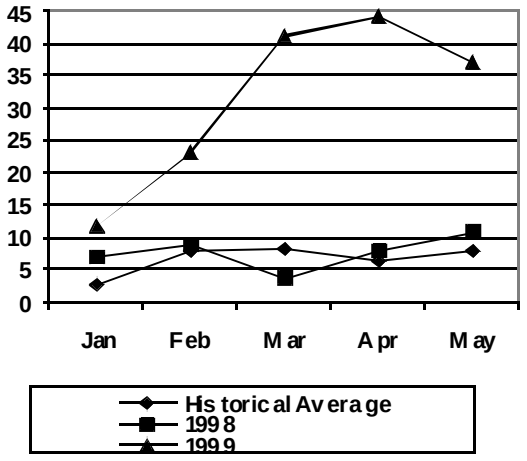

Figure 2. Notifications of leptospirosis by postcode, 1 January to 18 May 1999

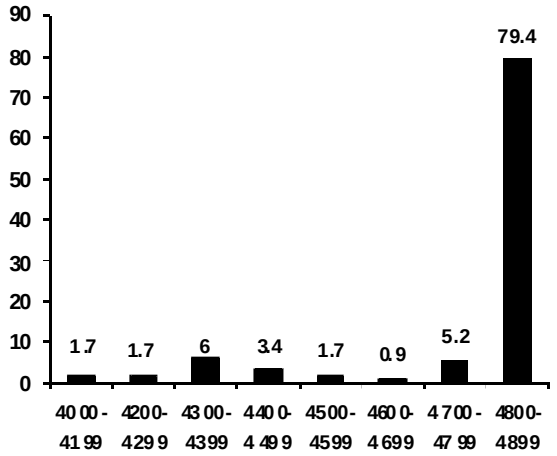

Table 1. Notifications of leptospirosis by serovar, 1 January to 18 May 1999

Serovar	% Notifications
positive cultures - unknown	26.5
zanoni	20.0
hardjo	16.1
australis	10.3
szwajizak	6.5
pomona	5.9
kremastos	3.2
canicola	3.2
robinsoni	1.9
tarassovi	1.3
grippotyphosa	1.3
celledoni	1.3
ballum	1.3
medanensis	0.6
bulgarica	0.6

hospitalisation rate is reported with the duration of stay ranging between 1 day and 20 days with an average of 6 days. Of the 153 notifications, 57 isolates have been recovered from either blood, urine or CSF. This is in comparison to 6 isolates recovered for the same period in 1998. All serology based notifications have been confirmed by the Microscopic Agglutination Test.

Table 2. Notifications of leptospirosis by symptoms, 1 January to 18 May 1999

Symptom	% Notifications
Headache	87
Chills	83
Severe Fever	78
Sweats	72
Myalgia	71
Arthralgia	59
Nausea	58
Vomiting	51
Back Pain	45
Conjunctival Suffusion	32
Mild Fever	26
Vision Disturbance	25
Respiratory Symptoms	23
Renal Involvement	16
Rash	9
Pulmonary Haemorrhage	9
Diarrhoea	4

Victorian measles outbreak

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The Victorian measles outbreak, which began in February 1999, appears to have drawn to a close. The last onset date for a laboratory-confirmed case of measles linked with the outbreak was 2 May 1999.

There has been one further laboratory-confirmed case of measles in Melbourne in May, a 12 year old male who is visiting from Indonesia. He arrived in Australia on 8 May to stay with his three older sisters who are attending university in Melbourne. He developed prodromal symptoms on 15 May and there have been no secondary cases linked to him at this stage (7 June 1999). None of his sisters were unwell with a measles-like illness at the time of his arrival.

The preliminary total of notified cases for the outbreak is 75, with 63 (84%) of these in the 18 to 30 years age group. Some of the cases in this age group appeared to falsely believe they were immune to measles either through parental reporting of childhood infection, or through a false belief of previous immunisation. Many thought that measles immunisation was included in the schoolgirl rubella program, or that parental reports of being 'up-to-date' with all immunisations afforded them protection against measles.

A complete report of the outbreak will be published in *Communicable Diseases Intelligence* in the near future.

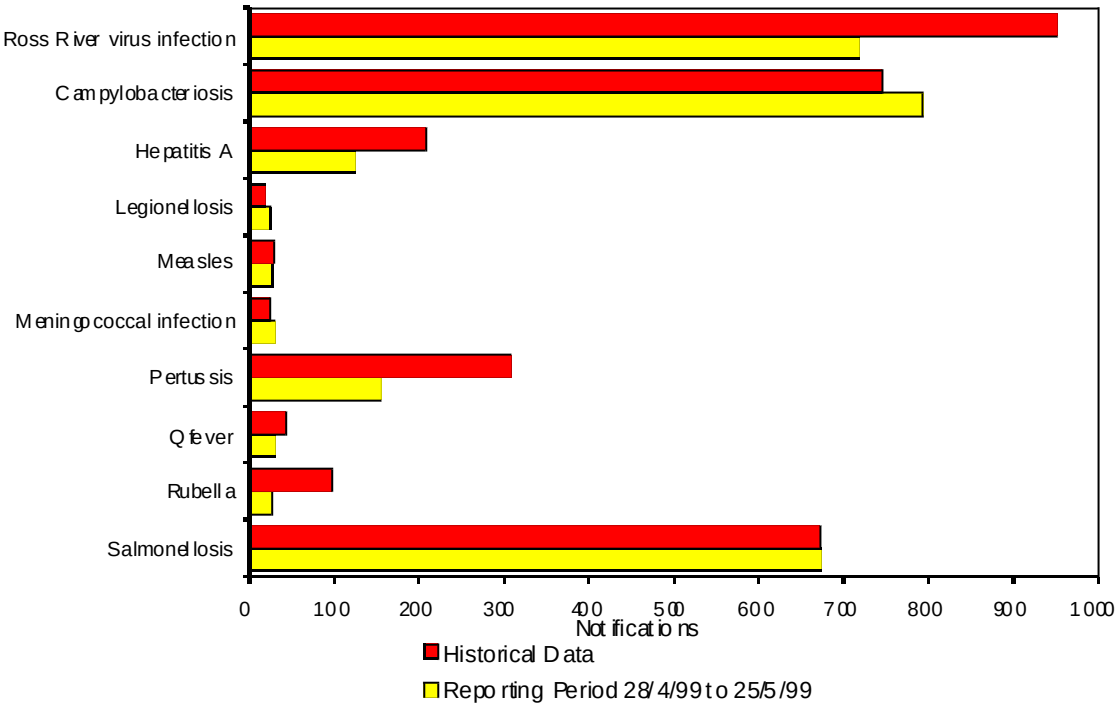
Tables

There were 6,590 notifications to the National Notifiable Diseases Surveillance System (NNDSS) in the four week period, 28 April to 25 May 1999 (Tables 3 and 4). The numbers of reports for selected diseases have been compared with historical data for corresponding periods in the previous three years (Figure 3).

There were 1,266 reports received by the *CDI* Virology and Serology Laboratory Reporting Scheme (LabVISE) in the four week period, 22 April to 19 May 1999 (Tables 5 and 6).

The Australian Sentinel Practice Research Network (ASPREN) data for weeks 17 to 20, ending 23 May 1999, are included in this issue of *CDI* (Table 7).

Figure 3. Selected National Notifiable Diseases Surveillance System reports, and historical data[1]



1. The historical data are the averages of the number of notifications in the corresponding 4 week periods of the last 3 years and the 2 week periods immediately preceding and following those.

Table 3. Notifications of diseases preventable by vaccines recommended by the NHMRC for routine childhood immunisation, received by State and Territory health authorities in the period 28 April to 25 May 1999

Disease[1,2]	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	This period 1999	This period 1998	Year to date 1999	Year to date 1998
Diphtheria	0	0	0	0	0	0	0	0	0	0	0	0
H. influenzae type b infection	0	0	0	0	0	0	0	1	1	1	15	7
Measles	4	1	1	3	2	0	11	6	28	24	141	137
Mumps	1	3	0	5	1	0	8	4	22	15	55	67
Pertussis	8	62	0	29	13	1	41	2	156	391	1,222	3,216
Rubella[3]	4	1	0	9	0	0	9	4	27	66	129	266
Tetanus	0	0	0	0	0	0	0	0	0	0	0	2

NN. Not Notifiable

1. No notification of poliomyelitis has been received since 1978.
2. Totals comprise data from all States and Territories. Cumulative figures are subject to retrospective revision, so there may be discrepancies between the number of new notifications and the increment in the cumulative figure from the previous period.
3. Includes congenital rubella.

Table 4. Notifications of diseases received by State and Territory health authorities in the period 28 April to 25 May 1999

Disease[1,2,3,4]	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	This period 1999	This period 1998	Year to date 1999	Year to date 1998
Arbovirus infection (NEC)	0	0	0	0	0	0	1	0	1	15	61	35
Barmah Forest virus infection	0	45	0	58	0	0	1	8	112	80	332	287
Brucellosis	0	0	0	0	0	0	0	0	0	2	8	17
Campylobacteriosis[5]	21	-	20	211	157	23	259	102	793	702	4,652	4,031
Chancroid	0	0	0	0	0	0	0	0	0	1	0	1
Chlamydial infection (NEC)[6]	13	NN	64	347	77	22	255	144	922	965	4,936	3,741
Cholera	0	0	0	0	0	0	0	0	0	0	2	2
Dengue	0	2	0	5	1	0	0	3	11	45	144	242
Donovanosis	0	NN	0	0	NN	0	0	1	1	1	6	19
Gonococcal infection[7]	2	87	81	78	11	1	59	77	396	492	2,054	1,885
Haemolytic uraemic syndrome[8]	NN	0	0	0	0	0	NN	0	0	3	11	6
Hepatitis A	1	40	2	41	11	0	10	20	125	282	667	1,213
Hepatitis B incident	0	1	0	5	2	0	7	7	22	21	116	105
Hepatitis B unspecified[9]	8	224	0	61	0	4	173	15	485	545	2,397	2,525
Hepatitis C incident	4	2	0	-	5	0	11	12	34	23	124	94
Hepatitis C unspecified[9]	25	496	15	253	64	24	645	64	1,586	1,752	7,465	7,992
Hepatitis (NEC)[10]	0	1	0	0	0	0	0	NN	1	1	3	7
Hydatid infection	0	0	0	0	1	0	3	0	4	2	11	12
Legionellosis	1	5	0	4	2	0	8	5	25	25	125	87
Leprosy	0	0	0	0	0	0	0	0	0	0	0	1
Leptospirosis	0	3	0	35	0	1	1	0	40	16	176	58
Listeriosis	0	1	0	1	0	0	0	0	2	2	17	23
Malaria	2	9	0	18	1	0	4	2	36	42	294	215
Meningococcal infection	0	15	2	1	1	3	7	2	31	27	135	84
Ornithosis	0	NN	0	0	0	0	10	0	10	4	30	12
Q Fever	0	15	0	16	0	0	0	0	31	53	171	196
Ross River virus infection	1	166	5	425	2	21	22	77	719	536	3,136	1,826
Salmonellosis (NEC)	4	125	46	222	46	13	138	80	674	758	4,195	3,645
Shigellosis[5]	1	-	12	16	9	0	10	10	58	59	256	259
SLTEC, VTEC[11]	NN	0	0	NN	0	0	NN	NN	0	1	11	5
Syphilis[12]	0	31	27	67	0	0	0	5	130	101	684	464
TTP[13]	0	0	0	0	0	0	0	0	0	0	0	0
Tuberculosis	0	31	3	13	9	1	30	7	94	84	541	451
Typhoid[14]	0	2	0	0	0	0	2	1	5	3	26	43
Yersiniosis (NEC)[5]	0	-	0	5	0	0	2	1	8	22	75	110

1. Diseases preventable by routine childhood immunisation are presented in Table 3.
2. For HIV and AIDS, see Tables 9 and 10.
3. Totals comprise data from all States and Territories. Cumulative figures are subject to retrospective revision so there may be discrepancies between the number of new notifications and the increment in the cumulative figure from the previous period.
4. No notifications have been received during 1999 for the following rare diseases: lymphogranuloma venereum, plague, rabies, yellow fever, or other viral haemorrhagic fevers.
5. Not reported for NSW because it is only notifiable as 'foodborne disease' or 'gastroenteritis in an institution'.
6. WA: genital only.
7. NT, Qld, SA and Vic: includes gonococcal neonatal ophthalmia.
8. Nationally reportable from August 1998.
9. Unspecified numbers should be interpreted with some caution as the magnitude may be a reflection of the numbers of testings being carried out.
10. Includes hepatitis D and E.
11. Infections with *Shiga*-like toxin (verotoxin) producing *E. Coli* (SLTEC/VTEC) became nationally reportable in August 1998.
12. Includes congenital syphilis.
13. Thrombotic thrombocytopaenic purpura became nationally reportable in August 1998.
14. NSW, Qld: includes paratyphoid.

NN Not Notifiable.

NEC Not Elsewhere Classified.

- Elsewhere Classified.

Table 5. Virology and serology laboratory reports by State or Territory[1] for the reporting period 22 April to 19 May 1999, and total reports for the year

	State or Territory[1]								Total this period	Total reported in *CDI* in 1999
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA		
Measles, mumps, rubella										
Measles virus							12	5	17	118
Mumps virus								8	8	26
Rubella virus				9				2	11	38
Hepatitis viruses										
Hepatitis A virus		2		7			1	12	22	171
Arboviruses										
Ross River virus		6	1	88			4	56	155	898
Barmah Forest virus		1		21			1	5	28	83
Dengue not typed			1					8	9	30
Adenoviruses										
Adenovirus type 3							1		1	18
Adenovirus type 40			1					5	6	26
Adenovirus not typed/pending		16		8			21	17	62	503
Herpes viruses										
Herpes virus type 6								1	1	3
Cytomegalovirus		12		15			35	7	69	490
Varicella-zoster virus		9	3	20			31	35	98	713
Epstein-Barr virus		14	1	50			6	26	97	1,072
Other DNA viruses										
Papovavirus group								4	4	5
Molluscum contagiosum								3	3	6
Contagious pustular dermatitis (Orf virus)								3	3	8
Parvovirus			1	3			13	8	25	161
Picorna virus family										
Echovirus type 6		1							1	13
Echovirus type 9		3							3	23
Echovirus type 11		5					1		6	36
Echovirus type 19		1							1	1
Rhinovirus (all types)		11		1				11	23	151
Enterovirus not typed/pending		1	2	2			6	51	62	326
Ortho/paramyxoviruses										
Influenza A virus		4	1	5			14	12	36	263
Influenza A virus H1N1							1		1	1
Influenza B virus							3	7	10	48
Parainfluenza virus type 1		1		1			1		3	19
Parainfluenza virus type 2							9		9	25
Parainfluenza virus type 3		5		1			13		19	297
Respiratory syncytial virus		64		18		1	12	20	115	448
Other RNA viruses										
Rotavirus		12		1			17	15	45	356
Astrovirus							1		1	1
Norwalk agent							4		4	34

Table 5. Virology and serology laboratory reports by State or Territory[1] for the reporting period 22 April to 19 May 1999, and total reports for the year (continued)

	State or Territory[1]									
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Total this period	Total reported in *CDI* in 1999
Other										
Chlamydia trachomatis not typed		15	15	63		2	15	82	192	1,140
Chlamydia psittaci							2		2	32
Chlamydia species				1					1	6
Mycoplasma pneumoniae		14	1	17			23	6	61	513
Coxiella burnetii (Q fever)				8			2		10	65
Salmonella species								1	1	2
Bordetella pertussis		5		23			12	1	41	250
TOTAL		202	27	362		3	261	411	1,266	8,419

1. State or Territory of postcode, if reported, otherwise State or Territory of reporting laboratory.

Table 6. Virology and serology laboratory reports by contributing laboratories for the reporting period 22 April to 19 May 1999

State or Territory	Laboratory	Reports
New South Wales	New Children's Hospital, Westmead	52
	Royal Prince Alfred Hospital, Camperdown	13
	South West Area Pathology Service, Liverpool	123
Queensland	Queensland Medical Laboratory, West End	361
	Townsville General Hospital	25
Tasmania	Northern Tasmanian Pathology Service, Launceston	3
Victoria	Monash Medical Centre, Melbourne	30
	Royal Children's Hospital, Melbourne	144
	Victorian Infectious Diseases Reference Laboratory, Fairfield	86
Western Australia	PathCentre Virology, Perth	429
TOTAL		1,266

Table 7. Australian Sentinel Practice Research Network reports, weeks 17 to 20, 1999

Week number	17		18		19		20	
Week ending on	2 May 1999		9 May 1999		16 May 1999		23 May 1999	
Doctors reporting	53		53		54		47	
Total encounters	6,109		6,717		7,271		5,938	
Condition	Reports	Rate per 1,000 encounters	Reports	Rate per 1,000 encounters	Reports	Rate per 1,000 encounters	Reports	Rate per 1,000 encounters
Influenza	22	3.6	26	3.9	30	4.1	40	6.7
Rubella	0	0.0	0	0.0	2	0.3	0	0.0
Measles	1	0.2	0	0.0	0	0.0	0	0.0
Chickenpox	6	1.0	7	1.0	15	2.1	9	1.5
New diagnosis of asthma	5	0.8	12	1.8	8	1.1	10	1.7
Post operative wound sepsis	7	1.1	8	1.2	3	0.4	3	0.5
Gastroenteritis	53	8.7	62	9.2	82	11.3	55	9.3

The NNDSS is conducted under the auspices of the Communicable Diseases Network Australia New Zealand. The system coordinates the national surveillance of more than 40 communicable diseases or disease groups endorsed by the National Health and Medical Research Council (NHMRC). Notifications of these diseases are made to State and Territory health authorities under the provisions of their respective public health legislations. De-identified core unit data are supplied fortnightly for collation, analysis and dissemination. For further information, see CDI 1999;23:55.

LabVISE is a sentinel reporting scheme. Twenty-one laboratories contribute data on the laboratory identification of viruses and other organisms. Data are collated and published in Communicable Diseases Intelligence every four weeks. These data should be interpreted with caution as the number and type of reports received is subject to a number of biases. For further information, see CDI 1999;23:58.

ASPREN currently comprises about 100 general practitioners from throughout the country. Up to 9,000 consultations are reported each week, with special attention to 12 conditions chosen for sentinel surveillance in 1999. CDI reports the consultation rates for seven of these. For further information, including case definitions, see CDI 1999;23:55-56.

Additional Reports

Sentinel Chicken Surveillance Programme

Sentinel chicken flocks are used to monitor flavivirus activity in Australia. The main viruses of concern are Murray Valley encephalitis (MVE) and Kunjin which cause the potentially fatal disease Australian encephalitis in humans. Currently 26 flocks are maintained in the north of Western Australia, seven in the Northern Territory, nine in New South Wales and ten in Victoria. The flocks in Western Australia and the Northern Territory are tested year round but those in New South Wales and Victoria are tested only from November to March, during the main risk season.

Results are coordinated by the Arbovirus Laboratory in Perth and reported bimonthly. For more information see CDI 1999;23:57-58

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March/April 1999

Sentinel chicken serology was carried out for 26 of the 27 flocks in Western Australia in March and April 1999. There were a large number of seroconversions to flaviviruses in both the Kimberley and Pilbara flocks during this period. The number of chickens positive for flavivirus antibodies by ELISA and the virus (or viruses) they were infected with is shown in Table 8. In addition there were also a number of unconfirmed seroconversions to MVE virus (not shown in the table) from Broome and Derby in the Kimberley and from Pardoo and Newman in the Pilbara.

Serum samples from all of the seven Northern Territory sentinel chicken flocks were tested in our laboratory in March and April 1999. There was one seroconversion to MVE in the Beatrice Hill Farm flock (near Darwin) in March. In addition there were two seroconversions during April 1999, one to MVE at Gove and one to a flavivirus only from Leanyer. The April seroconversions have not yet been confirmed.

The sentinel chicken programs in Victoria and New South Wales have now finished for the season.

Details of the locations of all chicken flocks are given in *Commun Dis Intell* 1999;23:57-58.

Table 8. Flavivirus seroconversions in Western Australian sentinel chicken flocks in March and April 1999

	March 1999				April 1999		
Location	MVE	KUN	MVE/KUN	FLAVI	MVE	KUN	MVE/KUN
Kimberley							
Kalumburu	4		1				
Wyndham	3						
Kununurra	1						
Halls Creek	7				1		
Fitzroy Crossing	5						
Pilbara							
Port Hedland					4	1	
Harding Dam*	5				12		
Pardoo	4		2	1			
Tom Price	4		1		5		1
Paraburdoo	4		1		3	1	
Onslow					3		
Newman*	5	1			1		
Gascoyne							
Carnarvon							

* 2 flocks of 12 chickens at these sites

MVE – Antibodies to Murray Valley encephalitis virus detected by ELISA

KUN – Antibodies to Kunjin virus detected by ELISA

MVE/KUN – Antibodies to both MVE and KUN viruses detected by ELISA

FLAVI – Antibodies to a flavivirus only (not MVE or KUN) detected by ELISA

HIV and AIDS Surveillance

National surveillance for HIV disease is coordinated by the National Centre in HIV Epidemiology and Clinical Research (NCHECR), in collaboration with State and Territory health authorities and the Commonwealth of Australia. Cases of HIV infection are notified to the National HIV Database on the first occasion of diagnosis in Australia, by either the diagnosing laboratory (ACT, New South Wales, Tasmania, Victoria) or by a combination of laboratory and doctor sources (Northern Territory, Queensland, South Australia, Western Australia). Cases of AIDS are notified through the State and Territory health authorities to the National AIDS Registry. Diagnoses of both HIV infection and AIDS are notified with the person's date of birth and name code, to minimise duplicate notifications while maintaining confidentiality.

Tabulations of diagnoses of HIV infection and AIDS are based on data available three months after the end of the reporting interval indicated, to allow for reporting delay and to incorporate newly available information. More detailed information on diagnoses of HIV infection and AIDS is published in the quarterly Australian HIV Surveillance Report, and annually in HIV/AIDS and related diseases in Australia Annual Surveillance Report. The reports are available from the National Centre in HIV Epidemiology and Clinical Research, 376 Victoria Street, Darlinghurst NSW 2010. Telephone: (02) 9332 4648; Facsimile: (02) 9332 1837; http://www.med.unsw.edu.qu/ncherc.

HIV and AIDS diagnoses and deaths following AIDS reported for 1 to 31 January 1999, as reported to 30 April 1999, are included in this issue of CDI (Tables 9 and 10).

Table 9. New diagnoses of HIV infection, new diagnoses of AIDS and deaths following AIDS occurring in the period 1 to 31 January 1999, by sex and State or Territory of diagnosis

										Totals for Australia			
		ACT	NSW	NT	Qld	SA	Tas	Vic	WA	This period 1999	This period 1998	Year to date 1999	Year to date 1998
HIV diagnoses	Female	0	2	0	0	0	0	0	1	3	2	3	2
	Male	0	23	0	8	1	0	8	3	43	62	43	62
	Sex not reported	0	0	0	0	0	0	1	0	1	0	1	0
	Total[1]	0	25	0	8	1	0	9	4	47	64	47	64
AIDS diagnoses	Female	0	0	0	0	0	0	0	0	0	2	0	2
	Male	0	3	0	0	0	0	1	0	4	26	4	26
	Total[1]	0	3	0	0	0	0	1	0	4	28	4	28
AIDS deaths	Female	0	0	0	0	0	0	0	0	0	0	0	0
	Male	0	7	0	5	0	0	3	1	16	12	16	12
	Total[1]	0	8	0	5	0	0	3	1	17	12	17	12

1. Persons whose sex was reported as transgender are included in the totals.

Table 10. Cumulative diagnoses of HIV infection, AIDS and deaths following AIDS since the introduction of HIV antibody testing to 30 April 1999, by sex and State or Territory

		State or Territory								
		ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
HIV diagnoses	Female	22	582	8	131	57	5	199	103	1,107
	Male	187	10,521	104	1,871	649	77	3,757	872	18,038
	Sex not reported	0	259	0	0	0	0	25	0	284
	Total [1]	209	11,381	112	2,009	706	82	3,994	978	19,471
AIDS diagnoses	Female	8	169	0	45	20	3	67	26	338
	Male	85	4,517	33	784	326	44	1,584	343	7,716
	Total [1]	93	4,698	33	831	346	47	1,658	371	8,077
AIDS deaths	Female	2	113	0	30	15	2	47	16	225
	Male	63	3,122	24	552	224	28	1,238	245	5,496
	Total [1]	65	3,243	24	584	239	30	1,291	262	5,738

1. Persons whose sex was reported as transgender are included in the totals.

Bulletin Board

The Australian Society for Microbiology Inc.
The 11th International Conference
International Congress of Virology
9-13 August 1999
International Congress of Bacteriology and Applied Microbiology
9-13 August 1999
International Congress of Mycology
16-20 August 1999
Sydney, New South Wales
Fax: 03 9262 3135
Email: tourhosts@tourhosts.com.au

The International Leptospirosis Society
2nd International Scientific Conference
22-25 August 1999
Kooringa Lodge, Marysville, Victoria
Phone: 03 9905 4815
Fax: 03 9905 4811
Web page and conference registration:
http://www.med.monash.edu.au/micro/department/leptconf/ils99.htm

The Public Health Association of Australia Inc.
31st Annual Conference
26-29 September 1999
Carlton Hotel
Darwin, Northern Territory
Details: PO Box 319
Curtin ACT 2605
Email: conference@pha.org.au

Advance notice

International Society of Travel Medicine/WHO/CDC
2nd European Conference of Travel Medicine
29-31 March 2000
Venice, Italy
Contact: Dr Walter Pasini, Italy
Phone: 390-541-24301
Fax: 390-541-25748
Email: wpasini@rimini.com

Australian Society for Infectious Diseases Meeting
April 16-19, 2000
Fairmont Resort Leura organisers:
Dart Associates:
Phone: 02 94189396
For scientific content: Contact Tom Gottlieb,
Concord Hospital
Phone: 02-97677533
Fax; 02-97677868 or
Email: Tom@micr.crg.cs.nsw.gov.au

Royal North Shore Hospital
Conference: *Outpatient Parenteral Therapy - beyond 2000*
17-22 September 2000
Fairmont Resort
Leura, New South Wales
Phone: 02 9956 8333
Fax: 02 0056 5154
Email: confact@conferenceaction.com.au

The Australasian Society for HIV Medicine
12th Annual Conference
16-19 November 2000
The Carlton Crest, Melbourne, Victoria
Phone: 02 9382 1656
Fax: 02 9382 3699
Email: B.Pearlman@unsw.edu.au

The Queensland Institute of Medical Research
Symposium on Q Fever
13-14 October 1999
Brisbane, Queensland
Phone: 07 3844 1138
Fax: 07 3844 0909
Email: qfever@icms.com.au

The CDI Bulletin Board is provided as a service to readers. Every effort has been made to provide accurate information, but readers are advised to contact the relevant organisation for confirmation of details. Information about the availability of resources is included when space allows. Inclusion of a resource on the Bulletin Board does not imply endorsement of the resource by either the Communicable Diseases Network Australia New Zealand or the Commonwealth Department of Health and Aged Care.

Contributions to the Bulletin Board are invited from those organisations with forthcoming events relevant to communicable disease control.

Overseas briefs

Source: World Health Organization (WHO)
This material has been condensed from information on the WHO internet site. A link to this site can be found under 'Other Australian and international communicable diseases sites' on the CDI homepage.

Plague

Namibia

The Ministry of Health and Social Services has reported plague cases in Ohangwena Region in the north western part of the country. The first suspected case was reported on 6 April and 39 cases have occurred up to 5 May, 6 of which have been laboratory confirmed. Eight patients have died of suspected plague.

The North West regional directorate team, which has had experience in dealing with plague, has undertaken control activities, including training courses for health workers, community mobilisation for preventive measures, additional nurses placed at local hospitals and dusting of homesteads.

The Ministry of Health report also states that, although plague has been endemic in this part of the country, it was successfully controlled in recent years, the last known cases having occurred in January 1994.

Suspected viral haemorrhagic fever

Zimbabwe

WHO has investigated recent reports of suspected viral haemorrhagic fever (VHF) in soldiers returning to Zimbabwe from the Democratic Republic of the Congo. Three suspected cases have been admitted to two hospitals. The soldiers became ill in the southern part of the Democratic Republic of the Congo and are reported to have had fever with chills, diarrhoea and headache. They had not been in or near the Marburg virus outbreak area of Watsa. In addition, there is no evidence that the soldiers had haemorrhagic features that would be consistent with VHF.

Blood samples from the three soldiers were sent to the National Institute for Virology (South Africa) and have been found negative for Marburg and Ebola in a range of tests.

Viral haemorrhagic fever/Marburg

Democratic Republic of the Congo - Update

The results of additional testing by the National Institute for Virology (South Africa), now confirm 5 cases of Marburg fever. Samples from 10 suspected cases have been collected and tested. Three confirmed cases had been reported previously. The two additional cases died on 1 May and 14 May 1999.

An active surveillance system is in place and selected staff from the coordination committee* remain on-site to monitor events.

* The coordination committee is composed of experts from: the Ministry of Health and local health authorities; WHO headquarters and the African Region; UNDP; Médecins sans frontières (Belgium and Holland); Centers for Disease Control and Prevention (United States); Institut Pasteur (France, French Guiana and Madagascar); Institute of Tropical Medicine (Belgium). The ecological team is composed of experts from: the National Institute for Virology (South Africa) and the Pest Infection Laboratory (Denmark).

Cholera

Sudan

The outbreak of cholera which began in early March is continuing. The areas of Padak, Mading, Wanding, Lankien, Akobo and Burmat have reported a total of 892 cases with 24 deaths up to 27 April 1999.

These figures represent cases admitted to hospital and are provisional. The epidemic mainly affects the Jonglei region in areas south of the river Sobat. As it is the beginning of the rainy season people have started moving with their animals from locations along the river to inland sites where other areas are likely to be affected.

A cholera response team coordinated by UNICEF is meeting twice weekly to review the situation, share information and plan the response strategy. UNICEF currently has ORS and tetracycline on standby for use as the need arises. WHO has sent an epidemiologist to assist local health authorities to assess the situation in the affected areas.

Cambodia

The Ministry of Health has reported a cholera outbreak in Rottanakiri province in the north eastern part of the country. Four districts in this province, which is one of Cambodia's least populated areas, have been affected to date. The outbreak started on 16 April and a total of 874 cases with 56 deaths was reported up to 16 May.

Lack of good hygiene and sanitation facilities, as well as difficulty in sending supplies because of poor road conditions in the area, are contributing to the spread of the epidemic. The Ministry of Health is providing oral rehydration salts and antibiotics and is also organising health education campaigns for the affected and surrounding villages.

Cholera is endemic in Cambodia and 1,197 cases and 66 deaths were notified to WHO in 1998.

Nigeria

An outbreak of cholera has been reported in Kano Municipal Local Government Area (LGA), Kano State, which started in late March. The outbreak was traced to the interruption of the domestic water supply for some days which forced people to use any water available. A total of 815 cases with 28 deaths has been recorded up to 6 May. The outbreak has now spread to Tofa LGA where 182 cases with 19 deaths were recorded over two weeks beginning in late April. Control measures including management and isolation of affected patients, intensification of health education and chlorination of all

wells in affected communities have been taken. WHO gave technical support during the investigation and management of the outbreak as well as emergency health kits.

Cholera outbreaks also occurred recently in Adamawa State (76 cases, 18 deaths) and in Edo State (49 cases 24 deaths). The outbreak in Adamawa State is now under control and no new cases have been reported in May. In Edo State technical assistance and transportation for the investigative team was given by WHO but basic drugs and supplies for management of patients were not available which led to the high case fatality rate.

Medecins sans frontières (MSF), Holland, has set up a temporary treatment centre and 6 Oral Rehydration Therapy (ORT) centres, and are currently organising a widespread health education campaign and training of local district health personnel.

Sylvatic yellow fever in South America

Bolivia: Cases of sylvatic yellow fever are still occurring, bringing the total number of confirmed cases for 1999 to 53 with 21 deaths (case fatality rate of 39.6%). All of the cases have occurred in the Department of Santa Cruz. The majority of cases have been in males (75.5%) and in persons >15 years of age (76.9%). No cases in children <1 year have been reported. Mass yellow fever vaccination campaigns have occurred in the two municipalities that have been most affected; Cabezas and Postrervalle, achieving coverage rates of 93% and 97% respectively. The last case identified occurred on 15 April 1999. The goal of the Ministry of Health is to vaccinate 100% of the population in the endemic yellow fever zones this year.

Brazil

For 1999, the total number of confirmed sylvatic yellow fever cases has reached 18, with 3 deaths (case fatality rate of 16.7%). Fifty per cent of the cases have been in persons >15 years old, 44.4% have been in children aged 1-15 years, and 5.6% (representing one case) have been in children <1 year of age. Most of the cases have occurred in males (72.2%). The outbreak seems to be concentrated in two municipalities - Afuá and Breves, in the State of Para. Reports from Brazil show that many of the cases from Afuá were identified through active surveillance and serological surveys after a death due to yellow fever occurred in February 1999.

Although a vaccination campaign was carried out in Afuá achieving 100% coverage, cases continue to occur due to the migration of unimmunised people into the area. Families are migrating to this area for work, primarily harvesting heart of palm. In the process of harvesting the trees, the habitat of the mosquitoes is disrupted and contact with humans, including unimmunised young children, occurs.

Colombia

To date in 1999, the total number of confirmed sylvatic cases is two and both cases were fatal. These two cases were males, aged 17 and 21 years. The cases occurred in the Departments of Caqueta and Meta. No cases have been reported since January.

Peru

The first confirmed case of sylvatic yellow fever for 1999 was reported in a 25 year old male from the Department of Loreto, Amazon region who died on 7 April. In response to this case, mass yellow fever vaccination was initiated in the area. Other cases have occurred in San Martin Department, in the districts of Moyobamba, Jepelacio and Alonso de Alvarado (26 cases), Ayacucho Department in the province of La Mar, district of Anco y Santa Rosa (12 cases), Huanuco Department (5 cases) and Junin Department (5 cases). Of these a total of 13 cases have been confirmed to date.

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