Australian Government
Department of Health and Ageing

Communicable Diseases Intelligence

Volume 32 Supplement June 2008

Vaccine Preventable Diseases and Vaccination Coverage in Aboriginal and Torres Strait Islander People, Australia, 2003 to 2006




National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases

ISBN: 1-74186-598-0
Online ISBN: 1-74186-599-9
Publications Number: P3 -3829

Communicable Diseases Intelligence aims to diseminate information on the epidemiology and control of communicable diseases in Australia. *Communicable Diseases Intelligence* invites contributions dealing with any aspect of communicable disease epidemiology, surveillance or prevention and control in Australia. Submissions can be in the form of original articles, short reports, surveillance summaries, reviews or correspondence. Instructions for authors can be found in *Commun Dis Intell* 2008;32:130–133.

Communicable Diseases Intelligence contributes to the work of the Communicable Diseases Network Australia (http://www.health.gov.au/cdna)

Website

http://www.health.gov.au/cda

Subscriptions and contacts

Communicable Diseases Intelligence is produced every quarter by:
Surveillance Branch
Office of Health Protection
Australian Government Department of Health and Ageing
GPO Box 9848, (MDP 6)
CANBERRA ACT 2601;
Telephone: +61 2 6289 2717
Facsimile: +61 2 6289 2600
Email: cdi.editor@health.gov.au

This journal is indexed by *Index Medicus*, Medline and the Australasian Medical Index

Disclaimer

Opinions expressed in *Communicable Diseases Intelligence* are those of the authors and not necessarily those of the Australian Government Department of Health and Ageing or the Communicable Diseases Network Australia. Data may be subject to revision.

WARNING: Aboriginal and Torres Strait Islander peoples are warned that the following publication may contain images of deceased persons.

Printed by Union Offset, Canberra

Vaccine Preventable Diseases and Vaccination Coverage in Aboriginal and Torres Strait Islander People, Australia 2003 to 2006

This report was prepared at the National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS) by:

Robert Menzies

Caroline Turnour

Clayton Chiu

Peter McIntyre

University of Sydney
Royal Alexandra Hospital for Children

Communicable Diseases Intelligence
Australian Government Department of Health and Ageing

NCIRS is a collaborating unit of the
Australian Institute of Health and Welfare

Australian Government
Department of Health and Ageing

The University of Sydney

Australian Government
Australian Institute of Health and Welfare

Contents

Cont'd next page

Contents, *continued*

Acknowledgements

We wish to acknowledge the following organisations for provision of data for this report:

The Surveillance Policy and Systems Section, Office of Health Protection, Australian Government Department of Health and Ageing, for data from the National Notifiable Diseases Surveillance System.

The Australian Institute of Health and Welfare, Hospitals Unit, Economics and Health Services Group, for data from the National Hospital Morbidity and Mortality databases.

The National Centre for Aboriginal and Torres Strait Islander Statistics, Australian Bureau of Statistics, for vaccination coverage data from the National Aboriginal and Torres Strait Islander Health Survey 2004–05 and National Health Surveys 2001 and 2004–05.

The Health Insurance Commission, for vaccination coverage data from the Australian Childhood Immunisation Register.

Thanks to the following for comments on drafts:

Dr Sophie Couzos, Ms Heather Cook, Mr Peter McGinnes, Dr Shelley Deeks, Ms Kirrily Harrison and The National Advisory Group on Aboriginal and Torres Strait Islander Health Information and Data.

Thanks also to Han Wang and Dr Amy Glasswell for assistance with data analysis, and Donna Armstrong for editing the final manuscript.

Caroline Turnour was a trainee with the NSW Health Public Health Officer Training Program while at the National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS).

NCIRS is supported by The Australian Government Department of Health and Ageing, the NSW Department of Health and The Children's Hospital at Westmead.

Executive summary

This, the second report on vaccine preventable diseases and vaccination coverage in Aboriginal and Torres Strait Islander people, brings together the relevant sources of routinely collected data on vaccine preventable diseases – notifications, hospitalisations, deaths, and childhood and adult vaccination coverage. As a result of continued improvements in the collection of data on Indigenous status, this second report is considerably more comprehensive, with data available from more jurisdictions, and more detailed presentation, including time trends and vaccination coverage by jurisdiction.

Vaccination coverage data provide evidence of successful program delivery and highlight some areas for improvement. For universally funded vaccines in children, coverage is similar in Indigenous and non-Indigenous children by 24 months of age. However, delayed vaccination is more common in Indigenous children, with 6%–8% fewer children fully vaccinated at 12 months of age. More timely vaccination, particularly within the first six months of life, is particularly important in reducing the disproportionate burdens of disease due to pertussis and *Haemophilus influenzae* type b (Hib).

For vaccination programs targeted specifically at Aboriginal and Torres Strait Islander children and adults, coverage is substantially lower than for those programs targeted at all Australians. This is true for hepatitis A and polysaccharide pneumococcal vaccine for children, and influenza and polysaccharide pneumococcal vaccine for adults. Targeted vaccination programs present a particular challenge for health services in urban areas.

Nevertheless, the impact of vaccination programs in preventing disease and reducing the disparity of disease burden between Aboriginal and Torres Strait Islander and non-Indigenous people has been substantial. This is evident in data on notifications, hospitalisations and deaths. Diseases which, in the past, have had devastating and often disproportionately high impact on Indigenous people, such as diphtheria, measles, poliomyelitis, smallpox and tetanus, are now completely or almost completely absent from Australia.

Hepatitis B infection, another disease responsible for high levels of infection and substantial serious illness and death in the pre-vaccine era, is also now well controlled in age groups eligible for vaccination.

Although invasive Hib disease is now rare in Australia since the introduction of vaccination in 1993, higher rates of disease persist in Aboriginal and Torres Strait Islander children. More research is needed into the contribution of environmental factors, delayed vaccination and vaccine failure to this continued disparity.

Hepatitis A has disproportionately affected Aboriginal and Torres Strait Islander children in the past. Vaccination programs in north Queensland and in various other countries have been very successful in reducing the burden of hepatitis A. It is too early to assess the impact of the vaccination program for Aboriginal and Torres Strait Islander children that commenced in regions outside north Queensland in November 2005.

For some other diseases the situation is more complicated. The substantial impact of the national meningococcal C vaccination program since 2003 is evident in this report, although the higher proportion of non-vaccine preventable serotype B disease in Aboriginal and Torres Strait Islander people underlines the need for a new vaccine to cover this serotype.

Pneumonia remains the most important communicable disease contributor to premature mortality in Aboriginal and Torres Strait Islander people of all ages. In young Indigenous adults, the eightfold higher rate of hospitalisation compared with their non-Indigenous peers, and the 11-fold higher rate of invasive pneumococcal disease, suggest the need for more widespread use of influenza and pneumococcal vaccines in this age group. Current coverage for Indigenous 15–49 year olds, where influenza and pneumococcal vaccines are funded only for those with risk factors, is low even though some 70% of this age group have one or more risk factors.

Overall, the data presented in this report provide powerful evidence for the impact of vaccines in reducing disease in Aboriginal and Torres Strait Islander people, and also point to areas for further improvement. Immunisation programs are an example of how preventive health programs in general can be enhanced to close the gap in morbidity and mortality between Indigenous and non-Indigenous Australians.

Introduction

This is the second report on vaccine preventable diseases and vaccination coverage in Aboriginal and Torres Strait Islander people. The first, published in 2004, covered data from 1999 to 2002.[1]

Documented improvements in the quality of Indigenous status data, noted in previous publications[1,2] and further documented in this report, have enabled this report to be substantially more comprehensive. The report includes notifiable disease data from five jurisdictions, up from four in the previous report, hospitalisation data by year for the first time, as well as vaccination coverage data from the Australian Childhood Immunisation Register and National Aboriginal and Torres Strait Islander Health Survey. Coverage data is reported for individual jurisdictions for the first time.

This report is modelled on two other regularly published national reports. It provides a comparison between Indigenous and non-Indigenous people not available in the *Vaccine Preventable Diseases and Vaccination Coverage in Australia* reports[3–5] produced by the National Centre for Immunisation Research and Surveillance (NCIRS), and detailed data on vaccine preventable disease and vaccination coverage not available in the *The Health and Welfare of Australia's Aboriginal and Torres Strait Islander Peoples* reports[6–8] produced by the Australian Institute of Health and Welfare (AIHW) and the Australian Bureau of Statistics (ABS). Data are provided for all diseases and vaccines included in the National Immunisation Program (NIP) for the period of analysis. Individual chapters are provided for those diseases responsible for a substantial burden of illness during the period. Data on diseases with very few or no cases are in the summary tables in Appendices A and B. Data on rotavirus and human papillomavirus are not included, as these vaccines were not included in the NIP during the period.

The aim of this report is to make available recent data from routinely collected sources, along with informed commentary, to facilitate service delivery, policy development and further research on the prevention of vaccine preventable diseases in Aboriginal and Torres Strait Islander people. The primary audience is health professionals. In the near future, a summary publication targeted at health workers in the Aboriginal community controlled sector will also be developed.

Methods

The methods used in this report are adapted from the first Vaccine Preventable Diseases and Vaccination Coverage in Aboriginal and Torres Strait Islander People, Australia, 1999 to 2002 report.[1]

Vaccine preventable diseases data

Three sources of routinely collected data were used for this report. Notification data were obtained from the National Notifiable Diseases Surveillance System (NNDSS), hospitalisation data from the Australian Institute of Health and Welfare National Hospital Morbidity Database, and mortality data from the AIHW Mortality Database.

In this report, Indigenous status consists of two categories: 'Indigenous' which records whether a person is identified as being of Aboriginal or Torres Strait Islander origin, and a composite category, 'other', which includes those recorded as non-Indigenous and those listed as 'not stated/inadequately described'.[2]

Notifications

The NNDSS database was established in its current form in 1991, and includes information about cases of vaccine preventable diseases (VPDs) reported by laboratories and health workers to state and territory authorities under their public health legislation.

State and territory notification criteria are based on the National Health and Medical Research Council (NHMRC) surveillance case definitions.[9] However, historically, application of these definitions has differed between jurisdictions, with some using the 1994 NHMRC case definitions as written (e.g. South Australia and Western Australia) and others using their own definitions (e.g. New South Wales and Victoria). In September 2003, new national case definitions for notifications reported to NNDSS were endorsed by the Communicable Diseases Network Australia.[10] All the jurisdictions included in this report implemented the new definitions in January 2004, except New South Wales which commenced in August 2004.

Disease notifications for cases with a date of diagnosis between 1 January 2003 and 31 December 2006 (four years), as at May 2007, are included in this report. Previous reports analysed notifications by date of onset as collected from the clinical history, where available, or the specimen collection date for laboratory-reported cases. As of mid 2005, a date of diagnosis field was generated for all NNDSS records. Date of diagnosis is determined using an algorithm whereby the earliest date in the fields date of onset, date of specimen, date of notification and date notification received (the only compulsory date field) is selected.[11]

The variables extracted for analysis for every disease were: date of diagnosis, Indigenous status, age at onset, and the state or territory from which the notification was received. Following an assessment of the completeness of the Indigenous status field (see below), notifications were included for New South Wales, the Northern Territory, South Australia, Victoria and Western Australia.

Detailed notification data are presented for *Haemophilus influenzae* type b (Hib) disease, hepatitis A, acute hepatitis B, measles, meningococcal disease, pertussis, and pneumococcal disease. For VPDs with few or no notifications in the period (diphtheria, mumps, polio, rubella and tetanus), data are not presented in the results section but summary data are presented in Appendix A. Varicella data are not presented as they are available only for part of the relevant period (2006), and neither rotavirus nor HPV is included as they were not nationally notifiable and a vaccine was not available in the period covered by this report. Data are not provided for influenza notifications due to the low level of completeness of the Indigenous status field.

Hospitalisations

The AIHW National Hospital Morbidity Database has received administrative, demographic and clinical information about patients admitted to public and private hospitals in Australia since 1993. Data are received by financial year of separation (discharge). The three most recent years for which data were available (2002/2003, 2003/2004, 2004/2005) are included in this report. Following AIHW recommendations on Indigenous identification data, only five states are included: New South Wales, the Northern Territory, Queensland, South Australia and Western Australia.[2] New South Wales hospitalisations have been included for the first time, following the demonstration of satisfactory rates of recording Indigenous status in hospitalisations in

2004–2005, and comparable reporting rates in the previous three years (Dr Fadwa Al-Yaman, AIHW, personal communication, October 2007). Trends over time for each disease for the years 1999/2000 to 2004/2005 include data from only the four jurisdictions where Indigenous status has been demonstrated as satisfactory over the whole period – the Northern Territory, Queensland, South Australia and Western Australia.

Data were extracted based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification (ICD-10-AM). Eligible separations included those with the code of interest listed in the principal diagnosis (the diagnosis chiefly responsible for the admission of the patient to hospital) or in any other diagnosis field. For acute hepatitis B, only principal diagnoses were included, consistent with previous practice.[12]

The variables extracted for analysis were: age at admission, state or territory of residence, Indigenous status, year of separation, and causes of admission (principal and other diagnoses – up to 31 diagnoses were recorded for each admission).

Detailed hospitalisation data are presented for hepatitis A, acute hepatitis B, influenza and pneumonia, measles, meningococcal disease, pertussis, pneumococcal disease and varicella. Separation data are not presented in the results section for those VPDs with few or no separations during the period (diphtheria, mumps, polio, rubella, tetanus); summary data are presented in Appendix B. No hospitalisation data are presented for invasive Hib disease as no type-specific code exists.

Deaths

Death data were obtained from the AIHW Mortality Database. These data are supplied annually to the AIHW from the Registrars of Births, Deaths and Marriages in each state and territory via the Australian Bureau of Statistics. Deaths include those in Australian waters as well as on Australian soil, whereas ABS published data exclude deaths in Australian waters. Since 1997, the International Classification of Diseases, 10th Revision (1992) (ICD-10) has been used to identify the cause of death. Although multiple causes of death have been recorded since 1997, this report included only those where the underlying cause of death was recorded as the disease of interest.

Deaths analysed in this report were for the three most recent years for which data were available (2003, 2004, 2005). The variables extracted for each death were: underlying cause, age, year the death was reported, Indigenous status, and state or territory in which the death was recorded.

Following previous practice,[3] mortality data were analysed only for those jurisdictions that met criteria for reliable reporting of Aboriginal and Torres Strait Islander deaths (the Northern Territory, Queensland, South Australia and Western Australia). For diseases in the results section, numbers of deaths are presented by age group. For those VPDs not included in the results section (diphtheria, mumps, polio, rubella and tetanus), summary data are provided in Appendix B.

Calculations and statistical methods

Incidence rates in Aboriginal and Torres Strait Islander people were calculated using the low series of ABS experimental estimates and projections, Aboriginal and Torres Strait Islander Australians, 30 June 1991 to 20 June 2009, for the relevant jurisdictions, from the 2001 Census. Incidence rates for other (presumed non-Indigenous) persons were calculated using as the denominator the total ABS-estimated resident population for the relevant jurisdictions as at June of that year, minus the relevant jurisdiction's Aboriginal and Torres Strait Islander population.

Direct standardisation is used to calculate rates for all ages combined, using the ABS 2005 population estimates. For hospitalisation data, the mid-year population estimate for the first half of the financial year was used as the denominator; for example, the June 2002 population estimate was used to calculate rates for 2002/2003.

A rate ratio for Indigenous versus other persons was calculated for each disease, with age-specific rate ratios where appropriate. All rates are presented as average annual rates per 100,000 total population or population by age group, as appropriate.

The 95% confidence intervals for rates were calculated from the Poisson distribution of the number of cases. For rate ratios, 95% confidence intervals were calculated using the method of Rothman,[13] and regarded as statistically significant if confidence intervals did not overlap 1.0.

Confidence intervals for age-standardised rates used the method of Draper.[14]

Vaccination coverage data

Data on vaccination coverage were provided by Medicare Australia from the Australian Childhood Immunisation Register (ACIR). Data on adults from the 2004–05 National Aboriginal and Torres Strait Islander Health Survey (NATSIHS), and 2004–05 and 2001 National Health Surveys (NHS) were provided by the National Centre for Aboriginal and Torres Strait Islander Statistics of the Australian Bureau of Statistics.

The ACIR is administered by Medicare Australia for the Australian Government Department of Health and Ageing, and records the vaccination service details of children aged less than 7 years from data supplied by vaccination service providers. Vaccination coverage estimates derived from ACIR data have been reported in *Communicable Diseases Intelligence* since early 1998. The methodology for calculating cohort-based vaccination coverage from the ACIR was published with the first coverage estimates in 1998.[15] Using this method, a cohort of children is defined by date of birth in three-month groups, the first cohort being born between 1 January 1996 and 31 March 1996. The vaccination status of each cohort is assessed at the three key milestones of 12 months, 24 months and 72 months of age. Coverage is measured several months after the due date for completion of each milestone, to allow for delayed notification to the ACIR. To minimise duplicate records, the cohort includes only children enrolled with Medicare (approximately 99% of children). When multiple doses are required, it is assumed that notification of receipt of a later vaccine dose implies receipt of earlier doses ('third-dose assumption').[15,16]

The reporting of Indigenous status has improved markedly in recent years so that, by 2005, 95% of the ABS-estimated cohort of Aboriginal and Torres Strait Islander babies were recorded as such on the ACIR, with a minimum of 75% across jurisdictions.[17] Variations in Indigenous status reporting rates were also shown to have little impact on coverage estimates,[17] with the estimates produced in 2003, when the ACIR included only 50% of the ABS-estimated cohort, comparable with the estimates from a household survey in Queensland.[18] Coverage for the 72 month milestone is presented for the first time in this report, as the ACIR now includes approximately 80% of the ABS-estimated Aboriginal and Torres Strait Islander cohort for this age group.

The methodology for the survey and for calculating vaccination coverage estimates in the 2004–05 National Aboriginal and Torres Strait Islander Health Survey have been published.[19] The 2004–05 NATSIHS was conducted in private dwellings selected throughout Australia, including remote areas. Information was obtained from both adults and children (0–17 years) in the selected households. The NATSIHS sample was combined with Aboriginal and Torres Strait Islander Australians enumerated as part of the 2004–05 NHS to provide a total sample of 10,439 Indigenous persons. It should be noted that Aboriginal and Torres Strait Islander children from remote areas, except for those aged 15–17 years, were not surveyed regarding vaccination, and Indigenous adults from remote areas were only asked a limited set of survey questions regarding vaccination. Remote areas are defined as those living in areas of remoteness classified as 'Remote Australia' or 'Very Remote Australia' according to the Australian Standard Geographic Classification used by the Australian Bureau of Statistics.

Vaccination status information was collected by face-to-face interviews. Adult respondents (aged 18 years or more) from both non-remote and remote areas were asked whether they had been vaccinated against pneumococcal disease in the last five years and against influenza in the last 12 months. The same questions were asked in the National Health Survey 2001.

Compared with the Indigenous supplementary component of the 2001 NHS, new vaccination information that was collected in the 2004–05 NATSIHS included influenza and pneumococcal vaccination status in Indigenous people aged 15–49 years in both non-remote and remote areas (in addition to adults aged 50 years or more).

Data collected through the NATSIHS on the prevalence of risk factors for which the influenza and pneumococcal vaccine were recommended in Aboriginal and Torres Strait Islander people aged 15–49 years[20] were also obtained. Appendix C lists the conditions that were selected as representing those risk factors.

Data quality and notes on interpreting data

Comparisons between the notification, hospitalisation and death databases should be made with caution as they differ in their purposes, reporting mechanisms and accuracy. To provide the most recent information available, and to account for the varied reporting formats, different time periods have been reviewed for each dataset. Due to variations in data quality, data from different jurisdictions have been included for notifications compared with hospitalisations and deaths, while data from all jurisdictions were used for vaccination coverage. As there were no unique identifying codes to link records for the same individual across databases, and because of differences in the accuracy of each database, it was not possible to analyse deaths and hospitalisations as a subset of notifications.

Comparing data from different collections is therefore problematic and should take account of the various factors outlined below.

Indigenous identification

The quality of Aboriginal and Torres Strait Islander health statistics depends on the accuracy of Indigenous population estimates and the level of completeness and accuracy of reporting achieved in the collection of Indigenous status for the condition of interest. Considerable work has been done in recent years on assessing and improving the quality of Aboriginal and Torres Strait Islander statistics in national, state and territory administrative data collections.[2,8,17] More work is needed to improve the quality of the data, as large variations in quality exist between data collections, and, within the same data collections, there are variations between jurisdictions and over time.

Notifications

Indigenous identification

The proportion of notifications lacking identification of Indigenous status were analysed by jurisdiction, year and disease. Adequate levels of completeness of Indigenous status identification between 2003 and 2006 were defined as at least 60% for a substantial majority of the diseases analysed. This level of completeness was achieved for New South Wales, the Northern Territory, South Australia, Victoria and Western Australia. After establishing that notification incidence estimates were not dominated by any one of these five jurisdictions of interest (data not shown), estimates are presented for the five jurisdictions combined. While the first report covering the period 2000 to 2002 excluded Victorian notification data, data completeness for this state between 2003 and 2006 substantially improved to be above the 60% threshold for all diseases except pertussis. Indigenous status was reported for approximately 50% of pertussis notification data for New South Wales and Victoria. Additional caution is therefore needed when analysing pertussis notification rates. The accuracy of Indigenous identification within the notification system has not been validated and therefore the possibility that some misreporting might have occurred should be considered in interpreting the data.

As a high proportion of influenza notifications lacked identification of Indigenous status in all states and territories, other than the Northern Territory, influenza was excluded from further analysis.

Other issues

A major limitation of the notification data is that, for most diseases, they represent only a proportion of the total cases occurring in the community, i.e. only those cases for which health care was sought and a diagnosis made, followed by a notification to health authorities.[11] This proportion may vary between diseases and over time, with infections diagnosed by a laboratory test more likely to be notified. States and territories may have varying reporting requirements by medical practitioners, laboratories and hospitals. Under-reporting of notifiable diseases by doctors and from hospitals has been documented in Australia[21] and this may vary between jurisdictions.[22]

Hospitalisations

Indigenous identification

Aggregated hospital separation data for New South Wales, the Northern Territory, Queensland, South Australia and Western Australia are used in this report. These aggregate data cover hospital use for a majority (60%) of the Aboriginal and Torres Strait Islander Australian population. It should be noted that the data from these five jurisdictions do not necessarily represent the national picture, as their hospital experiences will not necessarily be representative of Aboriginal and Torres Strait Islander people living in the other jurisdictions.[2] Jurisdictional differences in data quality, including the degree of Indigenous under-identification, should also be considered when interpreting the results.[2]

The analysis of hospitalisation rates over time should also be interpreted with caution, as hospitalisation rates for Aboriginal and Torres Strait Islander patients may be affected to a varying degree by improved identification over the period being analysed.[2]

Other issues

Recorded hospitalisations generally represent only the most severe end of the morbidity spectrum, so the ability of ICD codes to capture infectious disease-related morbidity varies between diseases. It must also be noted that the hospitalisation database contains a record for each admission, which means that there are separate records for each readmission or inter-hospital transfer. This is unlikely to have a major impact on the numbers reported for most diseases reviewed, as they are acute illnesses. For hospitalisations where the code of interest was not the principal diagnosis, the code of interest will have been recorded as a co-morbidity (additional or secondary diagnosis), the relative importance of which cannot be gauged.

Deaths

Indigenous identification

The accuracy of reporting Indigenous status on deaths has been previously evaluated by comparing the reported number with an expected, or predicted, number of Aboriginal and Torres Strait Islander deaths.[8] Reporting was found to be acceptable for deaths in 1997–1999 in the Northern Territory, Queensland, South Australia and Western Australia. Following previous practice,[8] reported deaths from these four jurisdictions only have been presented in this report. These combined rates may still underestimate Aboriginal and Torres Strait Islander death rates due to under-reporting, and the validity of the Indigenous status data has not been assessed. Mortality rates of Aboriginal and Torres Strait Islander people reported here may not be representative of mortality in the other four jurisdictions.

Other issues

Mortality data were analysed by year of registration rather than by year of death, thereby avoiding incomplete data for the latest available year. In recent years, less than 5% of deaths in a particular calendar year are registered in the subsequent year,[23] with the bulk comprising that calendar year's December deaths.

Vaccination coverage data

Indigenous status identification in the Australian Childhood Immunisation Register

In contrast with the previous report,[1] in which ACIR vaccination coverage data were reported only from selected jurisdictions due to data quality issues with Indigenous status identification, data from all jurisdictions have been used in this report. Rank and Menzies[17] showed that the reporting of Indigenous status in the ACIR had improved from 42% of the estimated national cohort of Aboriginal and Torres Strait Islander children aged 12–14 months in 2002 to 95% in 2006. With the exception of South Australia (where completeness remained at 72%–77%), Indigenous status identification was greater than 90% of expected levels in all jurisdictions by 2005, with the greatest improvement between 2003 and 2004 for most jurisdictions. This probably resulted from several initiatives during this period that improved recording of Indigenous status in

the ACIR. These included promotional efforts for reporting of Indigenous status, commencement of regular transfer of demographic data from Medicare to ACIR, and commencement of transfer of data from some jurisdictional immunisation registers to ACIR.

The use of ACIR coverage estimates for Aboriginal and Torres Strait Islander children relies on the assumption that, in addition to the completeness of recording, the recorded Indigenous status is valid. While the validity of the data has not been formally assessed, two lines of evidence support it. First, previous analysis has found that children reported as Indigenous on the ACIR were more likely to have been reported as receiving vaccines recommended only for Aboriginal and Torres Strait Islander children[1], and secondly, that the coverage estimates were similar to those obtained through a face-to-face survey supported by written records.[18]

Records with no data on Indigenous status have been classified as non-Indigenous for the purpose of this analysis.

General under-reporting in the Australian Childhood Immunisation Register

General limitations of data available from the ACIR must be considered when estimating vaccination coverage. A study conducted in 2001 found that the ACIR underestimated overall Australian immunisation coverage by 2.7% at 12 months of age and by 5% at 24 months of age.[24] Coverage is calculated only for children registered on Medicare; however, data have shown that, by the age of 12 months, practically all Australian children have been registered with Medicare (Kathi Williams, Health Insurance Commission, personal communication, April 2004).

Validity of reported vaccination status in the National Aboriginal and Torres Strait Islander Health Survey

Vaccination status data were collected by patient recall only. For adult vaccinations, some respondents were unfamiliar with the term 'pneumococcus', and some were confused between the influenza and pneumococcal vaccinations. However, it was found this mainly applied to persons who had not had either vaccination and that those who had been vaccinated could generally report with certainty.[19] The validity of self-reported vaccination status in elderly individuals has been shown to be higher for receipt of influenza vaccine within 12 months than for receipt of pneumococcal vaccine within the previous five years. Population coverage estimates for influenza vaccine using self-report have generally been slightly higher than provider-validated estimates (1%–10%).[25] For pneumococcal vaccine the differences have been more variable, but self-reported estimates have generally been lower than validated estimates by around 10%.[25] Validity has not been assessed in Indigenous or remote populations.

Risk factor prevalence information from the 2004–05 National Aboriginal and Torres Strait Islander Health Survey

While data from the 2004–05 NATSIHS enable, to a certain extent, estimation of the prevalence of risk factors for which the influenza and pneumococcal vaccine were recommended in Aboriginal and Torres Strait Islander people aged 15–49 years,[20] the survey was not primarily designed for collecting this information. Due to the questionnaire design, the classification of responses and the necessary data aggregation procedures undertaken by the ABS, conditions included in the prevalence estimates in this report do not exactly match the vaccination recommendations. Some specific conditions on the recommendation list could not be individually selected and included (e.g. cerebrospinal fluid leak, organ transplant recipients, chronic suppurative lung diseases), and chronicity and severity of some conditions (e.g. asthma) could not be differentiated. Overall, the selected list of conditions would probably provide the lower-end estimate of the true prevalence.

Aboriginal and Torres Strait Islander population estimates

Estimation of the size and age composition of the Aboriginal and Torres Strait Islander population is difficult. Increases in census counts of Aboriginal and Torres Strait Islander people between 1966 and 1996 are far greater than can be explained by simple demographic factors (births minus deaths).[26] Other factors thought to be important include changes in: the propensity to identify as Aboriginal and Torres Strait Islander in the Census; the proportion of children with only one Aboriginal and Torres Strait Islander parent identified as Indigenous; and Census enumeration procedures.[6,8,26]

In this report, Australian Bureau of Statistics experimental estimates and projections low series, Aboriginal and Torres Strait Islander Australians population figures, based on 2001 Census data, are used.

Results

Haemophilus influenzae type b disease

Haemophilus influenzae is a Gram-negative bacterium which occurs in both encapsulated and unencapsulated forms. It is a commensal of the nasopharynx, especially in young children. Before Hib vaccines became available, one encapsulated serotype, type b (Hib), caused at least 95% of invasive disease due to *H. influenzae* in children.[27,28] Prior to the introduction of Hib vaccination, the most common manifestation of invasive Hib disease was meningitis, with children aged less than 18 months most at risk.[27,28] Aboriginal and Torres Strait Islander children had a particularly elevated risk of Hib meningitis, with rates among the highest recorded anywhere in the world, but rarely developed epiglottitis.[29] Survivors of Hib meningitis commonly had neurological sequelae such as deafness and intellectual impairment.[27,28] Epiglottitis was the other major category of infection, most often occurring in children over the age of 18 months. Other manifestations of Hib disease include cellulitis, septic arthritis, pneumonia, pericarditis, osteomyelitis and septicaemia.

Case definitions

Notifications

National definition from January 2004:[10]

a. Isolation of *Haemophilus influenzae* type b (Hib) from a normally sterile site where typing has been confirmed at an approved reference laboratory; or

b. Detection of Hib antigen in cerebrospinal fluid when other laboratory parameters are consistent with meningitis.

(See Appendix D for pre-2004 definition)

Hospitalisations and deaths

c. Hospitalisations and deaths were not analysed as there are no ICD-10-AM/ICD-10 codes which specify Hib as a causative organism, as opposed to *Haemophilus influenzae* (type unspecified).

Distribution by Indigenous status and age

Of the total 51 notifications of invasive Hib disease recorded in New South Wales, the Northern Territory, South Australia, Victoria and Western Australia over the four years between 2003 to 2006, 10 (24%) were identified as occurring in Aboriginal and Torres Strait Islander people (Table 1).

Children 0–4 years of age accounted for 22 (43%) of all the Hib notifications and, of these, seven (32%) were identified as Aboriginal and Torres Strait Islander, with a rate of 4 per 100,000 (Table 1).

The overall Indigenous to non-Indigenous notification rate ratio was 8.8:1 and statistically significantly above 1.0 overall and in both age groups, highest in the 0–4 year age group (11 per 100,000, Table 1).

Comment

The Hib immunisation program in Australia commenced in April 1993, with catch-up immunisation for children up to 5 years of age from July 1993. Until June 2000, Aboriginal and Torres Strait Islander children were scheduled to receive a different Hib vaccine (conjugated to the outer membrane of *Neisseria meningitidis* type C, PRP-OMP) than other children who received a vaccine conjugated to a mutant diphtheria toxin (CRM197). The OMP vaccine provides protection at an earlier age than other Hib vaccines. From June 2000, all Australian children received PRP-OMP vaccine. In November 2005, a hexavalent combination vaccine (DTP-HepB-IPV-Hib) with PRP-T Hib component became available. From that time, Aboriginal and Torres Strait Islander children in the Northern Territory, Queensland, South Australia and Western Australia continued to receive the PRP-OMP vaccine, while non-Indigenous children and Indigenous children in other jurisdictions may receive either vaccine.

Table 1. Hib notifications, selected Australian states, 2003 to 2006, by age group and Indigenous status

Age group (years)	Indigenous status	Notifications* (2003–2006)		
		n	Rate†	Rate ratio
0–4	Indigenous	7	4.3	10.6
	Other	15	0.4	
5 and over	Indigenous	3	0.3	5.6
	Other	26	0.0	
All ages‡	Indigenous	10	0.6	8.8
	Other	41	0.1	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† Average annual age-specific rate per 100,000 population.

‡ Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 ($p<0.5$).

Vaccination has had a striking impact on the incidence of Hib disease in the age groups targeted by immunisation programs, among both Aboriginal and Torres Strait Islander and non-Indigenous children.[30] Compared with an incidence of 35–40 per 100,000 in non-Indigenous children and up to 280 per 100,000 in Indigenous children aged less than 5 years living in the Northern Territory,[31] notification rates presented in this report (0.4 and 4, respectively, in 2003–2006) represent a reduction of 50– to 100-fold since vaccination was introduced.

While the number of cases decreased markedly, the proportion of total Hib disease cases occurring in Aboriginal and Torres Strait Islander people increased from around 7% before 1993[30] to 28% in 2000–2002.[1] However, there does not appear to have been further exacerbation of this disparity during the period covered in this report as there have been slight decreases, in comparison with the previous report, in the proportion being Aboriginal and Torres Strait Islander (24%), in point estimates for the rate in Indigenous people (0.6/100,000 population/year vs 1.2) and in the Indigenous to non-Indigenous rate ratio (8.8:1 vs 9.7:1).

A similar pattern of substantially reduced incidence but widening disparity between rates in Indigenous and non-Indigenous populations was also seen in the United States[32] and New Zealand.[33] The disparity appears to have reduced in more recent data.[32,34]

Higher rates of Hib disease have been associated with crowded living conditions and consequent high levels of Hib colonisation in the nasopharynx. While there is no evidence of low vaccination coverage,[18,31,34,35] it cannot be ruled out in some local areas. Sustained high coverage with PRP-OMP vaccine in areas of high incidence and improvements in environmental living conditions are needed to eliminate this disparity.

Hib vaccination has been very successful in preventing disease in Aboriginal and Torres Strait Islander children. The number of Hib cases continues to decline; however, Aboriginal and Torres Strait Islander people still record rates nearly nine times higher than people presumed to be non-Indigenous. This difference is greatest in children 0–4 years of age.

Hepatitis A

Acute infection with the hepatitis A virus (HAV), a picornavirus, presents a clinical spectrum from malaise and diarrhoea to acute hepatitis with jaundice to fulminant liver failure. Onset of symptoms is usually abrupt with fever, anorexia, malaise, nausea and abdominal discomfort followed by jaundice and dark urine.[36,37] The single most important factor in determining the clinical presentation and outcome of HAV infection is age. Whilst only 10%–50% of infections acquired before the age of 5 years are symptomatic, 70%–95% of infected adults will show symptoms.[38]

Case definitions

Notifications

National definition from January 2004:[10]

a. Detection of anti-hepatitis A virus IgM antibody, in the absence of recent vaccination;

or

b. Detection of hepatitis A virus by nucleic acid testing;

or

c. Clinical hepatitis (jaundice and/or bilirubin in urine) without a non-infectious cause and an epidemiological link to a laboratory-confirmed case.

(See Appendix D for pre-2004 definition)

Hospitalisations and deaths

The ICD-10-AM/ICD-10 codes B15 (hepatitis A) were used to identify hospitalisations and deaths.

Distribution by Indigenous status and age

Of the total 1,169 notifications of hepatitis A recorded in New South Wales, the Northern Territory, South Australia, Victoria and Western Australia over the four years from 2003 to 2006, 162 (14%) were identified as occurring in Aboriginal and Torres Strait Islander people (Table 2). For hospitalisations, 66 (11%) of the total 581 cases were in Aboriginal and Torres Strait Islander people in the three-year period July 2002 to June 2005 in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia (Table 3).

Both notification and hospitalisation rates were highest among children aged 0–4 years identified as Aboriginal and Torres Strait Islander (34 and 12 per 100,000, respectively). Figure 1 illustrates the striking difference between young children and others when comparing notifications for Aboriginal and Torres Strait Islander and other people. All the hospitalisations and notifications aged 0–4 years that were recorded as Aboriginal and Torres Strait Islander were from the Northern Territory, Queensland, South Australia or Western Australia. Of the 55 notifications recorded as Aboriginal and Torres Strait Islander in that age group, 9 (16%) were diagnosed in 2006.

The overall Indigenous to non-Indigenous rate ratio was 4.9:1 for notifications and 3.6:1 for hospitalisations and both ratios were statistically significantly above 1.0. In children aged 0–4 years, the rate ratios were higher and statistically significant, at 24 for notifications and 157 for hospitalisations. This excess morbidity falls sharply with age, with smaller but substantial Indigenous versus other rate ratios among children 5–14 years of age (7.5:1 for notifications, 9.5:1 for hospitalisations), decreasing to 3:1 or less from age 15 years.

Over the six-year period July 1999 to June 2005, the difference in hospitalisation rates for hepatitis A for Aboriginal and Torres Strait Islander and other people for all age groups has declined in both groups with a more marked decline in Indigenous rates (Figure 2). The higher rates in 1999/2000 and 2002/2003 correspond to periods of higher rates in Western Australia.

During the period 2003 to 2005, there was one reported death due to hepatitis A in the Northern Territory, Queensland, South Australia and Western Australia. It occurred in an Aboriginal and Torres Strait Islander person aged over 50 years.

Table 2. Hepatitis A notification rates, selected Australian states, 2003 to 2006, by age group and Indigenous status

Age group (years)	Indigenous status	Notifications* (2003–2006)		
		n	Rate†	Rate ratio
0–4	Indigenous	55	33.9	24.4
	Other	51	1.4	
5–14	Indigenous	64	19.7	7.5
	Other	207	2.6	
15–24	Indigenous	20	7.5	3.4
	Other	182	2.2	
25–49	Indigenous	19	4.4	2.5
	Other	388	1.8	
50+	Indigenous	4	2.7	2.9
	Other	179	0.9	
All ages‡	Indigenous	162	8.1	4.9
	Other	1,007	1.7	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† Average annual age-specific rate per 100,000 population.

‡ Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Table 3. Hepatitis A hospitalisations and deaths, selected Australian states, 2002 to 2005, by age group and Indigenous status

Age group (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths† 2003–2005
		n	Rate‡	Rate ratio	n
0–4	Indigenous	20	12.3	157.0	0
	Other	2	0.1		0
5–14	Indigenous	14	4.3	9.5	0
	Other	25	0.5		0
15–24	Indigenous	7	2.7	2.6	0
	Other	60	1.0		0
25–49	Indigenous	21	5.0	3.1	0
	Other	245	1.6		0
50+	Indigenous	4	2.8	2.0	1
	Other	183	1.4		0
All ages§	Indigenous	66	4.4	3.6	1
	Other	515	1.2		0

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

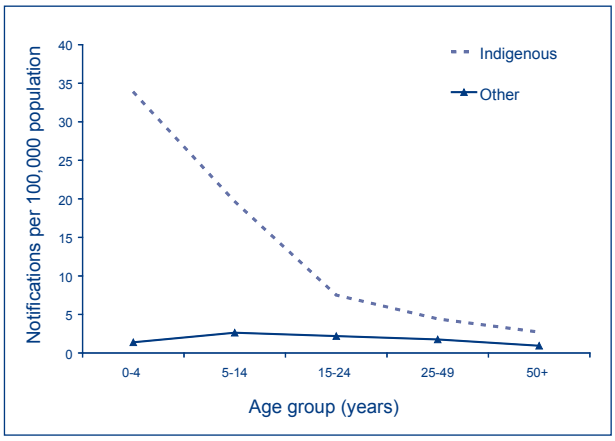
† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

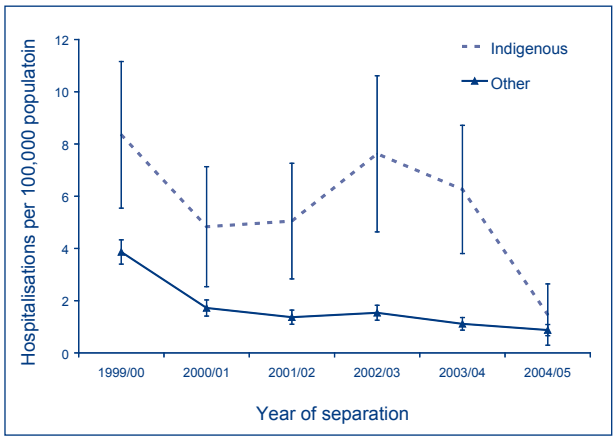
Figure 1. Hepatitis A notification rates, selected Australian states,* 2003 to 2006,† by age group and Indigenous status



* New South Wales, the Northern Territory, South Australia, Victoria and Western Australia.

† Notifications where the date of diagnosis was between 1 January 2003 and 31 December 2006.

Figure 2. Hepatitis A hospitalisation rates, selected Australian states,* 1999 to 2005,† by Indigenous status



* The Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 1999 and 30 June 2005. Rates are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Comment

In 1999, an immunisation program commenced for Aboriginal and Torres Strait Islander children, aged 18 months to 6 years living in north Queensland, which had a significant impact on reducing hepatitis A across the community.[39] This program was expanded in November 2005 to include all Aboriginal and Torres Strait Islander children aged 12–24 months in the Northern Territory, Queensland, South Australia and Western Australia.[40] The need for this program is underlined by the fact that all hospitalisations and notifications recorded as Indigenous in children aged 0–4 years in the period covered in this report were from these jurisdictions.

The pattern of acquisition of hepatitis A is known to vary substantially according to living standards. More advantaged communities have delayed or no exposure to hepatitis A, with the majority seronegative even in middle age. In contrast, communities living in crowded and/or less hygienic circumstances acquire infection and immunity to hepatitis A at an early age. In the Northern Territory in 1994, a serosurvey in rural Aboriginal populations found hepatitis A to be hyperendemic, with acquisition of the virus predominately in the first five years of life.[41] Temporal trends in hepatitis A are dominated by sporadic cases, point-source outbreaks and community epidemics. The decline in hospitalisation rates in non-Indigenous people seen in Figure 2 coincides with the end of an epidemic focused on men who have sex with men and injecting drug users,[42–45] while the more variable pattern in Aboriginal and Torres Strait Islander hospitalisations may be due to lower numbers and/or reflect local outbreaks. It may also show some impact of vaccination in north Queensland, but the data end shortly before the commencement of the expanded national program.

In the United States, hepatitis A cases decreased substantially following the recommendation of vaccination of children in communities with high rates of disease in 1996, and for children in states and counties with high hepatitis A notification rates in 1999. In 2006, this was expanded to include all US infants, as part of a staged implementation of progressively expanded vaccination.[46] Continued monitoring should be a priority in Australia, both to assess the impact of these recent changes, and the need for any further expansion of vaccination.

Aboriginal and Torres Strait Islander people of all ages experience rates of hepatitis A significantly higher than presumed non-Indigenous Australians. The rates per 100,000 are highest for young Aboriginal and Torres Strait Islander children less than 5 years of age. It is hoped that the recently commenced Indigenous childhood vaccination program in four jurisdictions will have a substantial impact on this discrepancy.

Hepatitis B (acute)

Acute infection with hepatitis B virus (HBV) produces a range of conditions from subclinical infection to acute and, rarely, fulminant hepatitis. The majority of HBV infections are not clinically recognised, with less than 10% of children and 30%–50% of adults experiencing jaundice.[36,47] When illness occurs, it is usually insidious, with anorexia, vague abdominal discomfort, nausea and vomiting, sometimes arthralgia and rash, often progressing to jaundice. The main burden of disease is related to chronic HBV infection. The risk of chronic infection is greatest in those infected as infants, particularly if infected in the perinatal period. Of people chronically infected with HBV, 15%–40% develop cirrhosis of the liver and/or hepatocellular carcinoma.[48,49]

HBV transmission occurs by percutaneous or permucosal exposure to infective body fluids such as blood, semen, vaginal secretions and any other body fluid containing blood.[36] Major modes of transmission include sexual or close household contact with an infected person, perinatal transmission from mother to infant, injecting drug use and nosocomial exposure.[36] The analysis in this report is restricted to acute hepatitis B.

Case definitions

Notifications

National definition for newly acquired hepatitis B from January 2004:[10]

a. Detection of hepatitis B surface antigen (HBsAg) in a patient shown to be negative within the last 24 months; or

b. Detection of HBsAg and IgM to hepatitis B core antigen, in the absence of prior evidence of hepatitis B virus infection; or

c. Detection of hepatitis B virus by nucleic acid testing, and IgM to hepatitis B core antigen, in the absence of prior evidence of hepatitis B virus infection.

(See Appendix D for pre-2004 definition)

Hospitalisations

The ICD-10-AM code used to identify hospitalisations was B16 (acute hepatitis B).

As in the previous report,[1] hospitalisations were included only where the relevant ICD code was the principal diagnosis.

Deaths

The ICD-10 code B16 (acute hepatitis B) was used to select deaths from acute hepatitis B.

Distribution by Indigenous status and age

Of the total 916 notifications of acute hepatitis B recorded in New South Wales, the Northern Territory, South Australia, Victoria and Western Australia over the four years from 2003 to 2006, 56 (6%) were identified as occurring in Aboriginal and Torres Strait Islander people (Table 4). For hospitalisations, 27 (9%) of the total 296 cases were recorded as Aboriginal and Torres Strait Islander in the three-year period July 2002 to June 2005 in New South Wales, the Northern Territory Queensland, South Australia and Western Australia (Table 5).

No hospitalised cases of hepatitis B were recorded as Aboriginal and Torres Strait Islander among children 0–4 years of age. However, one Aboriginal and Torres Strait Islander child in the 0–4 year age group was recorded in the hepatitis B notification data. Notification rates for acute hepatitis B increased progressively with age, peaking at age 15–24 years in those recorded as Indigenous and 25–49 years in presumed non-Indigenous people (Figure 3). Hospitalisation rates peaked in the 25–49 year age group for both cases identified as Indigenous and those presumed non-Indigenous.

The overall Indigenous to non-Indigenous rate ratio was 3.1:1 for notifications and 3.8:1 for hospitalisations and both ratios were statistically significantly above 1.0 (Table 4 and Table 5). The rate ratios for notifications were greater than 1.0 in all age groups, highest in those aged 5–14 years, and statistically significant in all age groups except 0–4 years. The rate ratios for hospitalisations were greater than 1.0 in all age groups except 0–4 years and statistically significant in the 25–49 year age group.

No time series analysis of hospitalisations was conducted due to small numbers.

Table 4. Hepatitis B notification rates, selected Australian states, 2003 to 2006, by age group and Indigenous status

Age group (years)	Indigenous status	Notifications* (2003–2006)		
		n	Rate†	Rate ratio
0–4	Indigenous	1	0.6	2.3
	Other	10	0.3	
5–14	Indigenous	3	0.9	8.1
	Other	9	0.1	
15–24	Indigenous	22	8.3	3.6
	Other	191	2.3	
25–49	Indigenous	26	6.0	2.4
	Other	559	2.5	
50+	Indigenous	4	2.7	5.6
	Other	91	0.5	
All ages‡	Indigenous	56	4.3	3.1
	Other	860	1.4	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† Average annual age-specific rate per 100,000 population.

‡ Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Table 5. Hepatitis B hospitalisations and deaths, selected Australian states, 2002 to 2005, by age group and Indigenous status

Age group (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths† 2003–2005
		n	Rate‡	Rate ratio	n
0–4	Indigenous	0	0.0	–	0
	Other	0	0.0		0
5–14	Indigenous	3	0.9	5.6	0
	Other	9	0.2		0
15–24	Indigenous	5	1.9	2.1	0
	Other	52	0.9		0
25–49	Indigenous	16	3.8	3.8	0
	Other	151	1.0		5
50+	Indigenous	3	2.1	4.8	0
	Other	57	0.4		9
All ages§	Indigenous	27	2.4	3.8	0
	Other	269	0.6		14

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

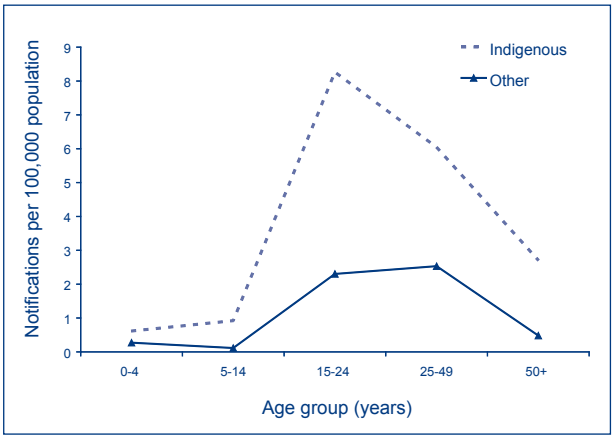
† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Figure 3. Hepatitis B notification rates, selected Australian states,* 2003 to 2006,† by age group and Indigenous status



* New South Wales, the Northern Territory, South Australia, Victoria and Western Australia.

† Notifications where the date of diagnosis was between 1 January 2003 and 31 December 2006.

There were no Aboriginal and Torres Strait Islander deaths from acute hepatitis B recorded in the Northern Territory, Queensland, South Australia and Western Australia between 2003 and 2005 and 14 in people presumed to be non-Indigenous.

Comment

Hepatitis B immunisation efforts initially focused, in both Indigenous and non-Indigenous Australians, on preventing maternal-infant transmission. During the late 1980s and 1990s, programs targeted newborn Aboriginal and Torres Strait Islander infants as one of several groups at high risk. In the Northern Territory, hepatitis B vaccine has been routinely given at birth to Aboriginal and Torres Strait Islander infants since 1988 and to all infants since August 1990. Adolescent vaccination programs commenced from 1997 and the universal infant hepatitis B immunisation program was introduced in all jurisdictions in May 2000.[20]

In the pre-vaccine era, high rates of chronic infection (5%–40%) in Aboriginal and Torres Strait Islander Australians were associated with infection in early childhood, and reflected in a rate of hepatocellular carcinoma up to 10 times that in non-Indigenous people.[47,50] In more recent years, there has been little reported infection in children and adolescents, the vast majority of reported disease occurring in those aged 15–49 years, and disproportionately high rates in Aboriginal and Torres Strait Islander people of all ages.[1] That pattern continues in the data presented here.

These data underestimate acute hepatitis B disease as they are unlikely to include asymptomatic infections, and do not reflect the significant chronic disease burden from hepatitis B, and later complications such as liver cirrhosis and hepatocellular carcinoma. However, the substantial impact of universal hepatitis B vaccination on all these manifestations of hepatitis B infection, on both high and low risk populations and Aboriginal and Torres Strait Islander people, has been demonstrated in Australia and overseas.[51–54]

Aboriginal and Torres Strait Islander people used to have high rates of infection in children, resulting in high rates of liver disease in adults. As a result of universal hepatitis B vaccination, rates of acute hepatitis B are low in Indigenous and non-Indigenous children. However, the rates are still significantly higher amongst unvaccinated Aboriginal and Torres Strait Islander adults.

Influenza and pneumonia

Influenza is an acute respiratory illness caused by influenza type A or B viruses. Symptoms include abrupt onset of fever, cough, malaise, myalgia, sore throat, and headache. Influenza epidemics usually occur during the winter months in temperate climates, causing an increase in hospitalisations for pneumonia and exacerbation of chronic diseases, and also contributing to increased mortality, particularly among the elderly and those with high risk underlying conditions. The most common complication of influenza is pneumonia. It is generally believed that hospitalisations and deaths coded as influenza significantly underestimate disease burden, with excess all-cause pneumonia and influenza combined, during the influenza season, being a better indicator of true burden.[55]

Case definitions

Notifications

Not included, due to low completeness of Indigenous status.

Hospitalisations and deaths

The ICD-10-AM/ICD-10 codes J10 and J11 (influenza) were used to identify hospitalisations and deaths from influenza. The ICD-10-AM/ICD-10 codes J10 to J18 were used to identify hospitalisations and deaths from influenza and all-cause pneumonia combined.

Distribution by Indigenous status and age

Of the total 7,378 hospitalisations for influenza and 223,863 hospitalisations for influenza and pneumonia combined in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia in the three-year period July 2002 to June 2005, 566 (8%) and 16,680 (7%) were identified as occurring in Aboriginal and Torres Strait Islander people, respectively (Table 6).

The annual age-standardised influenza hospitalisation rate was 38 per 100,000 for Aboriginal and Torres Strait Islander people compared with 16 per 100,000 for people presumed to be non-Indigenous. The equivalent rates for influenza and pneumonia combined were 1,696 and 486, respectively.

The rates for influenza and pneumonia combined are substantially higher than for influenza alone. However, the distribution by age and Indigenous status are broadly similar (see Figure 4 and Figure 5, allowing for different scales). This pattern consists of high rates for both Indigenous and non-Indigenous children 0–4 years of age, falling substantially for the age groups 5–14 and 15–24 years, before rising again in adults aged 25 years or more.

The overall Indigenous to non-Indigenous rate ratio was 2.3:1 for influenza and 3.5:1 for influenza and pneumonia combined, and both ratios were statistically significantly above 1.0 (Table 6). These rate ratios were greater than 1.0 and statistically significant in all age groups except 5–14 years for influenza. The highest rate ratio was 8 in the 25–49 year age group for influenza and pneumonia combined.

Of the total 49 deaths from influenza and 4,040 deaths from influenza or pneumonia in the Northern Territory, Queensland, South Australia and Western Australia between 2003 and 2005, 2 and 126, respectively, were identified as Aboriginal and Torres Strait Islander. The rate ratio for deaths was highest in those aged 25–49 years (20) and 15–24 years (9).

Over the six-year period July 1999 to June 2005, the age-standardised influenza hospitalisation rates for Aboriginal and Torres Strait Islander people have declined substantially, but still remain higher than in non-Indigenous people (Figure 6). In non-Indigenous people, the rates have also declined, with the exception of the year 2003/2004, but less dramatically. The decline in rates in Aboriginal and Torres Strait Islander people from 1999/2000 occurred predominantly in Western Australia and in adults aged 25 years or more, while increases in 2003/2004 occurred predominantly in 0–4 year olds and in the Northern Territory, South Australia and Western Australia (data not shown). This pattern is not repeated for the combined influenza and pneumonia rates. For the same six-year period, influenza and pneumonia hospitalisation rates in Aboriginal and Torres Strait Islander people have remained substantially higher than the rates for non-Indigenous people, with no evidence that the gap has narrowed (Figure 7). Rates for influenza and pneumonia combined

Table 6. Influenza and pneumonia hospitalisations and deaths, selected Australian states, 2002 to 2005, by age group and Indigenous status

Age groups (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)						Deaths† 2003–2005			
		Influenza			Influenza and pneumonia			Influenza	Influenza and pneumonia		
		n	Rate‡	Rate ratio	n	Rate‡	Rate ratio	n	n	Rate†	Rate ratio
0–4	Indigenous	330	202	2.1	4,615	2,830	3.5	0	0	0	0
	Other	2,432	95		20,818	813		1	4	0.3	
5–14	Indigenous	32	10	0.9	1,083	331	2.2	0	1	0.5	2.7
	Other	587	11		8,165	148		1	5	0.2	
15–24	Indigenous	47	18	2.2	993	380	4.4	0	2	1.1	8.7
	Other	482	8		4,999	87		1	4	0.1	
25–49	Indigenous	91	21	2.6	5,511	1,301	8.4	1	46	15.9	19.7
	Other	1,276	8		23,672	155		5	65	0.8	
50+	Indigenous	66	46	3.0	4,477	3,135	2.7	0	60	64.1	1.1
	Other	2,035	16		149,529	1,143		39	3,820	55.8	
All ages§	Indigenous	566	38	2.3	16,680	1,696	3.5	2	126	25.1	1.5
	Other	6,812	16		207,183	486		47	3,914	17.1	

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

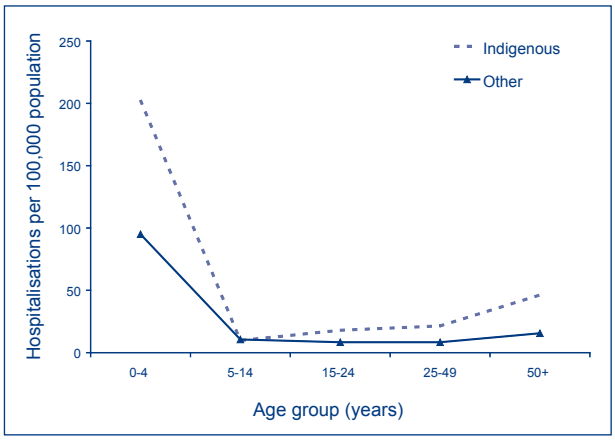
† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

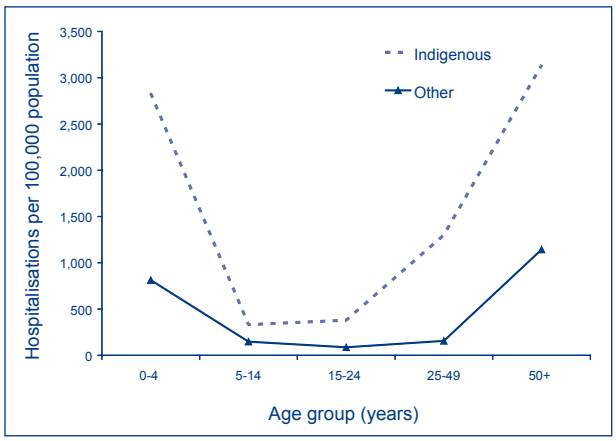
Figure 4. Influenza hospitalisation rates, selected Australian states,* 2002 to 2005,† by age group and Indigenous status



* New South Wales, the Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 2002 and 30 June 2005.

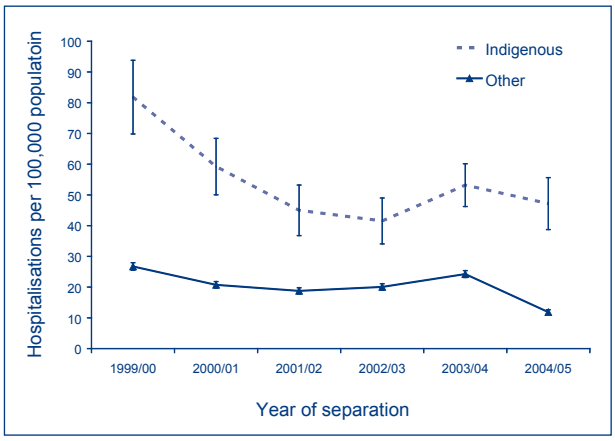
Figure 5. Influenza and all pneumonia combined hospitalisation rates, selected Australian states,* 2002 to 2005,† by age group and Indigenous status



* New South Wales, the Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 2002 and 30 June 2005.

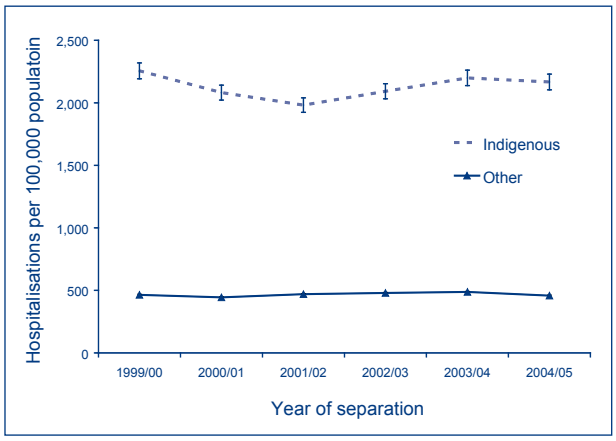
Figure 6. Influenza hospitalisation rates, selected Australian states,* 1999 to 2005,† by Indigenous status



* The Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 1999 and 30 June 2005. Rates are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Figure 7. Influenza and pneumonia hospitalisation rates, selected Australian states,* 1999 to 2005,† by Indigenous status



* The Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 1999 and 30 June 2005. Rates are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

have been relatively stable in both Indigenous and non-Indigenous people, with the exception of a transitory decline in Aboriginal and Torres Strait Islander people in 2001/2002.

Comment

The relatively high morbidity from influenza and related conditions in older Aboriginal and Torres Strait Islander adults led to a specific program for influenza vaccine being funded nationally from 1999 for Aboriginal and Torres Strait Islander adults aged 50 years or more and those aged 15–49 years with risk factors.[56] This is in contrast to the non-Indigenous population, for whom influenza vaccine was funded only from age 65 years. From 2007, annual influenza vaccination is recommended for all Aboriginal and Torres Strait Islander adults.[57]

Influenza hospitalisation time trends are usually dominated by peaks due to the sporadic appearance of new influenza strains. The 2003/2004 peak in influenza hospitalisations reflects a more severe influenza season nationally in 2003, followed by a mild season in 2004.[5] However, the disproportionate decline in Aboriginal and Torres Strait Islander hospitalisations from 1999/2000, predominantly in adults, suggests some possible impact of the Indigenous adult vaccination program. This does not appear to be the case for hospitalisations due to pneumonia or influenza, but the latter is a non-specific diagnosis with multiple aetiologies.

Young children experience higher morbidity from influenza than any other age group, and hospitalisation rates in those aged less than 5 years were double those in the previous report. This may reflect higher influenza morbidity in the four states presented in this report, and may also be influenced by different circulating strains or diagnostic practices. The importance of young children, both in terms of their own high morbidity from influenza and their role in transmission of influenza to adults, has been increasingly appreciated internationally in recent years.[58] This has led to recommendations in the United States and Canada that all children between 6 months and 5 years or 23 months of age, respectively, receive influenza vaccine.[59,60]

This recommendation is particularly pertinent to Aboriginal and Torres Strait Islander children in Australia, where influenza may contribute significantly to overall respiratory morbidity in children and in adults they are in contact with, especially in crowded living conditions.

Aboriginal and Torres Strait Islander people continue to experience significantly higher rates of influenza and pneumonia than non-Indigenous people, with children less than 5 years of age and adults aged 25 years or more most at risk.

Measles

Measles is an acute and highly communicable disease caused by a morbillivirus. The clinical picture primarily includes prodromal fever and Koplik spots on the buccal mucosa, rash, and often conjunctivitis, coryza and cough. Complications include otitis media, pneumonia and encephalitis. Subacute sclerosing panencephalitis (SSPE) occurs very rarely as a late sequela of wild infection but not vaccination.[36]

Case definitions

Notifications

National definition from January 2004:[10]

a. Isolation of measles virus (confirmed case); or

b. Detection of measles virus by nucleic acid testing (confirmed case); or

c. Detection of measles virus antigen (confirmed case); or

d. Measles virus-specific IgG seroconversion or significant increase in IgG antibody level or a fourfold or greater rise in antibody titre to measles virus, with paired sera tested in parallel and in the absence of receipt of measles-containing vaccine eight days to eight weeks prior to testing (confirmed case); or

e. Detection of measles virus-specific IgM antibody confirmed in an approved reference laboratory, in the absence of recent measles-containing vaccination (confirmed case); or

f. A clinical illness characterised by a generalised maculopapular rash lasting at least three days, fever of at least 38°C at the time of rash onset and either cough, coryza, conjunctivitis or Koplik spots, together with an epidemiological link to a confirmed case (confirmed case); or

g. A clinical illness as in point (f) above, together with detection of measles-specific IgM antibody other than by an approved reference laboratory (in the absence of recent measles-containing vaccination) (probable case).

(See Appendix D for pre-2004 definition)

Hospitalisations and deaths

The ICD-10-AM/ICD-10 code B05 (measles) was used to identify hospitalisations and deaths. SSPE was not included in these analyses.

Distribution by Indigenous status

Of the total 246 measles notifications recorded in New South Wales, the Northern Territory, South Australia, Victoria and Western Australia over the four years from 2003 to 2006, 9 (4%) were identified as occurring in Aboriginal and Torres Strait Islander people (Table 7). For hospitalisations, 4 (7%) of the total 55 measles cases were identified as Aboriginal and Torres Strait Islander in the three-year period July 2002 to June 2005 in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia (Table 8).

The overall Indigenous to non-Indigenous rate ratio was 0.6:1 for notifications and 2.0:1 for hospitalisations, neither ratio being statistically significantly different to 1.0 (Table 7 and Table 8).

No time series analysis of hospitalisations was conducted due to the small numbers.

One adult death was recorded from measles in the Northern Territory, Queensland, South Australia and Western Australia for the three years 2003 to 2005. However, on further investigation this was found to be due to subacute sclerosing panencephalitis, a rare sequela of childhood infection, and was not reported here.[5]

Comment

Measles vaccination was recommended for all Australian children at 12 months and 4 years of age for the period covered in this report. Epidemics of measles continued to occur in Australia for several decades after the introduction of vaccination in 1969.[5] Measles was associated with higher levels of morbidity, and some deaths, among Aboriginal and Torres Strait Islander children, prompting the Northern Territory in 1984 to immunise Aboriginal and Torres Strait Islander infants at 9 months of age, with a subsequent booster.[61]

Table 7. Measles notification rates, selected Australian states, 2003 to 2006, by age group and Indigenous status

Age group (years)	Indigenous status	Notifications* (2003–2006)		
		n	Rate†	Rate ratio
All ages‡	Indigenous	9	0.6	1.4
	Other	237	0.4	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† Average annual age-specific rate per 100,000 population.

‡ Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Table 8. Measles hospitalisations and deaths, selected Australian states, 2002 to 2005, for all ages combined, by Indigenous status

Age group (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths† 2003–2005
		n	Rate‡	Rate ratio	n
All ages§	Indigenous	4	0.2	2.0	0
	Other	51	0.1		0

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

This program ended in 1998,[62] the year of the national Measles Control Campaign, which involved catch-up immunisation of 1.3 million children aged 5–12 years, and the moving of the second dose of measles-mumps-rubella (MMR) vaccine from 12 to 4 years of age.[63]

Measles notifications and hospitalisations are now at record lows in Australia, dominated by limited local outbreaks, mainly among young adults who were born at a time when vaccination coverage was low, and triggered by cases acquired overseas.[5] No excess morbidity from measles in Aboriginal and Torres Strait Islander people is evident in data presented in this report, or the previous report covering 1999 to 2002.[1]

The successful control of measles in Aboriginal and Torres Strait Islander people is a reflection of the almost total success of immunisation in preventing measles transmission, in contrast to other VPDs such as pertussis or Hib disease. It illustrates the importance of universal programs, across all relevant age groups in the population, in disease prevention in both Indigenous and non-Indigenous people.

Universal measles vaccination has successfully controlled measles in Australia, including amongst Aboriginal and Torres Strait Islander people.

Meningococcal disease

Meningococcal disease is defined as isolation of *Neisseria meningitidis* from cerebrospinal fluid (CSF), blood and other normally sterile sites, as well as skin lesions. Clinical manifestations include meningitis, meningococcaemia without meningitis (which varies in presentation from fulminant to chronic), meningitis and meningococcaemia combined, and septic arthritis.

Case definitions

Notifications

National definition from January 2004:[10]

Confirmed cases require either laboratory definitive evidence or laboratory suggestive evidence and clinical evidence. Probable cases require specified clinical evidence only (as below) and are also notifiable.

a. Laboratory definitive evidence
   - Isolation of *Neisseria meningitidis* from a normally sterile site.

b. Laboratory suggestive evidence
   - Detection of meningococcus from a normally sterile site by nucleic acid testing; or
   - Detection of Gram-negative diplococci in Gram stain of specimen from a normally sterile site or from a suspicious skin lesion; or
   - High titre IgM or significant rise in IgM or IgG titres to outer membrane protein antigens of *N. meningitidis;* or
   - Positive polysaccharide antigen test in cerebrospinal fluid with other laboratory parameters consistent with meningitis.

c. Clinical evidence (for confirmed cases with laboratory suggestive evidence)
   - Disease which, in the opinion of the treating clinician, is compatible with invasive meningococcal disease.

d. Clinical evidence for notification of probable cases
   - The absence of evidence for other causes of clinical symptoms and either
   - Clinically compatible disease including haemorrhagic rash; or
   - Clinically compatible disease AND close contact with a confirmed case within the previous 60 days.

(See Appendix D for pre-2004 definition)

Hospitalisations and deaths

The ICD-10-AM code used to identify hospitalisations and deaths was A39 (meningococcal infection). This includes meningococcal meningitis (A39.0), Waterhouse-Friderichsen syndrome (A39.1), acute meningococcaemia (A39.2), chronic meningococcaemia (A39.3), meningococcaemia unspecified (A39.4), meningococcal heart disease (A39.5), other meningococcal infections (A39.8), and meningococcal infection unspecified (A39.9).

Distribution by Indigenous status and age

Of the total 1,263 notifications of meningococcal disease recorded in New South Wales, the Northern Territory, South Australia, Victoria and Western Australia over the four years from 2003 to 2006, 106 (8%) were identified as occurring in Aboriginal and Torres Strait Islander people (Table 9). For hospitalisations, 117 (8%) of the total 1,507 cases were in people identified as Aboriginal and Torres Strait Islander in the three-year period July 2002 to June 2005 in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia (Table 10).

Incidence was highest in 0–4 year olds for Indigenous and presumed non-Indigenous people. There was a smaller peak at age 15–24 years for non-Indigenous people and 25–49 years for Indigenous people (Table 9 and Table 10, Figure 8).

Table 9. Meningococcal notification rates, selected Australian states, 2003 to 2006, by age group and Indigenous status

Age group (years)	Indigenous status	Notifications* (2003–2006)		
		n	Rate†	Rate ratio
0–4	Indigenous	73	44.9	4.9
	Other	337	9.2	
5–14	Indigenous	14	4.3	2.5
	Other	133	1.7	
15–24	Indigenous	4	1.5	0.4
	Other	318	3.8	
25–49	Indigenous	13	3.0	3.5
	Other	189	0.9	
50+	Indigenous	2	1.4	1.4
	Other	180	1.0	
All ages‡	Indigenous	106	5.1	2.6
	Other	1,157	1.9	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† Average annual age-specific rate per 100,000 population.

‡ Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 ($p<0.5$).

The overall Indigenous to non-Indigenous rate ratio was 2.6:1 for notifications and 1.7:1 for hospitalisations, and both ratios were statistically significantly above 1.0. The Indigenous to non-Indigenous notification rate ratios were significantly above 1.0 for age groups 0–4, 5–14, and 25–49 years (Table 9) and, for hospitalisations, in age groups 0–4 and 25–49 years (Table 10).

Of the 21 deaths recorded from meningococcal disease in the Northern Territory, Queensland, South Australia and Western Australia, one was recorded as Aboriginal and Torres Strait Islander (Table 10).

Serogroup was recorded for 738 (59%) of the 1,263 notifications. For cases recorded as Aboriginal and Torres Strait Islander, meningococcal serogroup B was identified in 79 (89%) and serogroup C in 8 (9%), and other serogroups in 2%, compared with 71%, 22% and 7%, respectively, for presumed non-Indigenous cases (Chi sq. $p= 0.001$).

Over the six-year period July 1999 to June 2005, hospitalisation rates for meningococcal disease were higher for Indigenous people compared with people presumed to be non-Indigenous in years 2001/2002, 2003/2004 and 2004/2005 (Figure 9). A significant decline in rates in non-Indigenous people corresponded to the start of universal meningococcal C vaccination in 2003. The decline in rates in Aboriginal and Torres Strait Islander people over this period was more variable and not statistically significant.

Comment

The national meningococcal C vaccination program provided vaccine for all infants at 12 months of age from 2003 and a catch-up program for all aged up to 19 years.[20] Prior to that, only polysaccharide vaccines targeting serogroups A, C, Y and W_{135} were available, used for the control of outbreaks and for travellers to high incidence countries. The relative distributions of different meningococcal serogroups vary over time and between jurisdictions, due to a range of factors including the emergence or importation of previously unknown serotypes.[64] Historically, the incidence of meningococcal disease has been disproportionately higher among Aboriginal and Torres Strait Islander Australians, with well-recorded outbreaks in Central Australia[65] and north-west Queensland[66] due to serogroup A and serogroup C disease. The current pattern is of predominantly sporadic serogroup B disease in young children, similar to that seen in Maori and Pacific Islander children in New Zealand,[67] in whom living conditions have been shown to be an important disease risk fac-

Table 10. Meningococcal hospitalisations and deaths, selected Australian states, 2002 to 2005, by age group and Indigenous status

Age group (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths† 2003–2005
		n	Rate‡	Rate ratio	n
0–4	Indigenous	74	45.4	2.7	0
	Other	425	16.6		4
5–14	Indigenous	17	5.2	1.3	0
	Other	215	3.9		0
15–24	Indigenous	12	4.6	0.7	0
	Other	364	6.3		7
25–49	Indigenous	11	2.6	2.1	0
	Other	187	1.2		6
50+	Indigenous	3	2.1	1.4	0
	Other	199	1.5		2
All ages§	Indigenous	117	5.8	1.7	1
	Other	1,390	3.3		21

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

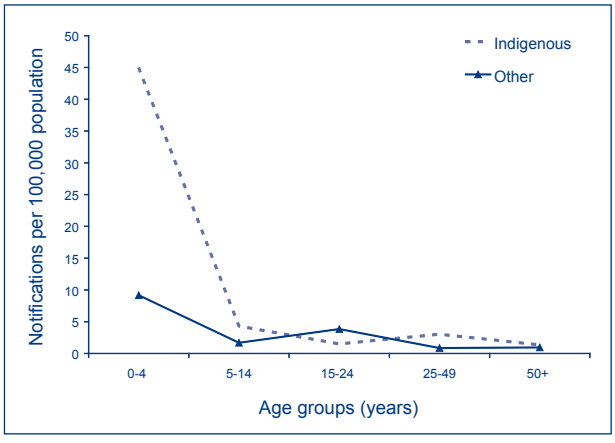
† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

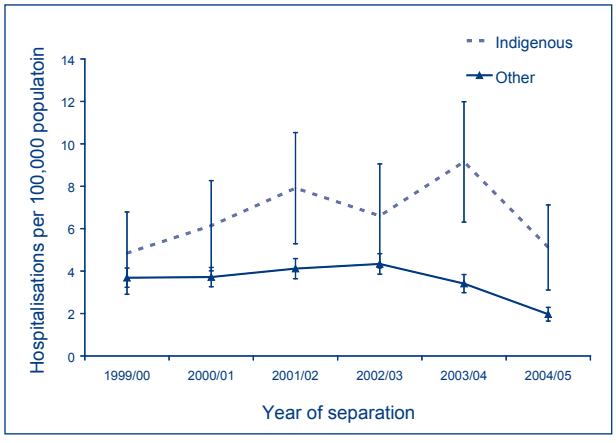
Figure 8. Meningococcal notification rates, selected Australian states,* 2003 to 2006,† by age group and Indigenous status



* New South Wales, the Northern Territory, South Australia, Victoria and Western Australia.

† Notifications where the date of diagnosis was between 1 January 2003 and 31 December 2006.

Figure 9. Meningococcal hospitalisation rates, selected Australian states,* 1999 to 2005,† by Indigenous status



* The Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 1999 and 30 June 2005. Rates are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

tor.[68] The apparently smaller impact of the national meningococcal C program in Indigenous compared with non-Indigenous people in the hospitalisation data presented here is consistent with the smaller proportion of cases being due to serogroup C in Indigenous people before the program started. Vaccines protecting against all subtypes of serogroup B disease could make an important contribution to decreasing the disparity between Indigenous and non-Indigenous people in the incidence of meningococcal disease. The vaccine against one serogroup B subtype that has been used so successfully in New Zealand[69] does not provide sufficient coverage of Australian subtypes. While work on developing other vaccines continues, a commercially available vaccine against a broad range of B disease is still some way off.[70]

Aboriginal and Torres Strait Islander children less than 5 years of age have the highest recorded rates of meningococcal disease, almost five times the rate for non-Indigenous children. Meningococcal serogroup B disease accounted for nearly 90% of the Aboriginal and Torres Strait Islander cases and, hence, a vaccine for this serogroup will be important for decreasing this disparity.

Pertussis

Pertussis (whooping cough) is an acute illness, caused by the *Bordetella pertussis* bacterium, involving the respiratory tract. Typically illness begins with an irritating cough that gradually becomes paroxysmal and lasts for one to two months or longer. Paroxysms are characterised by repeated violent coughs and are followed by a characteristic crowing or high-pitched inspiratory whoop. Infants less than 6 months of age, adolescents and adults often have fewer classical symptoms without paroxysms or whoop.[36]

Case definitions

Notifications

National definition from January 2004:[10]

Confirmed cases are those with definitive laboratory evidence, laboratory suggestive evidence and clinical evidence, or clinical evidence and an established epidemiological link to a confirmed case. Probable cases require clinical evidence (as below) only and are also notified.

a. Laboratory definitive evidence

- Isolation of *Bordetella pertussis* from a clinical specimen or detection of *B. pertussis* by nucleic acid testing.

b. Laboratory suggestive evidence

- Seroconversion or significant increase in antibody levels or fourfold or greater rise in titre to *B. pertussis,* in absence of recent vaccination; or
- Single high IgA titre to whole cells; or
- Detection of *B. pertussis* antigen by immunofluorescence assay (IFA).

c. Clinical evidence

- A coughing illness lasting two or more weeks; or
- Paroxysms of coughing or inspiratory whoop or post-tussive vomiting.

(See Appendix D for pre-2004 definition)

Hospitalisations and deaths

The ICD-10-AM/ICD-10 code A37 (whooping cough) was used to identify hospitalisations and deaths.

Distribution by Indigenous status and age

Of the total 29,050 notifications of pertussis recorded in New South Wales, the Northern Territory, South Australia, Victoria and Western Australia over the four years from 2003 to 2006, 439 (1.5%) were identified as occurring in Aboriginal and Torres Strait Islander people (Table 11). For hospitalisations, 111 (11%) of the total 1,057 cases were identified as Aboriginal and Torres Strait Islander in the three-year period July 2002 to June 2005 in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia (Table 12).

Both hospitalisation and notification rates were highest among children 0–4 years of age identified as Aboriginal and Torres Strait Islander (57 and 65 per 100,000, respectively). The rates were much lower in older age groups, the difference being more marked in hospitalisations than notifications. While hospitalisation rates were below 3 per 100,000 in older age groups, notification rates in Aboriginal and Torres Strait Islander people were somewhat lower in adults aged less than 50 years, but almost as high in those aged 50 years or more (55 per 100,000) as in young children (Figure 10).

The Indigenous to non-Indigenous rate ratios for notifications provided a very different picture of differential disease burden to that of hospitalisations (Table 11 and Table 12). For notifications, the rate ratio was significantly above 1.0 in the 0–4 year age group but significantly below 1.0 in most other age groups (Table 11). However, for hospitalisations, the rate ratios were above 1.0 in all age groups, except the 15–24 year age group, and these were statistically significant in the 0–4 year age group and all ages combined (Table 12).

During the period 2003 to 2005, there were no reported deaths due to pertussis in the Northern Territory, Queensland, South Australia and Western Australia.

Table 11. Pertussis notification rates, selected Australian states, 2003 to 2006, by age group and Indigenous status

Age group (years)	Indigenous status	Notifications* (2003–2006)		
		n	Rate†	Rate ratio
0–4	Indigenous	105	64.6	1.6
	Other	1,532	41.7	
5–14	Indigenous	70	21.5	0.6
	Other	2,946	37.4	
15–24	Indigenous	56	21.0	0.5
	Other	3,245	39.1	
25–49	Indigenous	127	29.5	0.6
	Other	10,589	47.9	
50+	Indigenous	81	54.9	1.0
	Other	10,293	54.3	
All ages‡	Indigenous	439	37.2	0.8
	Other	28,611	46.9	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† Average annual age-specific rate per 100,000 population.

‡ Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater or less than 1 (p<0.5).

Table 12. Pertussis hospitalisations and deaths, selected Australian states, 2002 to 2005, by age group and Indigenous status

Age group (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths† 2003–2005
		n	Rate‡	Rate ratio	n
0–4	Indigenous	93	57.0	3.0	0
	Other	479	18.7		0
5–14	Indigenous	5	1.5	1.0	0
	Other	82	1.5		0
15–24	Indigenous	1	0.4	0.9	0
	Other	24	0.4		0
25–49	Indigenous	9	2.1	2.2	0
	Other	149	1.0		0
50+	Indigenous	3	2.1	1.3	0
	Other	212	1.6		0
All ages§	Indigenous	111	5.2	2.3	0
	Other	946	2.3		0

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

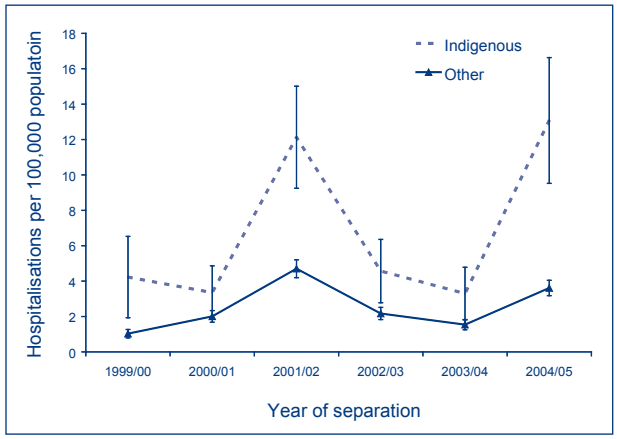
Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Figure 10. Pertussis notification rates, selected Australian states,* 2003 to 2006,† by age group and Indigenous status

* New South Wales, the Northern Territory, South Australia, Victoria and Western Australia.

† Notifications where the date of diagnosis was between 1 January 2003 and 31 December 2006.

Figure 11. Pertussis hospitalisation rates, selected Australian states,* 1999 to 2005,† by Indigenous status



* The Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 1999 and 30 June 2005. Rates are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Over the six-year period July 1999 to June 2005, there was substantial fluctuation in the age-adjusted hospitalisation rates for pertussis in Indigenous and non-Indigenous people. In particular, two peaks reflected widespread epidemics in 2001 and 2005 (Figure 11). The hospitalisation rate for non-Indigenous people was consistently below that for Indigenous people, and this difference was statistically significant in most years. During the peak in Indigenous cases in 2001/2002, there was a notable increase in the Northern Territory and Queensland, while the peak in 2004/2005 was related to more Indigenous cases in Western Australia (data not shown).

Comment

Universal childhood pertussis vaccination has been in place since the 1950s in Australia and an adolescent booster since 2004, earlier in some jurisdictions.[5]

Pertussis is the least well controlled of all diseases with long-standing, well-established vaccination programs. It has the highest notification rate for all ages for the total Australian population, and higher hospitalisation rates than most other vaccine preventable diseases. Interpretation of the data is complex, as the epidemiology of the disease has changed with waning immunity and changes in vaccination policy, and notification and hospitalisation data reflect different patterns of disease severity, and also perhaps the effects of changing patterns of diagnostic testing.[5] However, some conclusions can be drawn from these data.

Figure 11 shows that epidemics continue to occur in Aboriginal and Torres Strait Islander Australians, varying in time by geographic area. The disparity in hospitalisations has been linked to delayed vaccination in Aboriginal and Torres Strait Islander infants and environmental living conditions.[71] In other age groups, the situation is less clear, as the lower notification rates in Indigenous compared with non-Indigenous people in older age groups may reflect lower morbidity and/or poorer access to diagnostic testing for milder disease.

The relatively recent introduction of adolescent vaccination is expected to be reflected in reduced notifications in the near future and its impact on the disease disparity in Aboriginal and Torres Strait Islander infants should be monitored.

Pertussis continues to circulate, causing periodic epidemics in adolescents and adults and transmission to infants who are most vulnerable to severe disease. There is a disproportionate impact on Aboriginal and Torres Strait Islander infants. This underlines the importance of timely vaccination of infants.

Pneumococcal disease

Pneumococcal disease is caused by the bacterium *Streptococcus pneumoniae* (pneumococcus). Pneumococci are frequently isolated from the upper respiratory tract and can spread directly from the nasopharynx to cause infection in other parts of the respiratory tract (otitis media, sinusitis, pneumonia) or enter the bloodstream. Following bloodstream invasion, clinical manifestations include meningitis, pneumonia and infection at a number of less common sites, as well as septicaemia without focal infection. Invasive pneumococcal disease (IPD) is defined as a sterile site isolate of *S. pneumoniae*, usually from blood. In the absence of a sterile site isolate, a presumptive diagnosis of pneumococcal pneumonia may be based on a sputum isolate of *S. pneumoniae* and/or clinical features such as the chest x-ray appearance and prompt response to antibiotic therapy.[72]

Case definitions

Notifications

From January 2001, invasive pneumococcal disease became notifiable Australia wide, with cases identified by:

a. Isolation of *Streptococcus pneumoniae* by culture from a normally sterile site;

or

b. Detection of *Streptococcus pneumoniae* from a normally sterile site by nucleic acid testing.

Hospitalisations

The ICD-10-AM codes used to identify invasive pneumococcal disease hospitalisations were: G00.1 (pneumococcal meningitis); A40.3 (pneumococcal septicaemia). Analysis of pneumococcal pneumonia hospitalisations used J13 (pneumococcal pneumonia), excluding records that also contained codes for invasive disease.

Deaths

ICD-10 codes G00.1 and A40.3 were used to select deaths from IPD.

Distribution by Indigenous status and age

Of the total 5,941 notifications of IPD recorded in New South Wales, the Northern Territory, South Australia, Victoria and Western Australia over the four years from 2003 to 2006, 477 (8%) were recorded as occurring in Aboriginal and Torres Strait Islander people (Table 13). For IPD hospitalisations, 234 (11%) of the total 2,228 cases were recorded as Aboriginal and Torres Strait Islander in the three-year period July 2002 to June 2005 in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia (Table 14).

The 0–4 year age group had the highest rates in both Indigenous and non-Indigenous people. Rates were lowest in older children and young adults and increased with age (Figure 12). In those recorded as Indigenous, the increase was more marked in the 25–49 year age group while, in non-Indigenous people, the rates remained low in this age group and increased at age 50 years or more.

The Indigenous to non-Indigenous rate ratios were statistically significantly greater than 1.0 in all age groups for notifications and hospitalisations. The highest rate ratios were in the age group 25–49 years (Table 13 and Table 14). Hospitalisations for pneumococcal pneumonia showed a greater disparity between Indigenous and non-Indigenous adults, and less in children (Figure 13).

Serotype data were available for 4,851 (82%) of the total 5,941 IPD notifications. The proportion of 7-valent pneumococcal vaccine serotypes causing disease in Indigenous children in the 0–4 year age group (30%) was significantly lower than in non-Indigenous children in the same age group (81%, $p<0.0001$). Similarly, the proportion of 23-valent pneumococcal vaccine serotypes causing disease in Indigenous people older than 15 years was significantly lower (67%) than in non-Indigenous people in this age group (91%), $p<0.0001$).

During the period 2003 to 2005, there were 11 deaths recorded from IPD in the Northern Territory, Queensland, South Australia and Western Australia. Two were in persons identified as Aboriginal and Torres Strait Islander; one was in an adult over 50 years of age and the age for the other was unknown (Table 14).

Table 13. Invasive pneumococcal disease notification rates, selected Australian states, 2003 to 2006, by age group and Indigenous status

Age group (years)	Indigenous status	Notifications* (2003–2006)		
		n	Rate†	Rate ratio
0–4	Indigenous	106	65.2	1.8
	Other	1,315	35.8	
5–14	Indigenous	40	12.3	4.6
	Other	212	2.7	
15–24	Indigenous	35	13.1	5.8
	Other	187	2.3	
25–49	Indigenous	219	50.9	11.2
	Other	1,003	4.5	
50+	Indigenous	76	51.5	3.5
	Other	2,747	14.5	
All ages‡	Indigenous	477	41.7	4.6
	Other	5,464	9.0	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† Average annual age-specific rate per 100,000 population.

‡ Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Table 14. Invasive pneumococcal disease hospitalisations and deaths, selected Australian states, 2002 to 2005, by age group and Indigenous status

Age group (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths† 2003–2005
		n	Rate‡	Rate ratio	n
0–4	Indigenous	61	37.4	1.7	0
	Other	572	22.3		2
5–14	Indigenous	16	4.9	3.1	0
	Other	88	1.6		0
15–24	Indigenous	9	3.4	3.8	0
	Other	52	0.9		0
25–49	Indigenous	106	25.0	13.6	0
	Other	281	1.8		2
50+	Indigenous	42	29.4	3.8	1
	Other	1,001	7.7		4
All ages§	Indigenous	234	21.4	4.5	2
	Other	1,994	4.7		9

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Over the six-year period July 1999 to June 2005, age-adjusted hospitalisation rates for IPD remained significantly higher for Indigenous people compared with those presumed to be non-Indigenous (Figure 14), with no clear trend over time. In cases recorded as Indigenous there was a statistically significant decrease in the 0–4 year age group from 1999–2001 to 2003–2005 (p=0.0003), while in cases recorded as non-Indigenous there was also a decrease in that age group (p=0.0001) and an increase in cases aged 50 years or more (p=0.0001).

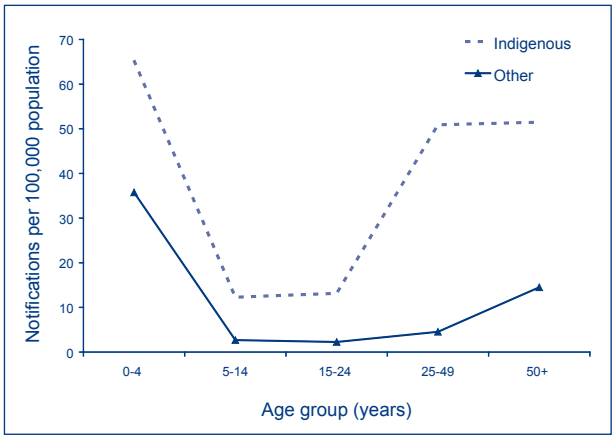
Comment

The period covered by this report saw the introduction (in 2005) of universally funded pneumococcal vaccination for infants (7-valent conjugate at 2, 4, 6 months of age) and the elderly (23-valent polysaccharide from 65 years of age). These were in addition to the pre-existing programs targeting Aboriginal and Torres Strait Islander and other high-risk infants (from 2001) and Indigenous adults aged 50 years or more and younger Indigenous adults with risk factors (from 1999).

Higher rates of IPD have been consistently found in Indigenous compared with non-Indigenous Australians of all ages, the highest rates in those aged less than 5 years and more than 25 years, and particularly in central and northern Australia. Funded pneumococcal vaccination programs were targeted to Aboriginal and Torres Strait Islander people for the first 2–2½ years of data presented here, the length of time varying with the dataset used, followed by between 6 months and 2 years covered by universal vaccination programs. Despite the longer period during which vaccination was funded for Indigenous people, whether during targeted or universal programs, substantially higher morbidity burdens were seen in Indigenous people. However, the Indigenous to non-Indigenous rate ratios were lowest in those age groups most directly targeted for vaccination, where the greatest benefits would be expected (i.e. 0–4 years and 50 years or more).

More detailed data have been published elsewhere, in particular annual reports of enhanced IPD surveillance.[73–77] They show that the reported deaths presented above are a substantial under-estimate of deaths due to invasive pneumococcal disease, with 128 deaths recorded nationally in 2005 by that enhanced surveillance system, nine in Aboriginal or Torres Strait Islander people,[77] compared with the data presented above from the AIHW mortality database, which has only nine deaths from four jurisdictions in the three-year period, two of whom were Indigenous. The enhanced surveillance data show that the disparity between Indigenous and non-Indigenous young children was eliminated following the implementation of the targeted vaccination program in 2001,[77] despite suboptimal vaccination coverage.[78] However, following the commencement of the universal infant program, the greater relative decrease in IPD rates in non-Indigenous children

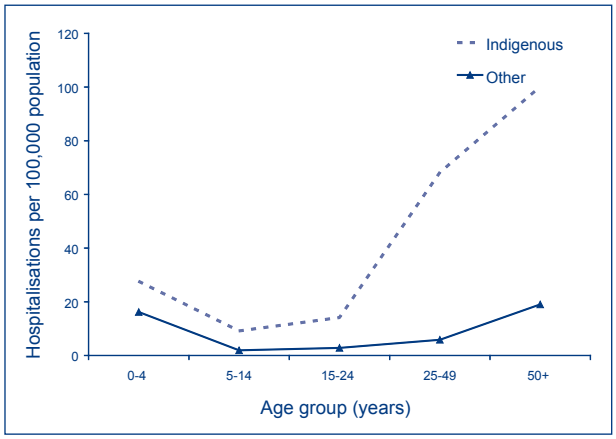
Figure 12. Invasive pneumococcal disease notification rates, selected Australian states,* 2003 to 2006,† by age group and Indigenous status



* New South Wales, the Northern Territory, South Australia, Victoria and Western Australia.

† Notifications where the date of diagnosis was between 1 January 2003 and 31 December 2006.

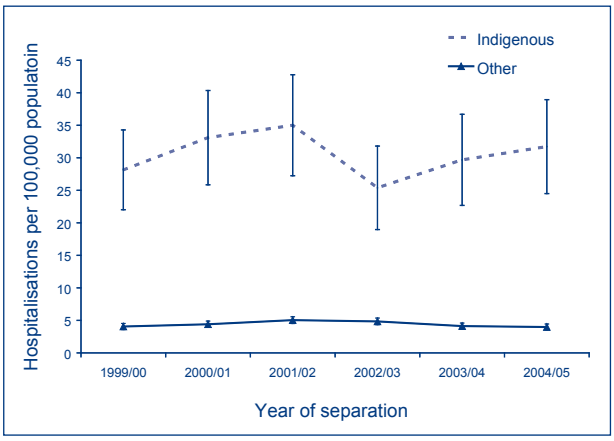
Figure 13. Pneumococcal pneumonia (not coded as meningitis or septicaemia) hospitalisation rates, selected Australian states,* 2002 to 2005,† by age group and Indigenous status



* New South Wales, the Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 2002 and 30 June 2005.

Figure 14. Invasive pneumococcal disease hospitalisation rates, selected Australian states,* 1999 to 2005,† by Indigenous status



* The Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 1999 and 30 June 2005. Rates are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

led to a re-emerging disparity between Indigenous and non-Indigenous children. Most importantly, total IPD rates are much lower than pre-vaccine levels in both Indigenous and non-Indigenous children. However, as non-vaccine type disease was and is more common in Indigenous children, a disparity between Indigenous and non-Indigenous children is difficult to eliminate.[77] Conjugate vaccines active across a broader range of IPD serotypes are needed to further reduce disease in Aboriginal and Torres Strait Islander children. The results of clinical trials on two new vaccines with broader serotype coverage are awaited with interest.[79,80]

The impact in adults has been less clear in both Indigenous and non-Indigenous people. There have been reports of decreases in IPD in Aboriginal and Torres Strait Islander adults following vaccination programs in north Queensland[81] and the Kimberley,[82] but no decrease in the Northern Territory.[83] Data from the first year of universal vaccination show reductions in IPD in adults, but it is not clear at this early stage whether these are attributable to adult vaccination, herd immunity from infant vaccination, or other causes.[5] However, the high rates of IPD in younger Indigenous adults, together with the reported low vaccination coverage in that age group, suggest there may be potential benefits from reducing the recommended age for universal vaccination of Indigenous adults below the current 50 years. Given the limitations of the polysaccharide vaccine, including lower effectiveness against IPD,[84] no proven effectiveness against other manifestations such as non-bacteraemic pneumonia,[84] and concerns about hypo-responsiveness to doses after the first,[85] the results of trials in adults of conjugate vaccines with broader serotype coverage are keenly anticipated.

Substantial benefits have been seen from pneumococcal vaccination of Aboriginal and Torres Strait Islander infants (since 2001), and to a lesser extent, adults (since 1999). Despite this, Indigenous people of all ages continue to suffer higher rates of pneumococcal disease compared with non-Indigenous people.

Varicella

Varicella (chickenpox) is a highly contagious infection caused by the varicella-zoster virus (VZV). The average incubation period is 14–16 days. The clinical picture includes sudden onset of slight fever, mild constitutional symptoms and a generalised pruritic vesicular rash. About 5% of infections are subclinical. Acute varicella may be complicated by cerebellitis, aseptic meningitis, transverse myelitis, thrombocytopenia and pneumonia.[36]

In unvaccinated populations, varicella is primarily a childhood illness with more than 90% of the population in temperate countries developing clinical or serological infection by adolescence.[86] In Australia, seropositivity was 83% by age 10–14 years in the pre-vaccine era.[87] Varicella is generally a benign, self-limiting illness in children, but morbidity and mortality rates are higher in adults,[88] at the extremes of ages, and in the immunocompromised.[89]

Case definitions

Notifications

Not available for the period covered in this report.

Hospitalisations and deaths

The ICD-10-AM/ICD-10 code B01 (varicella [chickenpox]) was used to identify varicella hospitalisations and deaths.

Distribution by Indigenous status and age

Of the total 3,205 hospitalisations for varicella in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia over the three-year period July 2002 to June 2005, 215 (7%) were identified as occurring in Aboriginal and Torres Strait Islander people (Table 15).

The incidence was highest in 0–4 year olds for Indigenous and presumed non-Indigenous people (Table 15, Figure 15). This age group represents 59% (127) of all hospitalisations identified as Indigenous and 36% (1,088) of hospitalisations in those presumed to be non-Indigenous.

The overall Indigenous to non-Indigenous rate ratio of 1.4:1 for hospitalisations was statistically significantly above 1.0, and also significantly above 1.0 for the age groups 0–4 and 5–14 years (Table 15).

Of the four deaths recorded from varicella in the Northern Territory, Queensland, South Australia and Western Australia, none were recorded for people identified as Aboriginal and Torres Strait Islander.

Over the six-year period July 1999 to June 2005, hospitalisation rates for varicella were statistically significantly higher for Indigenous people compared with people presumed to be non-Indigenous in years 2002/2003, 2003/2004 and 2004/2005 (Figure 16). For Indigenous people, there was no statistically significant change over time, while, for non-Indigenous people, there was a significant decrease in 2002/2003 followed by an increase in 2003/2004. Increases were consistent across age groups and jurisdictions (data not shown).

Comment

Varicella vaccination was recommended from September 2003 for all Australian infants, and adolescents who have no clinical history of chickenpox, and funded for these groups from November 2005.[20]

Chickenpox is not known as a disease of particular concern for Aboriginal and Torres Strait Islander people compared to others, and there are no known previous publications comparing the disease burden in Indigenous and non-Indigenous people, nationally or internationally. The hospitalisation data presented here show a statistically significantly higher rate in Indigenous compared with non-Indigenous children up to 14 years of age and all ages combined, but the scale of this disparity is smaller than most other vaccine preventable diseases (see Appendix B). As these data were all collected in the pre-vaccination era, and at least 90% of people are infected with varicella during their lifetime, the reasons for the slightly higher hospitalisation rates in Aboriginal and Torres Strait Islander people may be due to poorer access to primary care, particularly in remote areas, or a greater propensity for complicating skin and soft tissue infections, related

Table 15. Varicella hospitalisations and deaths, selected Australian states, 2002 to 2005, by age group and Indigenous status

Age group (years)	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths† 2003–2005
		n	Rate‡	Rate ratio	n
0–4	Indigenous	127	78	1.8	0
	Other	1,088	43		1
5–14	Indigenous	42	13	1.5	0
	Other	469	8		0
15–24	Indigenous	18	7	1.3	0
	Other	306	5		0
25–49	Indigenous	26	6	1.2	0
	Other	802	5		1
50+	Indigenous	2	1	0.6	0
	Other	325	2		2
All ages§	Indigenous	215	10	1.4	0
	Other	2,990	7		4

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005.

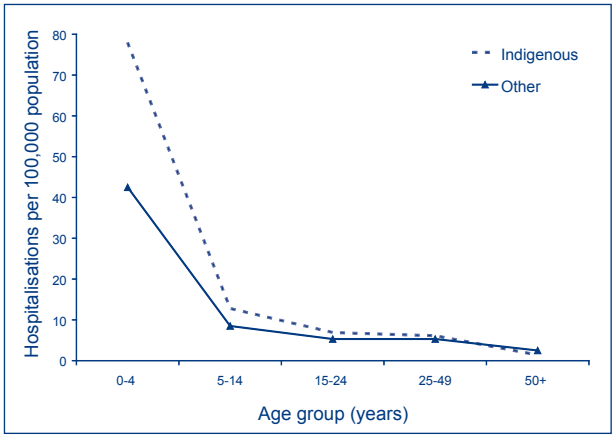
† Deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005.

‡ Average annual age-specific rate per 100,000 population.

§ Includes cases with unknown ages. Rates for all ages combined are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

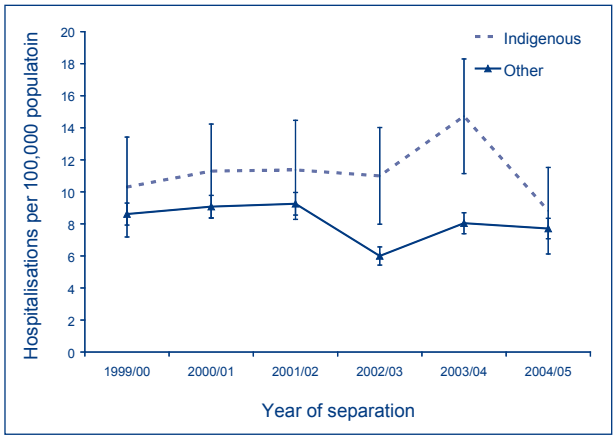
Figure 15. Varicella hospitalisation rates, selected Australian states,* 2002 to 2005,† by age group and Indigenous status



* New South Wales, the Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 2002 and 30 June 2005.

Figure 16. Varicella hospitalisation rates, selected Australian states,* 1999 to 2005,† by Indigenous status



* The Northern Territory, Queensland, South Australia and Western Australia.

† Hospitalisations where the date of separation was between 1 July 1999 and 30 June 2005. Rates are age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

to environmental living conditions. Changes in hospitalisation rates over time were not limited to particular demographic, age or geographic categories.

Varicella notifications were not reported here, as national surveillance only commenced in 2006, and surveillance was incomplete in that year.[20,90]

Aboriginal and Torres Strait Islander people suffer slightly higher hospitalisation rates for chickenpox compared with other Australians, and therefore should gain substantial benefits from funded universal vaccination, which commenced in November 2005.

Vaccination coverage

The Australian Standard Vaccination Schedule/National Immunisation Program 2003 to 2006

The Australian Standard Vaccination Schedule (ASVS) changed in January 2003, September 2003 and January 2005, and additional vaccines were universally funded from November 2005.

Children

The meningococcal C conjugate vaccine (MenCCV), to be administered at age 12 months, was introduced and funded for all children in January 2003, with a catch-up program for those aged up to 19 years.

In September 2003, the dose of DTP at 18 months of age was no longer recommended. The recommended schedule was also changed to include:

i. the 7-valent pneumococcal conjugate vaccine (7vPCV) at 2, 4 and 6 months of age for non-Indigenous infants, in addition to the previous recommendation for Indigenous and high-risk infants;
ii. the universal varicella-zoster vaccine at 18 months of age; and
iii. the inactivated poliomyelitis vaccine in place of the oral polio vaccine,
iv. although these recommendations were not funded.

In January 2005, universal 7vPCV was funded. In May 2005, the National Immunisation Program (NIP) Schedule replaced the ASVS (Table 16), with all recommended vaccines to be funded. These included, from November 2005, varicella vaccine and inactivated poliomyelitis vaccine for all infants, and hepatitis A vaccine for Aboriginal and Torres Strait Islander infants in the Northern Territory, Queensland, South Australia and Western Australia. For Hib vaccine, the previous recommendation of Hib PRP-OMP (purified polysaccharide conjugated to the outer membrane protein of the bacteria *N. meningitidis*) vaccine for all infants was changed to include other Hib vaccines for Indigenous infants in the Australian Capital Territory, New South Wales, Tasmania and Victoria, and all non-Indigenous infants.

Adolescents

From September 2003, the recommendation for the acellular pertussis antigen was added to the adolescent booster of diphtheria and tetanus vaccination. The NIP Schedule recommended catch-up hepatitis B vaccination for adolescents of one cohort within the age range of 10–13 years who had no prior history of disease or vaccination, and the schedule varied with different jurisdictions. Varicella vaccination was included for one cohort of adolescents between 10 and 13 years of age who had no prior history of chickenpox.

Adults

Pneumococcal vaccination for all Australians aged 65 years or more was funded nationally from January 2005.

Additional or specific recommendations for Aboriginal and Torres Strait Islander people

Of the vaccines listed in Table 16, some are recommended only for Aboriginal and Torres Strait Islander people, due to their higher risks of contracting the respective diseases.

The three-dose primary course of 7vPCV, administered at 2, 4 and 6 months of age, has been recommended and funded for Aboriginal and Torres Strait Islander children since June 2001 (in contrast to this vaccine being recommended for universal use for all Australian infants in September 2003 and funded since January 2005). A booster dose of pneumococcal vaccine using the 23-valent pneumococcal polysaccharide vaccine (23vPPV) is recommended specifically for Aboriginal and Torres Strait Islander children living in the Northern Territory, Queensland, South Australia and Western Australia, at age 18–24 months, following the primary 7vPCV course in infancy.

Table 16. The Australian National Immunisation Program Schedule for Aboriginal and Torres Strait Islander people, effective 1 November 2005

Age	Vaccine										
Birth	Hep B										BCG**
2 months	Hep B*	DTPa	Hib†	IPV				7vPCV			
4 months	Hep B*	DTPa	Hib†	IPV				7vPCV			
6 months	Hep B*	DTPa	Hib†	IPV				7vPCV			
12 months	Hep B*		Hib†		MMR		MenCCV				
12–18 months									Hep A‡		
18 months						VZV					
18–24 months								23vPPV‡	Hep A‡		
4 years		DTPa		IPV	MMR						
15–17 years		dTpa									
15–49 years								23vPPV§‖		Flu§¶	
≥50 years		dT						23vPPV‖		Flu¶	

* Three doses, either at 2, 4 and 6 months or 2, 4 and 12 months of age.

† Hib PRP-OMP: three doses, at 2, 4 and 12 months of age, for Aboriginal and Torres Strait Islander infants in the Northern Territory, Queensland, South Australia and Western Australia. Other infants may receive either PRP-OMP or PRP-T schedules. The Hib PRP-T schedule comprises four doses, at 2, 4, 6 and 12 months of age.

‡ For Aboriginal and Torres Strait Islander children in the Northern Territory, Queensland, South Australia and Western Australia.

§ For Aboriginal and Torres Strait Islander people who have at least one risk factor for which the vaccine is recommended, as per *The Australian Immunisation Handbook,* 9th edition.

‖ Recommendations for repeat doses as per *The Australian Immunisation Handbook,* 9th edition.

¶ For people recommended to be vaccinated against influenza, vaccination is to be repeated annually.

** For Aboriginal and Torres Strait Islander infants living in specific regions of high incidence only.

Regarding the vaccine against Hib infection, the preferred vaccine type for Aboriginal and Torres Strait Islander infants in the Northern Territory, Queensland, South Australia and Western Australia, who have an earlier peak incidence of disease and a higher risk of disease under 6 months of age, is a specific type (Hib PRP-OMP). This vaccine is immunogenic at an earlier age, and requires three doses to be administered at age 2, 4 and 12 months, without a dose required at age 6 months as with other types of Hib vaccine. Either PRP-OMP or other Hib vaccine conjugated to tetanus toxoid (in combination with other antigens) is recommended for other children.

A two-dose course of hepatitis A vaccine, administered six months apart, between ages 12 and 24 months, has been recommended and funded under the NIP Schedule for Aboriginal and Torres Strait Islander children living in the Northern Territory, Queensland, South Australia and Western Australia since November 2005, and since 1999 in northern Queensland.

Vaccination with Bacille Calmette-Guérin (BCG) against tuberculosis is recommended for all Aboriginal and Torres Strait Islander neonates in high incidence areas, primarily northern Australia.

Aboriginal and Torres Strait Islander adults aged 50 years or more, and those aged 15–49 years with medical conditions putting them at high risk of disease or complications,[20] are recommended for vaccination against influenza and pneumococcal disease. In the Northern Territory, all Aboriginal and Torres Strait Islander people aged 15 years or more, irrespective of presence of medical or behavioural risk factors, have been recommended for pneumococcal vaccination since 2000. Vaccination is recommended annually for influenza while, for pneumococcal disease, generally re-vaccination is recommended five years after the first dose in Aboriginal and Torres Strait Islander adults (see *The Australian Immunisation Handbook* 9th edition for more details.)[57] These two vaccines have been provided through the National Indigenous Pneumococcal and Influenza Immunisation (NIPII) Program since 1999, and earlier in some jurisdictions. For other (non-Indigenous) adult Australians, the recommended age to receive these two vaccines is 65 years or more, funded through the influenza vaccine program for older Australians since 1999 and the pneumococcal vaccination program for older Australians since January 2005.[20]

Vaccination coverage estimates from the Australian Childhood Immunisation Register for Aboriginal and Torres Strait Islander versus other children

Calculating vaccination coverage estimates from the ACIR

A child is now defined as being 'fully vaccinated' at 12 months of age if he or she has received a third dose of DTPa and poliomyelitis vaccine (oral or inactivated), a second or third dose of Hib vaccine, and either a second or a third dose of Hep B vaccine. Doses of 7vPCV, varicella and meningococcal C conjugate vaccines are not included in this calculation.

A child is now defined as being 'fully vaccinated' at 24 months of age if he or she has received a third or fourth dose of DTPa (depending on whether he or she is in the birth cohort for which the recommendation of DTPa at 18 months has been removed), a third dose of poliomyelitis vaccine (oral or inactivated), a third or fourth dose of Hib vaccine, either a second or a third dose of Hep B vaccine and a first dose of MMR vaccine.

A child is now defined as being 'fully vaccinated' at 72 months of age if he or she has received a fifth dose of DTPa (children born before March 2002 would have been subject to the recommendation of a DTPa dose at 18 months), a fourth dose of poliomyelitis vaccine (oral or inactivated), and a second dose of MMR vaccine.

Vaccination coverage of two vaccines that became relevant to Aboriginal and Torres Strait Islander children in the Northern Territory, Queensland, South Australia and Western Australia since 2003, namely the hepatitis A vaccine and the 23vPPV booster dose at 18–24 months of age, are published in this report for the first time. The two doses of the hepatitis A vaccine are scheduled for administration at 12 and 18 months of age in Western Australia and the Northern Territory, and at 18 and 24 months of age in Queensland and South Australia. The 23vPPV booster dose following the primary 7vPCV course in infancy is scheduled for administration at 18 months of age in Western Australia and the Northern Territory, and at 24 months of age in Queensland and South Australia. To enable comparability between jurisdictions for coverage of this 23vPPV booster dose, the observation time point at 6–<9 months after the scheduled dosing time adopted in the respective jurisdictions has been selected for reporting.

More detail on the methods used for these calculations, including issues pertaining to identification of Indigenous status in the ACIR, has been discussed in the Methods section of this report.

Fully vaccinated children

Vaccination coverage estimates for Aboriginal and Torres Strait Islander children, compared with children not identified as Aboriginal and Torres Strait Islander, expressed in terms of the percentage who were 'fully vaccinated' for age, are shown in Table 17 below.

At age 12 months, the proportion of Australian Aboriginal and Torres Strait Islander children who were fully vaccinated was 83%, compared with 91% for other children (Table 17). Coverage was lower in Aboriginal and Torres Strait Islander children compared with other children in all jurisdictions except for the Australian Capital Territory. The extent of the difference varied among jurisdictions, in some being more than 10 percentage points.

However, by age 24 months, the coverage estimates for Indigenous children had increased and the disparities with non-Indigenous children almost disappeared nationally and in most jurisdictions. The proportions of children who were fully vaccinated were 91% for Aboriginal and Torres Strait Islander children and 92% for other children nationally (Table 17).

At age 72 months, the proportion of Australian children who were recorded as being 'fully vaccinated' was generally lower than that at earlier age milestones. There was little difference between Indigenous and other children at the national level (76% and 77%, respectively) while, for individual jurisdictions, coverage in Indigenous children ranged from 9% lower to 12% higher than in non-Indigenous children (Table 17).

Coverage remained stable over time between 2003 and 2006 for both Indigenous and non-Indigenous children aged 12 months and 24 months (Figure E1 and Table E1 in Appendix E).

Table 17. Percentage of Australian children who were 'fully vaccinated' based on data on 3-month birth cohorts as at 31 March 2007 from the ACIR, by Indigenous status

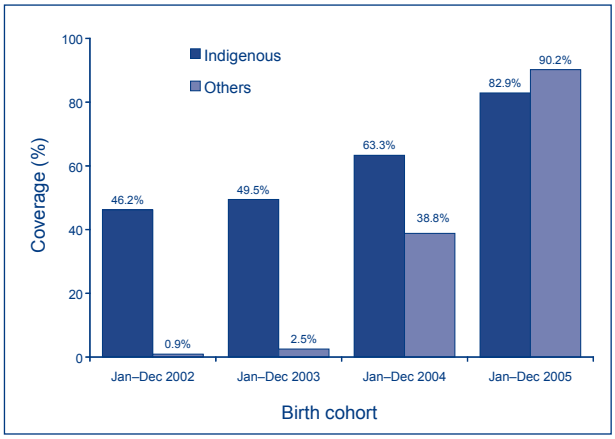
	State or territory								
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
'Fully vaccinated' at 12 months (born Oct–Dec 2005)									
Indigenous	95.8	85.8	84.8	84.2	77.7	84.9	88.2	75.1	83.3
Others	92.1	91.3	94.0	90.8	90.5	92.8	91.2	90.8	91.1
'Fully vaccinated' at 24 months (born Oct–Dec 2004)									
Indigenous	88.2	91.1	95.9	93.7	90.9	91.4	87.0	85.8	91.1
Others	93.4	91.3	93.7	91.2	92.8	94.3	93.2	90.8	92.0
'Fully vaccinated' at 72 months (born Oct–Dec 2000)									
Indigenous	75.0	69.8	86.8	80.7	64.7	82.5	72.5	70.5	75.6
Others	81.5	74.8	74.9	78.4	74.0	82.0	80.0	72.9	76.9

Individual vaccines or antigens

The proportion of Aboriginal and Torres Strait Islander children who had received three doses (primary course) of 7vPCV at age 12 months progressively increased, by yearly birth cohorts, since its recommendation in June 2001 (Figure 17). Given that universal infant vaccination with 7vPCV was recommended in September 2003 but not funded until January 2005, coverage of 7vPCV in other children lagged behind that of Aboriginal and Torres Strait Islander children until the program was funded. Under the funded universal program, coverage of 7vPCV was lower in Aboriginal and Torres Strait Islander children than other children for those born in 2005 (Figure 17). Coverage for individual jurisdictions showed a similar pattern (Table E2 in Appendix E).

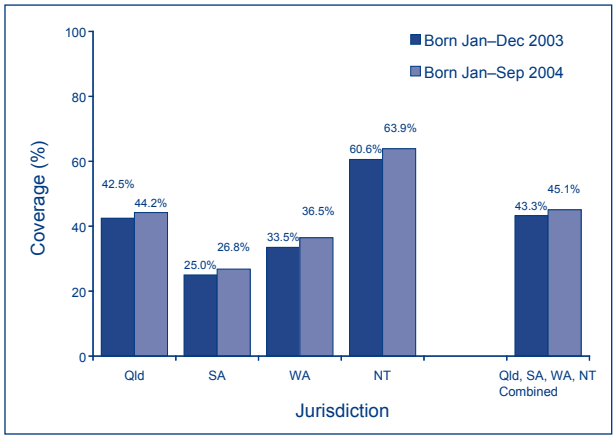
The proportions of Indigenous children who had received the 23vPPV booster, as recommended for Indigenous children in the Northern Territory, Queensland, South Australia and Western Australia at 18–24 months of age, are presented in Figure 18. Coverage varied among these jurisdictions, with the highest at about 64% in the Northern Territory (Figure 18). There was no clear trend in coverage of this dose over a two-year period; however, in all jurisdictions coverage increased between the two cohorts.

Figure 17. Percentage of Australian children who had received three doses of 7-valent pneumococcal conjugate vaccine at age 12 months, by Indigenous status and birth cohort



Source: Australian Childhood Immunisation Register, data as at 31 March 2007.

Figure 18. Percentage of Aboriginal and Torres Strait Islander children who had received the 23vPPV booster within 6 to <9 months after the due date (18–24 months of age)

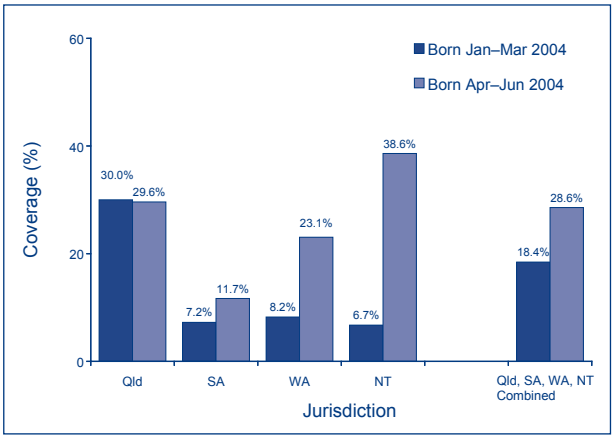


Source: Australian Childhood Immunisation Register, data as at 31 March 2007.

Figure 19 shows the coverage of hepatitis A vaccine (two doses) in Aboriginal and Torres Strait Islander children born between January and June 2004 by age 30–<33 months in these four jurisdictions. The coverage levels were initially higher in Queensland, probably reflecting the effect of the earlier regional program in northern Queensland and the variable uptake in the early phase of introduction of this vaccine in other relevant jurisdictions.

Coverage data for other individual vaccines or antigens by jurisdiction are provided in Tables E2, E3 and E4 in Appendix E, with the exception of varicella and meningococcal C vaccines, as estimates are not sufficiently reliable such a short time after their introduction.

Figure 19. Percentage of Aboriginal and Torres Strait Islander children born between January and June 2004 who had received two doses of hepatitis A vaccine at age 30 to <33 months, by jurisdiction



Source: Australian Childhood Immunisation Register, data as at 31 March 2007.

Vaccination coverage estimates from the National Aboriginal and Torres Strait Islander Health Survey and National Health Survey for Indigenous and non-Indigenous adults

The 2004–05 NATSIHS and NHS also provide data on coverage for the influenza and pneumococcal vaccines in adults, as well as the presence of high-risk medical conditions which are indications for vaccination in younger adults.

Prevalence of risk factors for which influenza and/or pneumococcal vaccination were recommended in Aboriginal and Torres Strait Islander adults aged less than 50 years

As the recommendations for influenza and pneumococcal vaccination for Indigenous adults aged 15–49 years are based on the presence of risk factors, data on the prevalence of those risk factors in Indigenous Australians are relevant for interpreting vaccination coverage in this population.

Risk factors for which the influenza vaccine is recommended include at least one of many chronic medical conditions, including severe asthma. In 2004–2005, approximately 17% of Aboriginal and Torres Strait Islander Australians aged 18–49 years reported at least one of the chronic medical conditions (listed in Appendix C (II)) that were considered risk factors of influenza for which vaccination was recommended. Diabetes mellitus, chronic cardiovascular, respiratory and kidney conditions predominated. The proportion of this population with at least one risk factor rose to 29% when current asthma was included.

Risk factors for which the pneumococcal vaccine is recommended include at least one of many chronic medical conditions (but not including asthma), heavy alcohol use and tobacco smoking. In 2004–2005, the proportion of Aboriginal and Torres Strait Islander Australians aged 18–49 years who reported at least one chronic medical condition (as listed in Appendix C (I)) or heavy alcohol use was 32%, and rose to about 66% when tobacco smoking was added.

There was a gender difference in reported prevalence of risk factors that are indications for influenza vaccine in Aboriginal and Torres Strait Islander Australians aged 18–49 years, with lower rates in males compared with females for chronic conditions including asthma (21% and 36%, respectively). However, there was no gender difference for the risk factor indications for pneumococcal vaccine, which includes smoking (66% for both genders).

When comparing remote and non-remote areas, while the prevalence of a risk factor for which the influenza vaccine was recommended was not significantly different between Aboriginal and Torres Strait Islander residents of remote and non-remote areas (26% and 30%, respectively), a higher prevalence was reported in residents of remote areas who had a risk factor for which the pneumococcal vaccine was recommended (71% for remote residents compared with 64% for non-remote residents). There was no significant difference in prevalence of these risk factors among various jurisdictions of residence (see Tables E5 and E6 in Appendix E).

The prevalence of risk factors generally increased with age, although this trend was more marked for risk factors that were indications for influenza vaccine than for pneumococcal vaccine (Figure 20).

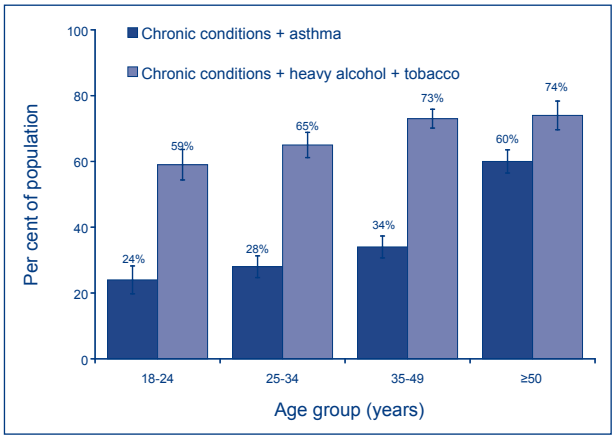
Coverage of influenza and pneumococcal vaccination in Aboriginal and Torres Strait Islander adults

Coverage of influenza and pneumococcal vaccinations by age groups

Vaccination coverage in various age and risk groups, in both Indigenous and non-Indigenous adults, are shown for influenza vaccine in Figure 21 and pneumococcal vaccine in Figure 22.

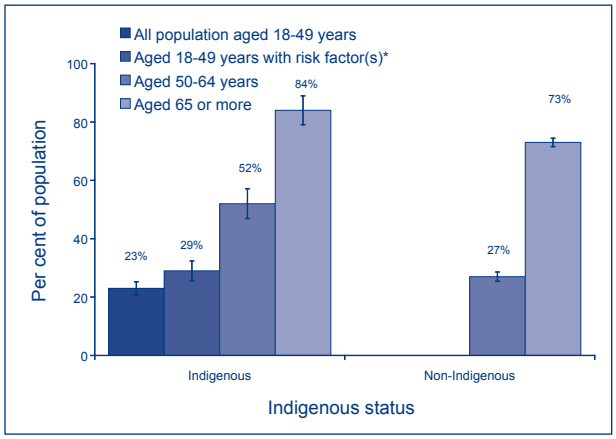
While the percentage of people who were fully vaccinated for influenza was consistently higher than that for pneumococcal vaccine, for both vaccines a similar pattern was seen between the age and risk groups represented.

Figure 20. Percentage of Aboriginal and Torres Strait Islander persons aged 18 years or more who had risk factors for contracting influenza or pneumococcal disease reported in 2004–2005, by age group, Australia



Source: Australian Bureau of Statistics National Aboriginal and Torres Strait Islander Health Survey, 2004–05.

Figure 21. Percentage of population who reported having influenza vaccination in the last 12 months prior to survey in 2004–2005, by Indigenous status and age group, Australia



* Chronic disease or asthma.

Source: Australian Bureau of Statistics National Aboriginal and Torres Strait Islander Health Survey, 2004–05.

In Aboriginal and Torres Strait Islander adults, the lowest coverage was in younger adults (15–49 years) with no statistically significant difference in coverage between those for whom the vaccine was recommended (with risk factors) and those for whom it was not recommended (without risk factors). In older Aboriginal and Torres Strait Islander adults, all of whom were recommended to be vaccinated, the coverage was higher. Coverage was highest in the oldest age group (65 years or more), for which vaccination was also recommended and funded for non-Indigenous adults. In the age group for which vaccination was only recommended and funded for Aboriginal and Torres Strait Islander adults (50–64 years), coverage was significantly lower.

There were no significant differences in coverage between genders in the categories shown in these figures (data not shown).

Coverage was significantly higher in Indigenous compared with non-Indigenous adults in their respective age groups, with the exception of pneumococcal vaccine in those age 65 years or more. It should be noted that pneumococcal vaccine was funded for non-Indigenous adults in that age group for only part of the period covered by the survey.

Vaccination coverage by jurisdiction by remoteness and risk factor category is presented in Tables E5 to E8 in Appendix E.

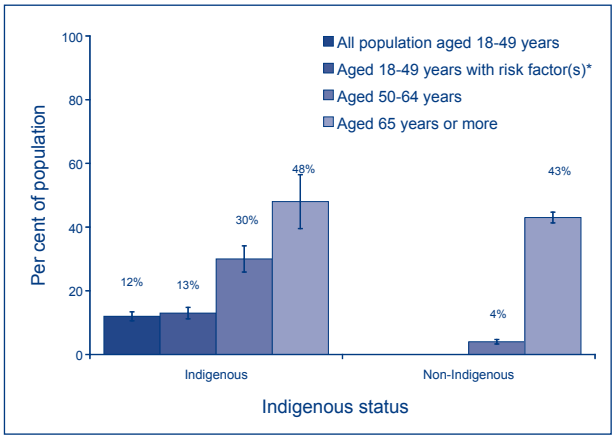
Increase in uptake of influenza and pneumococcal vaccination over time

Among Aboriginal and Torres Strait Islander adults aged 50 years or more, for whom the influenza and pneumococcal vaccines were universally recommended, vaccine uptake increased from 2001 to 2004–2005 for both vaccines, although the increases did not reach statistical significance (Figure 23).

Differential uptake of influenza and pneumococcal vaccinations by remoteness of residence

A significantly higher uptake of both vaccines was observed in Aboriginal and Torres Strait Islander adults aged 50 years or more living in remote areas compared with non-remote areas (Figure 24). A similar pattern was seen in younger adults for both vaccines, and older adults (65 years or more) for pneumococcal vaccine, but there was no statistically significant difference in influenza coverage by remoteness for older adults (data not shown).

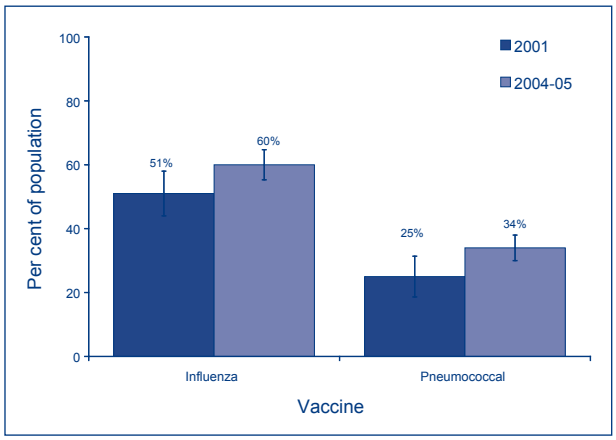
Figure 22. Percentage of population who reported having pneumococcal vaccination in the last five years prior to survey in 2004–2005, by Indigenous status and age group, Australia



* Chronic disease, heavy alcohol use or smoking.

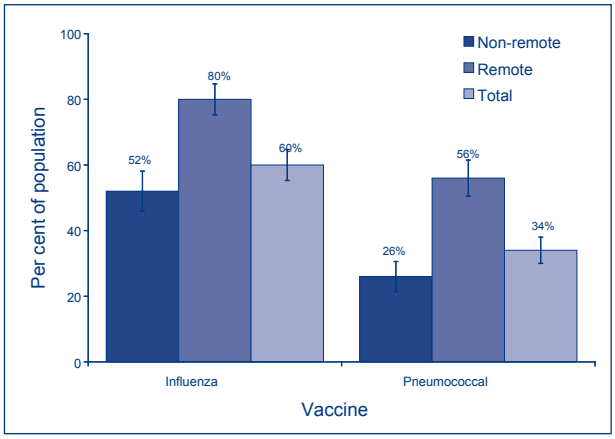
Source: Australian Bureau of Statistics, National Aboriginal and Torres Strait Islander Health Survey, and National Health Survey, 2004–05.

Figure 23. Vaccination coverage of Aboriginal and Torres Strait Islander adults aged ≥50 years, 2004–2005 compared with 2001, by vaccine



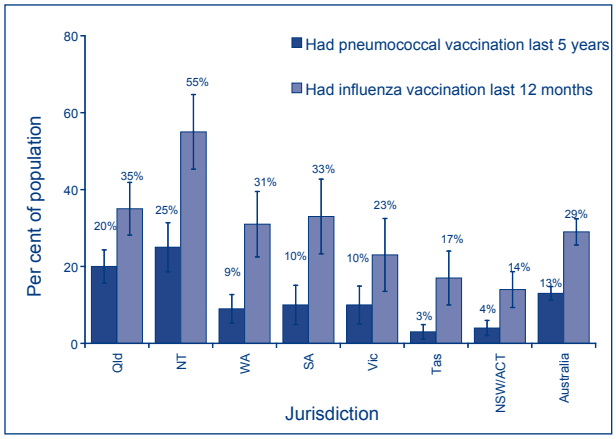
Source: Australian Bureau of Statistics, National Health Survey 2001 Indigenous supplemental survey, and National Aboriginal and Torres Strait Islander Health Survey, 2004–05.

Figure 24. Vaccination coverage of Aboriginal and Torres Strait Islander adults aged ≥50 years, by remoteness of residence and vaccine, 2004–2005



Source: Australian Bureau of Statistics National Aboriginal and Torres Strait Islander Health Survey, 2004–05.

Figure 25. Percentage of Aboriginal and Torres Strait Islander persons aged 18–49 years with at least one relevant risk factor who had vaccination prior to survey in 2004–2005, by jurisdiction of residence, Australia



Source: Australian Bureau of Statistics National Aboriginal and Torres Strait Islander Health Survey, 2004–05.

Variation in uptake of influenza and pneumococcal vaccinations among Australian states and territories

For both influenza and pneumococcal vaccines, there was substantial variation in vaccination coverage between jurisdictions in Aboriginal and Torres Strait Islander adults. Data for those aged 18–49 years who had at least one relevant risk factor are presented in Figure 25, and more detailed data on that age group in Tables E5 and E6 in Appendix E. The highest coverage was reported in the Northern Territory for both vaccines, where the pneumococcal vaccine (but not the influenza vaccine) was recommended for all Aboriginal and Torres Strait Islander adults.

Comment

This report is the broadest in scope and most detailed presentation of vaccination coverage data on Aboriginal and Torres Strait Islander people yet published. This has been made possible by improvements in ACIR data quality and the increased sample size of the NATSIHS compared with previous surveys.

For vaccines recommended for all children, coverage in Indigenous children at age 12 months was between 2% and 9% lower than in non-Indigenous infants nationally. This discrepancy disappeared by age 24 months, suggesting that delayed vaccination was more common in Aboriginal and Torres Strait Islander infants, who eventually caught up with the recommended doses by 24 months. At 5 years of age, fewer children had received all the recommended vaccines, but there was no disparity between Indigenous and non-Indigenous children at the national level. This pattern was not uniform across all jurisdictions, with coverage in Aboriginal and Torres Strait Islander children lower than the national average in some, while in others coverage was actually higher. This improved data quality now provides the opportunity for the ACIR to be used to assist providers and program managers to identify regions where increased attention is required to improve coverage in Aboriginal and Torres Strait Islander children.

For vaccines recommended only for Aboriginal and Torres Strait Islander people, coverage was consistently and substantially lower than for the universal vaccines. This may be partly due to under-reporting of these vaccines to the ACIR, but the same phenomenon has been reported in surveys, of adults (reported here) and children.[18] This demonstrates the greater difficulty in delivering these targeted programs, to all ages, and the need for improved systems to deliver them. While lower coverage was found in non-remote areas in Aboriginal and Torres Strait Islander adults, and previously in children,[35] more recent analyses of ACIR data do not find this to be the case for universal vaccines with higher coverage.[17] The low coverage for hepatitis A and 23vPPV in Aboriginal and Torres Strait Islander children in this report, vaccines which are only recommended in the north and west of Australia, demonstrates that difficulties in achieving high coverage are not limited to urbanised areas.

Among Aboriginal and Torres Strait Islander adults, it is generally observed that the coverage is higher with the influenza vaccine than the pneumococcal vaccine in most ages, jurisdictions and remoteness strata. This may be partly explained by the limitations in the self-reporting methods used in data as discussed in the Methods section, yet the scale of the difference suggests it is likely that there is some true difference between the uptake of these two vaccines.

In younger Aboriginal and Torres Strait Islander adults with a risk-factor-based program, vaccination was not delivered to a high proportion of eligible people. The substantially higher coverage in older adults is very suggestive of the superiority of an age-based program over an age-and-risk-based vaccination program.

In fact, the Australian Technical Advisory Group on Immunisation (ATAGI) has recently recommended annual influenza vaccination for all Aboriginal and Torres Strait Islander adults,[57] although this recommendation is not yet publicly funded.

Discussion

This is the second report to provide detailed data on VPDs and vaccination coverage in Aboriginal and Torres Strait Islander people. More detailed analysis and presentation of data has been made possible by improvements to the ACIR, NATSIHS and hospitalisation data.

Vaccination coverage

Vaccination coverage for the standard vaccines nationally is 6%–8% lower in Indigenous compared with non-Indigenous infants at 12 months of age, largely due to the higher prevalence of delayed vaccination in Indigenous children. By 24 months of age, that difference has disappeared and coverage is over 90%.

In adults, where universal vaccination programs are in place (for those aged 65 years or more, influenza and pneumococcal vaccine), there is no significant difference in national coverage between Indigenous and non-Indigenous people. Where these universal programs have achieved high coverage, the previously seen coverage gradient in Aboriginal and Torres Strait Islander people from higher in remote areas to lower in urban areas appears to no longer be the case.

However, for vaccines or age groups where vaccination is targeted only at Aboriginal and Torres Strait Islander people, such as hepatitis A, 23vPPV for infants, or influenza and 23vPPV in adults aged less than 65 years, coverage is markedly lower, although still higher than in the non-target population. Along with lower coverage, the gradient from remote to urban is still evident for the adult vaccines.

Impact

The achievement of high coverage for standard vaccines has had a substantial positive impact on the health of Aboriginal and Torres Strait Islander people. A number of diseases which have been eliminated from Australia by vaccination, or for which endemic transmission has been largely controlled, caused significant disease burdens in the past, and disproportionately affected Aboriginal and Torres Strait Islander people. The pre-vaccination impacts on Aboriginal and Torres Strait Islander people have been documented for some of these diseases, such as smallpox,[91] measles,[61] hepatitis B,[50] and invasive Hib disease,[92] while, for others, it can be assumed to be at least as severe as for the rest of the population, such as diphtheria, tetanus and poliomyelitis.

However, for some standard vaccines, high coverage has not been sufficient to control the disease. Pertussis epidemics continue to occur in Australia due to waning vaccine-induced immunity, and this is likely to continue until older Australians are immunised and/or an improved vaccine is developed. It seems likely that higher hospitalisation rates in Aboriginal and Torres Strait Islander infants are caused by a combination of more common delayed vaccination and generally poorer environmental living conditions.

Although Hib vaccine has resulted in a greater than 90% decrease in Hib disease, the few remaining cases occur at much higher rates in Aboriginal and Torres Strait Islander children. A similar situation has been reported in other indigenous populations that had high pre-vaccination rates of disease and this may be less marked in recent years.[32,93] However, more research is needed to clarify the potential roles of continued carriage, delayed vaccination and vaccine failure.

For IPD and meningococcal disease, the universal vaccination programs have been very successful, but a greater proportion of cases in Aboriginal and Torres Strait Islander people are of serotypes not prevented by the vaccine. There have historically been much higher rates of IPD in Indigenous compared with non-Indigenous children and adults.[94,95] There has been a substantial impact of the 7vPCV vaccine on disease rates, but higher rates remain in Aboriginal and Torres Strait Islander children, largely due to serotypes not contained in the vaccine. Hoped for impact on the more common manifestations of pneumococcal infection – non-bacteraemic pneumonia and otitis media – have been seen overseas but not in Australian Indigenous people. In the US, a post-vaccination increase has been observed in IPD due to serotypes not covered by the vaccine, and this has been most marked in Alaskan indigenous people.[96] While there is no clear evidence of that in Australia so far, this needs to be closely monitored. New vaccines with broader IPD serotype coverage are likely to be available in the near future[79,80] and may have an important role for Indigenous people. The impact of 23vPPV vaccination in the second year of life in preventing IPD and the emergence of non-7vPCV serotypes also needs further examination.

The impact of the universal meningococcal C vaccination program from 2003 is evident in data in this report. Although serogroup C meningococcal disease has seriously affected Indigenous people in the past,[66,97] currently a greater proportion of disease in Indigenous, compared with non-Indigenous, people is serogroup B and therefore not covered by the vaccine. A serogroup B vaccine with broad coverage of relevant subtypes would be valuable.

Vaccination programs targeted specifically at Indigenous people are often necessary where large disparities in disease burden exist and the cost-effectiveness of vaccination of non-Indigenous people is less clear. Data in this report show that coverage is consistently lower for these programs.

In young Indigenous adults, the extent of the disease burden from IPD, pneumonia and influenza, and the substantial disparity in comparison with non-Indigenous people of the same age, are evident. The impact of adult vaccination on Aboriginal and Torres Strait Islander adults has not yet been clearly established, but this may be due to the fact that the vast majority of disease occurs in younger adults, in whom coverage has been low. Expansion of the age-based recommendations for 23vPPV down to 30 years, and for influenza vaccine to all Aboriginal and Torres Strait Islander adults, may have an impact if funded and implemented. Unfunded recommendations present a challenge to service providers to maximise the potential benefits from vaccination in these age groups.

High hospitalisation rates for influenza in infants, significantly higher for Indigenous compared with non-Indigenous infants, suggest a possible role for vaccination. Universal infant vaccination is in place in the US and Canada. Either a universal or targeted program may be justified in Australia, and this is currently under consideration by ATAGI.

Appendix A. Summary of notifications in Australia,* for vaccine preventable diseases,† 2003 to 2006, by Indigenous status

Disease‡	Indigenous status	Notifications* (2003–2006)		
		n	Rate§	Rate ratio
Diphtheria‖	Indigenous	0	–	–
	Other	0	–	
Hib disease (invasive)	Indigenous	10	0.6	8.8
	Other	41	0.1	
Hepatitis A	Indigenous	162	8.1	4.9
	Other	1,007	1.7	
Hepatitis B	Indigenous	56	4.3	3.1
	Other	860	1.4	
Measles	Indigenous	9	0.6	1.4
	Other	237	0.4	
Meningococcal disease	Indigenous	106	5.1	2.6
	Other	1,157	1.9	
Mumps¶	Indigenous	3	0.2	0.2
	Other	529	0.9	
Pertussis	Indigenous	439	37.2	0.8
	Other	28,611	46.9	
Pneumococcal disease	Indigenous	477	41.7	4.6
	Other	5,464	9.0	
Poliomyelitis	Indigenous	0	–	–
	Other	0	–	
Rubella**	Indigenous	1	0.05	0.3
	Other	118	0.19	
Tetanus††	Indigenous	0	–	–
	Other	8	–	

* Notifications (New South Wales, the Northern Territory, South Australia, Victoria and Western Australia only) where the date of diagnosis was between 1 January 2003 and 31 December 2006.

† See Results section for case definitions. For diseases not included in Results section, case definitions are listed below.

‡ Influenza not included because of low completeness of Indigenous status field.

§ Rates are per 100,000 population for all ages combined, age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

‖ Diphtheria notifications: see Appendix D for pre-2004 definition. National definition from January 2004: Isolation of toxigenic *Corynebacterium diphtheriae* or toxigenic *C. ulcerans* (confirmed case); or Isolation of *Corynebacterium diphtheriae* or *C. ulcerans* (toxin production unknown) and one of the following presentations as clinical evidence: pharyngitis and/or laryngitis (with or without membrane); or toxic (cardiac or neurological) symptoms (probable case); or clinical evidence as above and an epidemiological link to a confirmed case (probable case).

¶ Mumps notifications: see Appendix D for pre-2004 definition. National definition from January 2004: Confirmed cases require either laboratory definitive evidence, or laboratory suggestive evidence and clinical evidence, or clinical evidence and an epidemiological link to a laboratory-confirmed case. a) Laboratory definitive evidence: Isolation of mumps virus; or Detection of mumps virus by nucleic acid testing; or IgG seroconversion or a significant increase in antibody level or a fourfold or greater rise in titre to mumps virus in the absence of recent vaccination. b). Laboratory suggestive evidence: Detection of mumps-specific IgM antibody in the absence of recent vaccination. c) Clinical evidence: A clinically compatible illness characterised by swelling of the parotid or salivary glands lasting two days or more without other apparent cause.

** Rubella notifications: see Appendix D for pre-2004 definition. National definition from January 2004: A confirmed case requires laboratory definitive evidence. A probable case requires clinical evidence and either laboratory suggestive evidence or an epidemiological link to a laboratory-confirmed case. a) Laboratory definitive evidence: Isolation of rubella virus; or Detection of rubella virus by nucleic acid testing; or IgG seroconversion or a significant increase in antibody level or a fourfold or greater rise in titre to rubella virus in the absence of recent rubella vaccination in paired sera tested in parallel; or Detection of rubella-specific IgM antibody in the absence of recent rubella vaccination (must be confirmed in a reference laboratory in pregnant women). b) Laboratory suggestive evidence: In a pregnant patient, the detection of rubella-specific IgM antibody that has not been confirmed in a reference laboratory, in the absence of recent rubella vaccination. c) Clinical evidence: A generalised maculopapular rash and fever, and one or more of: arthralgia/arthritis or lymphadenopathy or conjunctivitis.

†† Tetanus notifications: see Appendix D for pre-2004 definition. National definition from January 2004: Confirmed cases require either laboratory definitive evidence or clinical evidence. a) Laboratory definitive evidence: Isolation of *Clostridium tetani* from a wound in a compatible clinical setting and prevention of positive tetanospasm in mouse test from such an isolate using specific tetanus antitoxin. b) Clinical evidence: A clinically compatible illness without apparent cause.

Indicates statistically significant, 95% confidence intervals greater or less than 1 ($p<0.5$).

Appendix B. Summary of hospitalisations and deaths in Australia,* for vaccine preventable diseases,† 2002 to 2005, by Indigenous status

Disease‡	Indigenous status	Hospitalisations* (July 2002–June 2005)			Deaths* 2003–2005		
		n	Rate§	Rate ratio	n	Rate§	Rate ratio
Diphtheria‖	Indigenous	24	2.2	25.1	0	–	–
	Other	38	0.1		0	–	
Hepatitis A	Indigenous	66	4.4	3.6	1	–	–
	Other	515	1.2		0	–	
Hepatitis B	Indigenous	27	2.4	3.8	0	–	–
	Other	269	0.6		14	–	
Influenza	Indigenous	566	38	2.3	2	–	–
	Other	6,812	16		47	–	
Measles	Indigenous	4	0.2	2.0	1	–	–
	Other	51	0.1		0	–	
Meningococcal disease	Indigenous	117	5.8	1.7	1	–	–
	Other	1,390	3.3		21	–	
Mumps¶	Indigenous	4	0.2	1.0	0	–	–
	Other	95	0.2		0	–	
Pertussis	Indigenous	111	5.2	2.3	0	–	–
	Other	946	2.3		0	–	
Pneumonia	Indigenous	16,680	1,696	3.5	126	25.1	1.5
	Other	207,183	486		3,914	17.1	
Pneumococcal disease**	Indigenous	234	21.4	4.5	2	–	–
	Other	1,994	4.7		9	–	
Poliomyelitis††	Indigenous	0	–	–	0	–	–
	Other	51	0.1		0	–	
Rubella‡‡	Indigenous	1	0.04	0.6	0	–	–
	Other	28	0.07		0	–	
Tetanus§§	Indigenous	0	–	–	0	–	–
	Other	54	0.1		0	–	
Varicella	Indigenous	215	10	1.4	0	–	–
	Other	2,990	7		4	–	

* Hospitalisations (New South Wales, the Northern Territory, Queensland, South Australia and Western Australia only) where the date of separation was between 1 July 2002 and 30 June 2005; deaths (the Northern Territory, Queensland, South Australia and Western Australia only) where the death was recorded between 1 January 2003 and 31 December 2005. Includes cases with unknown ages.

† See Results section for case definitions. For diseases not included in Results section, case definitions are listed below. Hospitalisations for rare disease should be interpreted with caution as they may include coding errors.

‡ *Haemophilus influenzae* type b hospitalisations and deaths not included because there is no ICD-10 code specific to *Haemophilus influenzae* type b.

§ Rates are per 100,000 population for all ages combined, age-standardised to the Australian Bureau of Statistics Australian population estimates for 2005.

‖ Diphtheria: The ICD-10-AM/ICD-10 code A36 (diphtheria) was used to identify hospitalisations and deaths. There were no cases of pharyngeal, nasopharyngeal, or laryngeal diphtheria recorded. 37 of the diphtheria cases recorded were cutaneous and 28 (76%) of these cases were from the Northern Territory.

¶ Mumps: The ICD-10-AM/ICD-10 code B26 (mumps) was used to identify hospitalisations and deaths.

** Pneumococcal disease (invasive): The ICD-10-AM/ICD-10 codes G00.1 (pneumococcal meningitis) and A40.3 (pneumococcal septicaemia) were used to identify hospitalisations due to invasive pneumococcal disease.

†† Poliomyelitis: The ICD-10-AM/ICD-10 code A80 (acute poliomyelitis) was used to identify hospitalisations and deaths. Sequelae of poliomyelitis (ICD-10 code B91) were not included in these analyses. A description of the hospitalisations is included in the 2003–2005 Vaccine Preventable Diseases and Vaccination Coverage report.[5]

‡‡ Rubella: The ICD-10-AM/ICD-10 code B06 (rubella [German measles]) was used to identify hospitalisations and deaths. Congenital rubella cases were not included in this summary.

§§ Tetanus: The ICD-10-AM/ICD-10 codes A34 (obstetrical tetanus) and A35 (other tetanus) were used to identify hospitalisations and deaths.

Indicates statistically significant, 95% confidence intervals greater than 1 (p<0.5).

Appendix C. List of health conditions of interest from the National Aboriginal and Torres Strait Islander Health Survey selected as indicators of prevalence of risk factors for which pneumococcal or influenza vaccination was recommended in Indigenous adults

Pneumococcal vaccination

Common long-term medical risk conditions of interest

Logical 'OR' combination of any one or more of these:

Output data item list – Health Status Indicators (taken from National Aboriginal and Torres Strait Islander Health Survey Data Reference Package[19])

Items and categories	SAS name
4. Cancer	
Cancer status – leukaemia	**NHPACANH**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term	
Cancer status – lymphoma	**NHPACANI**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term	

5. Heart and circulatory conditions	
Heart and circulatory condition status – rheumatic heart disease	**NHPAHARA**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – heart attack	**NHPAHARB**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – angina	**NHPAHARD**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – fluid problems/fluid retention	**NHPAHARH**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – rapid or irregular heartbeat	**NHPAHARJ**
1 Ever told has condition, still current and long-term	
Heart and circulatory condition status – heart murmur/heart valve disorder	**NHPAHARK**
1 Ever told has condition, still current and long-term	

6. Diabetes	
Diabetes status/Hormone sensitive lipase (HSL) status history	**NHPADIAF**
1 Ever told has diabetes (any type), and diabetes (any type) reported as current 2 Ever told has HSL (but not diabetes), and HSL reported as current	

7. Kidney disease and dialysis	
Kidney disease status	**KIDSTAT**
1 Ever told has condition, still current and long-term	

10. Long-term conditions	
(Type of) All long-term condition ICPC	**ICPC**
3 digit input codes grouped by ICPC categories	

ABS input code	ICPC code	Label
83	B90	HIV–infection/AIDS
70 71 929	B72	Hodgkin's disease/lymphoma
72 928	B73	Leukaemia
73 74 85 876	B74	Malignant neoplasm blood other
76	B78	Hereditary haemolytic anaemia
376	K70	Infection of circulatory system
377 935	K71	Rheumatic fever/heart disease
381	K73	Congenital anomaly cardiovascular
117 382 938	K74	Ischaemic heart disease with angina
383	K75	Acute myocardial infarction
384	K76	Ischaemic heart disease without angina
385	K77	Heart failure
390	K82	Pulmonary heart disease
136	K83	Heart valve disease not otherwise specified
583 979	R79	Chronic bronchitis
587	R83	Respiratory infection other
596 981	R95	Chronic obstructive pulmonary disease
599	R99	Respiratory disease other
688 947	T89	Diabetes insulin dependent
90 689 948	T90	Diabetes non-insulin dependent
705	U28	Limited function/disability (urinary)
203	U70	Pyelonephritis/pyelitis
204	U88	Glomerulonephritis/nephrosis

ICPC: International Classification of Primary Care (version 2)

Alcohol consumption at at-risk levels

Output data item list – Health Risk Factors:

2. Alcohol consumption	
Alcohol risk level 7 day average (2000 guidelines)	**AL2K7DAY**
2 Medium risk 3 High risk	

Current smokers

Output data item list – Health Risk Factors:

9. Smoking	
Smoker status	**SMSTATUS**
1 Current smoker daily 2 Current smoker weekly (at least once a week but not daily) 3 Current smoker less than weekly	

Influenza vaccination

Common long-term medical risk conditions of interest

Logical 'OR' combination of any one or more of these:

Output data item list – Health Status Indicators:

Items and categories	SAS name
4. Cancer	
Cancer status – leukaemia	**NHPACANH**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term	
Cancer status – lymphoma	**NHPACANI**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term	

5. Heart and circulatory conditions	
Heart and circulatory condition status – rheumatic heart disease	**NHPAHARA**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – heart attack	**NHPAHARB**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – angina	**NHPAHARD**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – fluid problems/fluid retention	**NHPAHARH**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term 3 Ever told has condition, not current	
Heart and circulatory condition status – rapid or irregular heartbeat	**NHPAHARJ**
1 Ever told has condition, still current and long-term	
Heart and circulatory condition status – heart murmur/heart valve disorder	**NHPAHARK**
1 Ever told has condition, still current and long-term	

6. Diabetes	
Diabetes status/High sugar level (HSL) status history	**NHPADIAF**
1 Ever told has diabetes (any type), and diabetes (any type) reported as current 2 Ever told has HSL (but not diabetes), and HSL reported as current	

7. Kidney disease and dialysis	
Kidney disease status	**KIDSTAT**
1 Ever told has condition, still current and long-term	

10. Long-term conditions	
(Type of) All long-term condition ICPC	**ICPC**
3 digit input codes grouped by ICPC categories	

ABS input code	ICPC code	Label
83	B90	HIV–infection/AIDS
70 71 929	B72	Hodgkin's disease/lymphoma
72 928	B73	Leukaemia
73 74 85 876	B74	Malignant neoplasm blood other
76	B78	Hereditary haemolytic anaemia
376	K70	Infection of circulatory system
377 935	K71	Rheumatic fever/heart disease
381	K73	Congenital anomaly cardiovascular
117 382 938	K74	Ischaemic heart disease with angina
383	K75	Acute myocardial infarction
384	K76	Ischaemic heart disease without angina
385	K77	Heart failure
390	K82	Pulmonary heart disease
136	K83	Heart valve disease not otherwise specified
583 979	R79	Chronic bronchitis
587	R83	Respiratory infection other
596 981	R95	Chronic obstructive pulmonary disease
599	R99	Respiratory disease other
688 947	T89	Diabetes insulin dependent
90 689 948	T90	Diabetes non-insulin dependent
705	U28	Limited function/disability (urinary)
203	U70	Pyelonephritis/pyelitis
204	U88	Glomerulonephritis/nephrosis

ICPC: International Classification of Primary Care (version 2)

Asthma

Output data item list – Health Status Indicators:

3. Asthma	
Asthma status	**NHPASTHM**
1 Ever told has condition, still current and long-term 2 Ever told has condition, still current but not long-term	

OR

ABS input code	ICPC code	Label
597	R96	Asthma

Appendix D. Notifiable diseases definitions in use prior to 2004

In September 2003, new national case definitions for notifications reported to NNDSS were endorsed by the Communicable Diseases Network Australia,[1,10] with nearly all jurisdictions implementing the new definitions in January 2004 (New South Wales commenced August 2004). Prior to the adoption of the national definitions, some jurisdictions used the 1994 NHMRC case definitions[9] as written (e.g. South Australia and Western Australia) and others used their own definitions (e.g. New South Wales and Victoria). This Appendix describes the definitions in use for notifiable diseases data prior to 2004 (i.e. the first year (2003) of the three-year review period of this report). Further detail about definitions previously in use can be found in earlier reports in this series[3,4,12] and in Skull 2001.[98]

Diphtheria

Notifications prior to 2004

Isolation of toxigenic *Corynebacterium diphtheriae* and one of the following:

- pharyngitis and/or laryngitis (with or without membrane); or
- toxic (cardiac or neurological) symptoms.

Hib

Notifications prior to 2004

a. A clinically compatible illness (meningitis, epiglottitis, cellulitis, septic arthritis, osteomyelitis, pneumonia, pericarditis or septicaemia) and either:

- the isolation of *Haemophilus influenzae* type b (Hib) from blood; or
- detection of Hib antigen (in a clinically compatible case); or
- detection of Gram-negative bacteria where the organism fails to grow in a clinical case

or

b. A confident diagnosis of epiglottitis by direct vision, laryngoscopy or x-ray.

Note: From 2002 in Victoria, notifications only included cases where Hib was laboratory confirmed.[99]

Hepatitis A

Notifications prior to 2004

a. Detection of anti-hepatitis A virus IgM antibody, in the absence of recent vaccination

or

b. A clinical case of hepatitis (jaundice, elevated aminotransferase levels without a non-infectious cause), and an epidemiological link to a serologically confirmed case.

Hepatitis B

Notifications prior to 2004

People who have a positive hepatitis B surface antigen (HBsAg) and one of the following:

a. hepatitis B core antibody (Anti-HBc) IgM

or

b. demonstration of a clinical illness consistent with acute viral hepatitis (jaundice, elevated aminotransferase).

Influenza

Became a notifiable disease in 2001 and the definition has remained unchanged.

Measles

Notifications prior to 2004

a. An illness characterised by all of the following features:
   - a generalised maculopapular rash lasting three or more days, and
   - a fever (at least 38ºC if measured), and
   - cough or coryza or conjunctivitis or Koplik spots

or

b. Demonstration of measles-specific IgM antibody

or

c. A fourfold or greater change in measles antibody titre between acute and convalescent phase sera obtained at least two weeks apart, with tests preferably conducted at the same laboratory

or

d. Isolation of measles virus from a clinical specimen

or

e. A clinically compatible case epidemiologically related to another case.

Meningococcal disease

Notifications prior to 2004

In jurisdictions apart from New South Wales and the Northern Territory, a notification of meningococcal disease required supportive laboratory evidence, although the nature of this varied. In New South Wales, the Northern Territory and Queensland, a clinical diagnosis of meningococcal disease without laboratory evidence was accepted as a presumptive (New South Wales) or probable (the Northern Territory, Queensland) case.

Mumps

Notifications prior to 2004

a. Isolation of mumps virus from a clinical specimen

or

b. Significant rise in mumps antibody level by any standard serological assay, except following vaccination

or

c. A clinically compatible illness (unilateral or bilateral swelling of the parotid or other salivary glands lasting two days or more without other apparent cause).

Notes: In New South Wales, only laboratory-confirmed cases [(a) or (b)] were notifiable. Mumps was not notifiable in Queensland between July 1999 and June 2001. From July 2001, notifications based on a clinical case definition alone [(c)] were no longer notifiable in Victoria.

Pertussis

Notifications prior to 2004

a. Isolation of *Bordetella pertussis* from a clinical specimen

or

b. Elevated *B. pertussis*-specific IgA in serum or the detection of *B. pertussis* antigen in a nasopharyngeal specimen using immunofluorescence with history of a clinically compatible illness

or

c. An illness lasting two weeks or more with one of the following:

- paroxysms of coughing; or
- inspiratory whoop without other apparent causes; or
- post-tussive vomiting

or

d. An illness characterised by a cough lasting at least two weeks in a patient who is epidemiologically linked to a laboratory-confirmed case.

Invasive pneumococcal disease

Became a notifiable disease in 2001 and the definition has remained unchanged.

Polio

Notifications prior to 2004

Acute-onset flaccid paralysis of one or more limbs with decreased or absent tendon reflexes in the affected limbs without apparent cause, and without sensory or cognitive loss.

Rubella

Notifications prior to 2004

a. A generalised maculopapular rash, fever, and one or more of arthralgia/arthritis or lymphadenopathy or conjunctivitis, and an epidemiological link to a confirmed case

or

b. Demonstration of rubella-specific IgM antibody, except following vaccination

or

c. A fourfold or greater rise in rubella antibody titre between acute and convalescent phase sera obtained at least two weeks apart

or

d. Isolation of rubella virus from a clinical specimen.

Note: From July 2001 to July 2002, enhanced rubella surveillance was undertaken in Victoria leading to an increase in the specificity of notifications.[100]

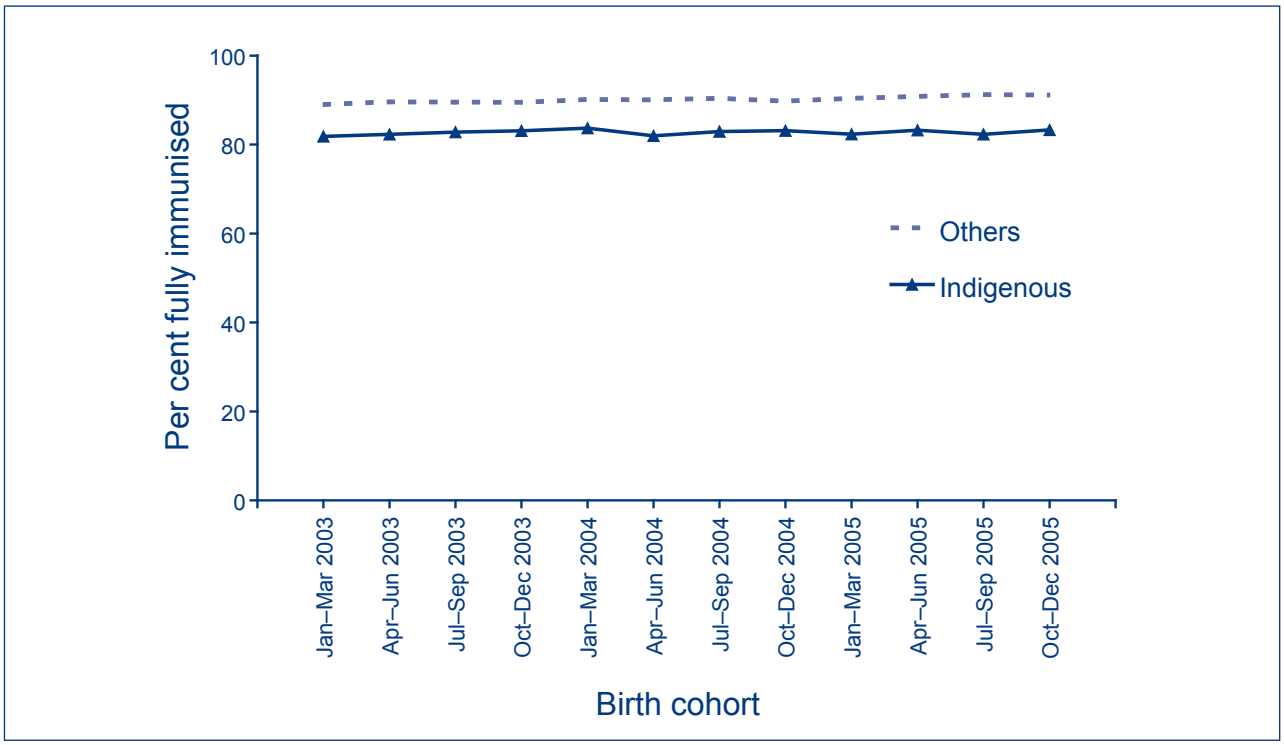
Tetanus

Notifications prior to 2004

A clinically compatible illness without other apparent cause, with or without a history of injury, and with or without laboratory evidence of the organism or its toxin.

Appendix E. Additional tables on risk factor prevalence and vaccination coverage data

Figure E1. Percentage of children born between January 2003 and December 2005 who were fully vaccinated at age 12 months, by Indigenous status and birth cohort, Australia



Source: Australian Childhood Immunisation Register, data as at 31 March 2007.

Table E1. Percentage of children at age 24 to <27 months who were 'fully vaccinated', by birth cohort

	Indigenous	Others
Born Jan–Mar 2004	92.5	91.8
Born Apr–Jun 2004	90.5	91.9
Born Jul–Sep 2004	91.9	92.2
Born Oct–Dec 2004	91.1	92.0

Table E2. Vaccine coverage of Australian children born between October and December 2005, at age 12 to <15 months (data as at 31 March 2007)

	State or territory								
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
DTP 3 doses									
Indigenous	95.8	85.8	87.1	85.3	79.2	84.9	90.7	76.7	84.4
Others	92.5	91.8	94.6	92.2	92.0	93.0	92.6	91.4	92.1
Polio 3 doses									
Indigenous	95.8	88.0	88.1	87.0	83.1	86.9	91.8	80.4	86.6
Others	95.5	95.0	97.4	95.9	94.9	95.3	95.3	94.6	95.2
Hib (2 or 3 doses)									
Indigenous	95.8	93.6	92.1	92.5	87.7	89.5	91.9	87.5	91.6
Others	95.4	94.6	96.1	93.7	94.0	96.3	94.6	94.6	94.5
Hep B (2 or 3 doses)									
Indigenous	95.8	93.6	94.4	92.5	88.5	89.5	92.6	88.7	92.2
Others	95.5	94.7	96.3	93.7	93.9	96.3	94.7	94.5	94.5
'Fully vaccinated'									
Indigenous	95.8	85.8	84.8	84.2	77.7	84.9	88.2	75.1	83.3
Others	92.1	91.3	94.0	90.8	90.5	92.8	91.2	90.8	91.1
Pneumococcal conjugate vaccine 3 doses (children born between Jan–Dec 2005)									
Indigenous	86.1	83.2	85.7	84.9	78.1	86.3	84.8	75.4	82.9
Others	90.2	89.7	91.8	90.2	90.7	92.0	91.3	88.3	90.2

Table E3. Vaccine coverage of Australian children born between October and December 2004, at age 24 to <27 months (data as at 31 March 2007)

	State or territory								
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
DTP 3 doses									
Indigenous	94.1	94.7	95.9	96.4	93.0	97.1	90.7	90.5	94.5
Others	95.9	94.3	96.1	93.8	94.9	96.2	95.4	94.6	94.6
Polio 3 doses									
Indigenous	100.0	95.0	95.0	96.9	93.7	97.1	91.9	92.4	95.0
Others	98.4	97.3	98.8	97.5	98.0	98.5	98.0	97.7	97.7
Hib (2 or 3 doses)									
Indigenous	94.1	96.4	98.8	97.9	96.5	98.6	96.3	95.3	97.0
Others	96.3	95.1	96.6	94.6	95.5	96.1	95.9	94.5	95.3
Hep B (2 or 3 doses)									
Indigenous	94.1	98.7	99.1	98.1	96.5	100.0	96.3	95.5	97.8
Others	96.3	95.3	96.9	94.9	95.6	96.6	96.2	95.2	95.5
MMR first dose									
Indigenous	93.8	94.8	96.5	95.6	94.4	94.3	93.8	91.6	94.7
Others	96.9	96.1	97.0	96.6	97.4	97.3	97.5	96.0	96.7
'Fully vaccinated'									
Indigenous	88.2	91.1	95.9	93.7	90.9	91.4	87.0	85.8	91.1
Others	93.4	91.3	93.7	91.2	92.8	94.3	93.2	90.8	92.0

Table E4. Vaccine coverage of Australian children born between October and December 2000, at age 72–<75 months (data as at 31 Mar 2007)

	State or territory								
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
MMR 2 doses									
Indigenous	87.5	88.8	92.9	92.9	80.2	93.0	88.7	84.3	89.5
Others	89.9	89.0	84.9	88.0	87.1	91.5	91.7	84.4	88.9
'Fully vaccinated'									
Indigenous	75.0	69.8	86.8	80.7	64.7	82.5	72.5	70.5	75.6
Others	81.5	74.8	74.9	78.4	74.0	82.0	80.0	72.9	76.9

Table E5. Prevalence of self-reported risk factors and proportion of the specified population who had influenza vaccination in the last 12 months prior to survey in 2004–2005 in Aboriginal and Torres Strait Islander adults aged 18–49 years, by state or territory

	State or territory							
	NSW/ACT	NT	Qld	SA	Tas	Vic	WA	Australia
Risk factor(s) prevalence in Indigenous population aged 18–49 years								
Chronic conditions	15	22	17	16	15	16	20	17
Chronic conditions + asthma	28	26	31	25	30	29	29	29
Proportion of the specified population who had influenza vaccination in the last 12 months								
Subset of Indigenous population aged 18–49 years who reported at least one risk factor	14	55	35	33	17	23	31	29
Total Indigenous population aged 18–49 years	10	48	29	21	11	16	20	23
% of total Indigenous population aged 18–49 years who had influenza vaccination in the last 12 months, by risk factor status and jurisdiction (calculated based on data above)								
Of total Indigenous population aged 18–49 years reporting at least one risk factor	3.9	14.3	10.9	8.3	5.1	6.7	9.0	8.4
Of total Indigenous population aged 18–49 years not reporting any risk factor	6.1	33.7	18.2	12.8	5.9	9.3	11.0	14.6

Table E6. Prevalence of self-reported risk factors and proportion of the specified population who had pneumococcal vaccination in the last five years prior to survey in 2004–2005 in Aboriginal and Torres Strait Islander adults aged 18–49 years, by state or territory

	State or territory							
	NSW/ ACT	NT	Qld	SA	Tas	Vic	WA	Australia
Risk factor(s) prevalence in Indigenous population aged 18–49 years								
Chronic conditions	15	22	17	16	15	16	20	17
Chronic conditions + heavy alcohol	31	28	34	30	26	30	38	32
Chronic conditions + heavy alcohol + tobacco	67	69	65	67	62	62	67	66
Proportion of the specified population who had pneumococcal vaccination in the last 5 years								
Subset of Indigenous population aged 18–49 years who reported at least one risk factor	4	25	20	10	3	10	9	13
Total Indigenous population aged 18–49 years	4	26	17	12	3	8	7	12
% of total Indigenous population aged 18–49 years who had pneumococcal vaccination in the last 5 years, by risk factor status and jurisdiction (calculated based on data above)								
Of total Indigenous population aged 18–49 years reporting at least one risk factor	2.7	17.3	13.0	6.7	1.9	6.2	6.0	8.6
Of total Indigenous population aged 18–49 years not reporting any risk factor	1.3	8.8	4.0	5.3	1.1	1.8	1.0	3.4

Table E7. Percentage of Aboriginal and Torres Strait Islander persons aged 50–64 years who had received influenza vaccination in the last 12 months prior to survey in 2004–2005, by state or territory and remoteness of residence

	State or territory							
	NSW/ ACT	NT	Qld	SA	Tas	NT	Vic	WA	Australia
Remote Indigenous population aged 50–64 years	54	82	85	90	–	82	–	65	76
Non-remote Indigenous population aged 50–64 years	39	23	42	66	40	23	50	48	43
Total Indigenous population aged 50–64 years	40	73	54	71	39	73	50	55	52

Table E8. Percentage of Aboriginal and Torres Strait Islander persons aged 50–64 years who had received pneumococcal vaccination in the last five years prior to survey in 2004–2005, by state or territory and remoteness of residence

	State or territory							
	NSW/ ACT	NT	Qld	SA	Tas	Vic	WA	Australia
Remote Indigenous population aged 50–64 years	30	65	52	45	–	–	40	52
Non-remote Indigenous population aged 50–64 years	20	4	26	25	31	13	24	22
Total Indigenous population aged 50–64 years	20	55	33	29	33	13	31	30

Abbreviations

7vPCV	7-valent pneumococcal conjugate vaccine
23vPPV	23-valent pneumococcal polysaccharide vaccine
ABS	Australian Bureau of Statistics
ACIR	Australian Childhood Immunisation Register
AIHW	Australian Institute of Health and Welfare
Anti-HBc	Hepatitis B core antibody
ASVS	Australian Standard Vaccination Schedule
ATAGI	Australian Technical Advisory Group on Immunisation
BCG	Bacille Calmette-Guérin
DT (dT)	Diphtheria-tetanus
DTP	Diphtheria-tetanus-pertussis
DTPa	Diphtheria-tetanus-pertussis (acellular)
dTpa	Adolescent/adult diphtheria-tetanus-pertussis (acellular)
HAV	Hepatitis A virus
HBV	Hepatitis B virus
HBsAg	Hepatitis B surface antigen
Hep A	Hepatitis A (vaccine abbreviation)
Hep B	Hepatitis B (vaccine abbreviation)
Hib	*Haemophilus influenzae* type b
ICD	International Classification of Diseases
ICD-10	International Classification of Diseases, 10th Revision
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification
IgG	Immunoglobulin G
IgM	Immunoglobulin M
IPD	Invasive pneumococcal disease
IPV	Inactivated poliomyelitis vaccine
MenCCV	Meningococcal C conjugate vaccine
MMR	Measles-mumps-rubella
NATSIHS	National Aboriginal and Torres Strait Islander Health Survey
NCIRS	National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases
NHMRC	National Health and Medical Research Council
NHS	National Health Survey
NIP	National Immunisation Program
NIPII	National Indigenous Pneumococcal and Influenza Immunisation (Program)
NNDSS	National Notifiable Diseases Surveillance System
PRP-OMP	*Haemophilus influenzae* type b polysaccharide conjugated to the outer membrane protein of *Neisseria meningitidis*
PRP-T	*Haemophilus influenzae* type b polysaccharide conjugated to tetanus toxoid
SSPE	Subacute sclerosing panencephalitis
VPD	Vaccine preventable disease
VZV	Varicella-zoster virus

References

1. Menzies R, McIntyre P, Beard F. Vaccine preventable diseases and vaccination coverage in Aboriginal and Torres Strait Islander people, Australia, 1999 to 2002. *Commun Dis Intell* 2004;28 Suppl 1:S1–S45.
2. Australian Institute of Health and Welfare. Improving the quality of Indigenous identification in hospital separations data. Australian Institute of Health and Welfare Cat. No. HSE101. Canberra: Australian Institute of Health and Welfare, 2005.
3. McIntyre P, Gidding H, Gilmour R, et al. Vaccine preventable diseases and vaccination coverage in Australia, 1999 to 2000. *Commun Dis Intell* 2002;26 Suppl:i–111.
4. Brotherton J, McIntyre P, Puech M, et al. Vaccine preventable diseases and vaccination coverage in Australia, 2001 to 2002. *Commun Dis Intell* 2004;28 Suppl 1:S1–S116.
5. Brotherton J, Wang H, Schaffer A, et al. Vaccine preventable diseases and vaccination coverage in Australia, 2003 to 2005. *Commun Dis Intell* 2007;31 Suppl 1:viii–S152.
6. Australian Bureau of Statistics, Australian Institute of Health and Welfare. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples: 2001. Cat. No. 4704.0. Canberra: Australian Bureau of Statistics, 2001.
7. Australian Bureau of Statistics, Australian Institute of Health and Welfare. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples: 2003. Cat. No. 4704.0. Canberra: Australian Bureau of Statistics, 2003.
8. Australian Bureau of Statistics, Australian Institute of Health and Welfare. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples, 2005. Cat. No. 4704.0. Canberra: Australian Bureau of Statistics, 2005.
9. Public Health Committee, National Health and Medical Reasearch Council. Surveillance case definitions. Canberra: Australian Government Printing Service, 1994.
10. Communicable Diseases Network Australia. Interim surveillance case definitions for the Australian National Notifiable Diseases Surveillance System. Version 1. 2004. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/cda_surveil-nndss-dislist.htm/$FILE/casedef.pdf Accessed on 18 May 2007.
11. Owen R, Roche P, Hope K, et al. Australia's notifiable disease status, 2005: annual report of the National Notifiable Disease Surveillance System. *Commun Dis Intell* 2007;31:1–70.
12. McIntyre P, Amin J, Gidding H, et al. Vaccine preventable diseases and vaccination coverage in Australia, 1993–1998. *Commun Dis Intell* 2000;24 Suppl:v–83.
13. Rothman KJ. Modern epidemiology. Boston: Little, Brown and Company, 1986.
14. Draper G, Turrell G, Oldenburg B. Health inequality in Australia: mortality. Health Inequalities Monitoring Series Number 1. AIHW Cat. No. PHE55. Canberra: Queensland University of Technology and Australian Institute of Health and Welfare, 2004.
15. O'Brien ED, Sam GA, Mead C. Methodology for measuring Australia's childhood immunisation coverage. *Commun Dis Intell* 1998;22:36–37.
16. Hull BP, McIntyre PB. Immunisation coverage reporting through the Australian Childhood Immunisation Register—an evaluation of the third-dose assumption. *Aust N Z J Public Health* 2000;24:17–21.
17. Rank C, Menzies RI. How reliable are Australian Childhood Immunisation Register coverage estimates for Indigenous children? An assessment of data quality and coverage. *Commun Dis Intell* 2007;31:283–287.
18. Vlack SA, Foster R, Menzies R, et al. Immunisation coverage of Queensland Indigenous two year old children by cluster sampling and by register. *Aust N Z J Public Health* 2007;31:67–72.
19. Australian Bureau of Statistics. National Aboriginal and Torres Strait Islander Health Survey: Users' Guide, 2004–05. Cat. No. 4715.0.55.004. Canberra: Australian Bureau of Statistics, 2006.
20. National Health and Medical Research Council. The Australian immunisation handbook. 8th ed. Canberra: Australian Government Department of Health and Ageing, 2003.
21. Allen CJ, Ferson MJ. Notification of infectious diseases by general practitioners: a quantitative and qualitative study. *Med J Aust* 2000;172:325–328.
22. Bonacruz-Kazzi G, McIntyre P, Hanlon M, Menzies R. Diagnostic testing and discharge coding for whooping cough in a children's hospital. *J Paediatr Child Health* 2003;39:586–590.
23. Australian Institute of Health and Welfare. Mortality over the twentieth century in Australia: trends and patterns in major causes of death. Mortality Surveillance Series No. 4. Australian Institute of Health and Welfare Cat. No. PHE73. Canberra: Australian Institute of Health and Welfare, 2005.
24. Hull B, Lawrence G, MacIntyre CR, McIntyre P. Immunisation coverage: Australia 2001. Canberra: Commonwealth Department of Health and Ageing, 2002.
25. Skull SA, Andrews RM, Byrnes GB, et al. Validity of self-reported influenza and pneumococcal vaccination status among a cohort of hospitalised elderly patients. *Vaccine* 2007;25:4775–4783.
26. Ross K. Occasional paper: Population issues, Indigenous Australians, 1996. ABS Cat. No. 4708.0. Canberra: Australian Bureau of Statistics, 1999.
27. Gilbert GL, Clements DA, Broughton SJ. *Haemophilus influenzae* type b infections in Victoria, Australia, 1985 to 1987. *Pediatr Infect Dis J* 1990;9:252–257.
28. McIntyre PB, Leeder SR, Irwig LM. Invasive *Haemophilus influenzae* type b disease in Sydney children 1985–1987: a population-based study. *Med J Aust* 1991;154:832–837.

29. Hanna J. The epidemiology and prevention of *Haemophilus influenzae* infections in Australian aboriginal children. *J Paediatr Child Health* 1992;28:354–361.
30. Horby P, Gilmour R, Wang H, McIntyre P. Progress towards eliminating Hib in Australia: an evaluation of *Haemophilus influenzae* type b prevention in Australia, 1 July 1993 to 30 June 2000. *Commun Dis Intell* 2003;27:324–341.
31. Markey P, Krause V, Boslego JW, et al. The effectiveness of *Haemophilus influenzae* type b conjugate vaccines in a high risk population measured using immunization register data. *Epidemiol Infect* 2001;126:31–36.
32. Singleton R, Hammit L, Hennessey T, et al. The Alaska *Haemophilus influenzae* type b experience: lessons in controlling a vaccine-preventable disease. *Pediatrics* 2006;118:e421–e429.
33. Wilson N, Wenger J, Mansoor O, Baker M, Martin D. The beneficial impact of Hib vaccine on disease rates in New Zealand children. *N Z Med J* 2002;115:U122-U128.
34. Institute of Environmental Science and Research Ltd. Notifiable and other diseases in New Zealand. Annual report 2004. 2005. Available from: http://www.surv.esr.cri.nz/surveillance/annual_surveillance.php Accessed on 20 April 2006.
35. Hull BP, McIntyre PB, Couzos S. Evaluation of immunisation coverage for Aboriginal and Torres Strait Islander children using the Australian Childhood Immunisation Register. *Aust N Z J Public Health* 2004;28:47–52.
36. Heymann DL, ed. Control of communicable diseases manual. 18th ed. Washington, D.C.: American Public Health Association, 2004.
37. Bell BP, Shapiro C, Alter MJ, et al. The diverse patterns of hepatitis A epidemiology in the United States—implications for vaccination strategies. *J Infect Dis* 1998;178:1579–1584.
38. Plotkin SA, Orenstein WA, eds. Vaccines. 4th ed. Philadelphia: WB Saunders, 2004.
39. Hanna JN, Hills SL, Humphreys JL. Impact of hepatitis A vaccination of Indigenous children on notifications of hepatitis A in north Queensland. *Med J Aust* 2004;181:482–485.
40. Minister for Health and Ageing. Government provides free hepatitis A vaccine to Indigenous children. Media release. 2005. Available from: http://www.health.gov.au/internet/ministers/publishing.nsf/content/health-mediarel-yr2005-ta-abb079.htm/$FILE/abb079.pdf Accessed on 18 May 2007.
41. Bowden FJ, Currie BJ, Miller NC, Locarnini SA, Krause VL. Should aboriginals in the "top end" of the Northern Territory be vaccinated against hepatitis A? *Med J Aust* 1994;161:372–373.
42. Hanna JN, Warnock TH, Shepherd RW, Selvey LA. Fulminant hepatitis A in indigenous children in north Queensland. *Med J Aust* 2000;172:19–21.
43. Ferson MJ, Young LC, Stokes ML. Changing epidemiology of hepatitis A in the 1990s in Sydney, Australia. *Epidemiol Infect* 1998;121:631–636.
44. Amin J, Gilbert GL, Escott RG, Heath TC, Burgess MA. Hepatitis A epidemiology in Australia: national seroprevalence and notifications. *Med J Aust* 2001;174:338–341.
45. Gilroy NM, Tribe IG, Passaris I, Hall R, Beers MY. Hepatitis A in injecting drug users: a national problem. *Med J Aust* 2000;172:142–143.
46. Centers for Disease Control and Prevention. Prevention of hepatitis A through active or passive immunization: Recommendations of the Advisory Committee on Immunization Practices. *MMWR Recomm Rep* 1999;48(RR12):1–37.
47. Kaldor JM, Plant AJ, Thompson SC, Longbottom H, Rowbottom J. The incidence of hepatitis B infection in Australia: an epidemiological review. *Med J Aust* 1996;165:322–326.
48. Ryder SD, Beckingham IJ. ABC of diseases of liver, pancreas, and biliary system: Chronic viral hepatitis. *BMJ* 2001;322:219–221.
49. O'Sullivan BG, Gidding HF, Law M, et al. Estimates of chronic hepatitis B virus infection in Australia, 2000. *Aust N Z J Public Health* 2004;28:212–216.
50. Wan X, Mathews JD. Primary hepatocellular carcinoma in Aboriginal Australians. *Aust N Z J Public Health* 1994;18:286–290.
51. Menzies R, McIntyre P. Vaccine preventable diseases and vaccination policy for indigenous populations. *Epidemiol Rev* 2006;28:71–80.
52. Williams A. Reduction in the hepatitis B related burden of disease—measuring the success of universal immunisation programs. *Commun Dis Intell* 2002;26:458–460.
53. Kao JH, Hsu HM, Shau WY, Chang MH, Chen DS. Universal hepatitis B vaccination and the decreased mortality from fulminant hepatitis in infants in Taiwan. *J Pediatr* 2001;139:349–352.
54. Huang K, Lin S. Nationwide vaccination: a success story in Taiwan. *Vaccine* 2000;18 Suppl 1:S35–S38.
55. Mandell GL, Bennett JE, Dolin R, eds. Mandell, Douglas, and Bennett's Principles and practice of infectious diseases. 5th ed. Philadelphia: Churchill Livingstone, 2000.
56. National Health and Medical Research Council. The Australian immunisation handbook. 7th ed. Canberra: Australian Government Printing Service, 1999.
57. National Health and Medical Research Council. The Australian immunisation handbook. 9th ed. Canberra: Australian Government Department of Health and Ageing, 2008.
58. Izurieta HS, Thompson WW, Kramarz P, et al. Influenza and the rates of hospitalization for respiratory disease among infants and young children. *N Engl J Med* 2000;342:232–239.

59. Centers for Disease Control and Prevention. Recommended childhood and adolescent immunization schedule—United States, 2006. *MMWR Morb Mortal Wkly Rep* 2006;54:Q1–Q4.

60. National Advisory Committee on Immunization. Statement on influenza vaccination for the 2004–2005 season. *Can Commun Dis Rep* 2004;30 ACS–3:1–32.

61. Patel M, Lush D. Measles vaccine effectiveness in central Australian aboriginal children vaccinated at or after eight months of age. *Aust N Z J Public Health* 1998;22:729–730.

62. Miller N. Changes to the Northern Territory childhood vaccination schedule—MMR. *The Northern Territory Disease Control Bulletin* 1998;5:1–2.

63. Turnbull FM, Burgess MA, McIntyre PB, et al. The Australian Measles Control Campaign, 1998. *Bull World Health Organ* 2001;79:882–888.

64. Patel M. Meningococcal disease in Australia; looking at the past, thinking of the future. *Commun Dis Intell* 1997;21:233–236.

65. Patel MS, Merianos A, Hanna JN, et al. Epidemic meningococcal meningitis in central Australia, 1987–1991. *Med J Aust* 1993;158:336–340.

66. Pearce MC, Sheridan JW, Jones DM, et al. Control of group C meningococcal disease in Australian aboriginal children by mass rifampicin chemoprophylaxis and vaccination. *Lancet* 1995;346:20–23.

67. Baker MG, Martin DR, Kieft CE, Lennon D. A 10-year serogroup B meningococcal disease epidemic in New Zealand: descriptive epidemiology, 1991–2000. *J Paediatr Child Health* 2001;37:S13–S19.

68. Baker M, McNicholas A, Garrett N, et al. Household crowding a major risk factor for epidemic meningococcal disease in Auckland children. *Pediatr Infect Dis J* 2000;19:983–990.

69. Thorton V, Lennon D, Rasanathan K, et al. Safety and immunogenicity of New Zealand strain meningococcal serogroup B OMV vaccine in healthy adults: beginning of epidemic control. *Vaccine* 2006;24:1395–1400.

70. Borrow R, Carlone GM, Rosenstein N. *Neisseria meningitidis* group B correlates of protection and assay standardization—international meeting report Emory University, Atlanta, Georgia, United States, 16–17 March 2005. *Vaccine* 2006;24:5093–5107.

71. Kolos V, Menzies R, McIntyre P. Higher pertussis hospitalization rates in indigenous Australian infants, and delayed vaccination. *Vaccine* 2007;25:588–590.

72. Mandell GL, Bennett JE, Dolin R, eds. Mandell, Douglas, and Bennett's Principles and practice of infectious diseases. 6th ed. Philadelphia: Elsevier Churchill Livingstone, 2005.

73. Roche P, Krause V. Invasive pneumococcal disease in Australia, 2001. *Commun Dis Intell* 2002;26:505–519.

74. Roche P, Krause V, Andrews R, et al. Invasive pneumococcal disease in Australia, 2002. *Commun Dis Intell* 2003;27:466–477.

75. Roche P, Krause V, Bartlett M, et al. Invasive pneumococcal disease in Australia, 2003. *Commun Dis Intell* 2004;28:441–454.

76. Roche P, Krause V, Bartlett M, et al. Invasive pneumococcal disease in Australia, 2004. *Commun Dis Intell* 2006;30:80–92.

77. Roche P, Krause V, Cook H. Invasive pneumococcal disease in Australia, 2005. *Commun Dis Intell* 2007;31:86–100.

78. Hull BP, McIntyre PB. What do we know about 7vPCV coverage in Aboriginal and Torres Strait Islander children? *Commun Dis Intell* 2004;28:238–243.

79. Prymula R, Peeters P, Chrobok V, et al. Pneumococcal capsular polysaccharides conjugated to protein D for prevention of acute otitis media caused by both *Streptococcus pneumoniae* and non-typable *Haemophilus influenzae*: a randomised double-blind efficacy study. *Lancet* 2006;367:740–748.

80. Scott DA, Komjathy SF, Hu BT, et al. Phase 1 trial of a 13-valent pneumococcal conjugate vaccine in healthy adults. *Vaccine* 2007;25:6164–6166.

81. Hanna J, Humphreys JL, Murphy DM. Invasive pneumococcal disease in Indigenous people in north Queensland, 1999–2004. *Med J Aust* 2006;184:118–121.

82. Mak DB. Invasive pneumococcal disease in the Kimberley, 1995–2001. *Aust J Rural Health* 2004;12:237–240.

83. Krause V, Cook H, Selvey CE. Impact of 7vPCV and 23vPPV booster in eligible children in the Northern Territory of Australia: impressive, but not the total answer. 5th International Symposium on Pneumococci and Pneumococcal Diseases, Alice Springs, April 2006.

84. Moberley SA, Holden J, Tatham DP, Andrews RM. Vaccines for preventing pneumococcal infection in adults. *Cochrane Database Syst Rev* 2007;2008, Issue 1:Art. No.: CD000422. DOI: 10.1002/14651858.CD000422.pub2.

85. O'Brien KL, Hochman M, Goldblatt D. Combined schedules of pneumococcal conjugate and polysaccharide vaccines: is hyporesponsiveness an issue? *Lancet Infect Dis* 2007;7:597–606.

86. Preblud SR, Orenstein WA, Bart KJ. Varicella: clinical manifestations, epidemiology and health impact in children. *Pediatr Infect Dis* 1984;3:505–509.

87. Gidding HF, MacIntyre CR, Burgess MA, Gilbert GL. The seroepidemiology and transmission dynamics of varicella in Australia. *Epidemiol Infect* 2003;131:1085–1089.

88. Guess HA, Broughton DD, Melton LJ, III, Kurland LT. Population-based studies of varicella complications. *Pediatrics* 1986;78:723–727.

89. Brody MB, Moyer D. Varicella-zoster virus infection: the complex prevention-treatment picture. *Postgrad Med* 1997;102:187–190,192–194.

90. Communicable disease surveillance: highlights for 3rd quarter 2006. *Commun Dis Intell* 2007;30:471–476.

91. Boughton CR. Smallpox and Australia. *Intern Med J* 2002;32:59–61.

92. Hanna JN. The epidemiology of invasive *Haemophilus influenzae* infections in children under five years of age in the Northern Territory: a three year study. *Med J Aust* 1990;152:234–240.

93. Degani N, Navarro C, Deeks S, Lovgren M. Invasive bacterial diseases in northern Canada. *Emerg Infect Dis* 2008;14:34–40.

94. Krause VL, Reid SJ, Merianos A. Invasive pneumococcal disease in the Northern Territory of Australia, 1994–1998. *Med J Aust* 2000;173 Suppl:S27–S31.

95. Torzillo PJ, Hanna J, Morey F, et al. Invasive pneumococcal disease in central Australia. *Med J Aust* 1995;162:182–186.

96. Singleton RJ, Hennessey T, Bulkow L, et al. Invasive pneumococcal disease caused by nonvaccine serotypes among Alaska Native children with high levels of 7-valent pneumococcal conjugate vaccine coverage. *JAMA* 2007;297:1784–1792.

97. Hanna JN, McCall B, Murphy D. Invasive meningococcal disease in north Queensland, 1990–1994. *Commun Dis Intell* 1996;20:320–324.

98. Skull SA. A review of national notifiable disease case definitions [report to Communicable Diseases Network Australia New Zealand]. January 2001.

99. O'Grady KA, Counahan M, Birbilis E, Tallis G, eds. Surveillance of notifiable infectious diseases Victoria. Melbourne: Communicable Diseases Section, Rural and Regional Health and Aged Care Service, Victoria Department of Human Services, 2003.

100. Guy RJ, Andrews RM, Kelly HA, et al. Mumps and rubella: a year of enhanced surveillance and laboratory testing. *Epidemiol Infect* 2004;132:391–398.