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The burden of vaccine preventable diseases in Australia

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Australian Institute of Health and Welfare
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Contents

Summary ..... **v**

1 Introduction **1**

Diseases included in the BVPD study 1

What is burden of disease? 3

Overarching burden of disease methods 5

Disease model building 6

Main data sources 7

Modelling infectious diseases 7

Additional material 8

2 National results **9**

Overall burden of vaccine preventable diseases 9

Which diseases caused the most burden? 11

Changes in the overall burden since 2005 15

Burden for individual diseases 16

3 Indigenous Australians **45**

Overall burden among Indigenous Australians 45

Which diseases caused the most burden? 45

Changes in burden since 2005 47

Gap in burden 48

4 Discussion **51**

Burden of vaccine preventable diseases in 2015 51

Changes in burden over time 52

Comparison with ABDS 2015 results 56

Comparison with other incidence-based studies 58

Limitations 59

Appendix A: Individual state/territory results **61**

New South Wales 61

Victoria 63

Queensland 65

Western Australia 67

South Australia 69

Tasmania 71

Australian Capital Territory 73

Northern Territory 75

Appendix B: Additional methodological information 77
Overarching inputs and methodological choices 77
Methods for deriving state and territory estimates 78
Methods for deriving Indigenous estimates 79
Main data sources 80
Appendix C: Disease models 86
Diphtheria 86
Haemophilus influenzae type b 87
Hepatitis A 89
Hepatitis B 90
Human papillomavirus 92
Influenza 94
Measles 96
Meningococcal disease (invasive) 97
Mumps 99
Pneumococcal disease (invasive) 100
Polio 102
Rotavirus 103
Rubella and Congenital Rubella Syndrome 104
Tetanus 106
Varicella zoster (chickenpox and shingles) 107
Whooping cough 109
Appendix D: Supplementary tables 111
Appendix E: Methods and results for diseases not covered by NIP vaccines 128
Q fever 128
Respiratory syncytial virus 130
Acknowledgments 132
Abbreviations 133
Symbols 134
Glossary 135
References 136
List of tables 141
List of figures 144
List of boxes 146
Related publications 146

Summary

This report presents results from the Burden of Vaccine Preventable Diseases in Australia study (BVPD study). The BVPD study used incidence-based modelling to estimate burden. This approach reflects the burden of all new cases of disease that occur in the reference year and their immediate and future consequences (including death). Due to differences in methods, results from this report should not be directly compared with those from the Australian Burden of Disease Study or the Global Burden of Disease study.

The Australian Government provides free vaccines to eligible people, including young children, older Australians, Aboriginal and Torres Strait Islander Australians, and others who are at greater risk of serious harm from vaccine preventable diseases (VPD), such as pregnant women. In 2018, the Australian National Immunisation Program (NIP) provided vaccines against 17 diseases.

Results of the BVPD study show a reduction in the burden for a number of diseases for which vaccines have been added to, or vaccine eligibility extended on, the NIP schedule during the past 20 years. These include human papillomavirus (HPV), chickenpox, hepatitis A, hepatitis B, meningococcal disease, pneumococcal disease and rotavirus.

In 2015:

- 5 diseases accounted for almost 95% of the VPD burden: influenza (36%), pneumococcal disease (24%), HPV (24%), shingles (7%) and meningococcal disease (4%)
- over three-quarters (80%) of the VPD burden was due to premature death
- the rate of VPD burden was highest in infants and older Australians (85 years and over). Among those aged 1–74, young adults aged 25–29 had the highest rate of burden. The majority of the burden in this age group is due to the potential long-term outcome of developing cervical cancer following HPV infection.

Between 2005 and 2015:

- there was a 31% decrease in the overall age-standardised rate of burden due to the 17 VPD included on the NIP schedule
- the VPD burden rate decreased among infants, young children and young adults, and increased among those aged 65 and over
- decreased burden in young children was mostly driven by declines in the incidence of rotavirus, pneumococcal and meningococcal diseases, while the sharp decreases for young adults were driven by declines in HPV infection
- the increased burden in older adults (65 years and over) was mainly due to the increased incidence of influenza and shingles, along with greater numbers of deaths from these 2 diseases.

Estimates of the burden among Indigenous Australians were calculated for 13 VPD: chickenpox, *Haemophilus influenzae* type b (Hib), hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, mumps, pneumococcal disease, rotavirus, shingles and whooping cough.

- In 2015, 10% of the burden due to these 13 VPD was among Indigenous Australians. The Indigenous VPD burden rate was 4.1 times the rate for non-Indigenous Australians.
- Between 2005 and 2015, the age-standardised rate of burden among Indigenous Australians due to the 13 specified VPD decreased by almost 41%.

1 Introduction

According to the Australian Burden of Disease Study (ABDS) 2015, infectious diseases (also known as communicable diseases) were responsible for 2% of the total burden of disease in Australia in 2015 (AIHW 2019b). Around 11% of infectious disease burden was due to vaccine preventable diseases (VPD).

A vaccine preventable disease is one that can be prevented, or its impact reduced, through immunisation (generally with a vaccine). Examples include polio, measles and hepatitis B. Vaccines stimulate the body's immune system to protect against subsequent infection. The World Health Organization (WHO) estimates that immunisation prevents 2 to 3 million deaths worldwide each year and recognises immunisation as 'one of the most successful and cost-effective health interventions known' (WHO 2013). In 2019, the WHO listed 'vaccine hesitancy' (see Glossary) as a key global threat to health (WHO 2019a).

The Burden of Vaccine Preventable Diseases in Australia study (BVPD study) was undertaken to further investigate the burden due to VPD in Australia. The analysis in this report responds to the following broad questions:

1. What is the current burden due to VPD in Australia and how has it changed over time?
2. How does the burden vary by sex, across age groups, for Aboriginal and Torres Strait Islanders and by states and territories?

Diseases included in the BVPD study

As part of the Australian Government's response to VPD in Australia, certain key vaccines are provided free of charge at specified ages. The National Immunisation Program (NIP) schedule sets out which vaccines are provided at which ages, as well as noting certain at-risk groups (for example, Indigenous Australians, and those with certain medical conditions) who are eligible for vaccines under the program (see Table 1.2).

The BVPD study included 19 diseases: the 17 diseases with vaccines in the NIP schedule in 2018 and 2 additional diseases not currently covered by the NIP, but for which vaccines are either available at individual cost or are under development (Table 1.1). The methods and results for these 2 additional diseases are presented in Appendix E.

Table 1.1: Diseases included in the BVPD study

Diseases for which vaccines are available under the NIP schedule		
Chickenpox (varicella)	Diphtheria	*Haemophilus influenzae* type b (Hib)
Hepatitis A[(a)]	Hepatitis B	Human papillomavirus (HPV)
Influenza	Measles	Meningococcal disease (invasive)
Mumps	Pneumococcal disease (invasive)	Poliomyelitis
Rotavirus	Rubella	Shingles (herpes zoster)
Tetanus	Whooping cough (pertussis)	
Diseases for which vaccines are available at individual cost or are under development		
Q fever	Respiratory syncytial virus (RSV)	

(a) Vaccine is available under the NIP for Indigenous children living in Queensland, Western Australia, South Australia and the Northern Territory.

Table 1.2: NIP schedule as at 8 August 2018

Age	Disease
Childhood vaccinations	
Birth	Hepatitis B[(a)]
2 months (can be given from 6 weeks of age)	Diphtheria, tetanus, pertussis (whooping cough), hepatitis B, polio, *Haemophilus influenzae* type b (Hib)
	Pneumococcal
	Rotavirus[(b)]
4 months	Diphtheria, tetanus, pertussis (whooping cough), hepatitis B, polio, *Haemophilus influenzae* type b (Hib)
	Pneumococcal
	Rotavirus[(b)]
6 months	Diphtheria, tetanus, pertussis (whooping cough), hepatitis B, polio, *Haemophilus influenzae* type b (Hib)
6 months: Additional vaccine for medically at-risk children[(c)]	Pneumococcal
6 months: Additional vaccine for Aboriginal and Torres Strait Islander children (in Qld, NT, WA and SA)	Pneumococcal
12 months	Meningococcal serotypes ACWY
	Measles, mumps, rubella
	Pneumococcal
12 months: Additional vaccine for Aboriginal and Torres Strait Islander children (in Qld, NT, WA and SA)	Hepatitis A
18 months	*Haemophilus influenzae* type b (Hib)
	Measles, mumps, rubella, varicella (chickenpox)
	Diphtheria, tetanus, pertussis (whooping cough)
18 months: Additional vaccine for Aboriginal and Torres Strait Islander children (in Qld, NT, WA and SA)	Hepatitis A
4 years	Diphtheria, tetanus, pertussis (whooping cough), polio
4 years: Additional vaccine for medically at-risk children[(c)]	Pneumococcal
Adolescent vaccinations	
10<15 years (school programs[(d)])	Human papillomavirus (HPV)[(e)]
	Diphtheria, tetanus, pertussis (whooping cough)
Adult vaccinations	
15–49 years Aboriginal and Torres Strait Islander people with medical risk factors[(c)]	Pneumococcal
50 years and over Aboriginal and Torres Strait Islander people	Pneumococcal
65 years and over	Pneumococcal
70–79 years[(f)]	Shingles (herpes zoster)
Pregnant women	Pertussis (whooping cough)[(g)]

(continued)

Table 1.2 (continued): NIP schedule as at 8 August 2018

Age	Disease
Funded annual influenza vaccination	
People 6 months and over with certain medical risk factors[(c)]	Influenza
Aboriginal and Torres Strait Islander children 6 months to less than 5 years	
Aboriginal and Torres Strait Islander people 15 years and over	
People 65 years and over	
Pregnant women	

(a) The Hepatitis B vaccine should be given to all infants as soon as practicable after birth; the greatest benefit is if given within 24 hours. The vaccine must be given within 7 days of birth.

(b) First dose must be given by 14 weeks of age, and the second dose by 24 weeks of age.

(c) See the current edition of *The Australian Immunisation Handbook* for all medical risk factors.

(d) Contact your state or territory health service for school grades eligible for vaccination.

(e) Observe Gardasil®9 dosing schedules by age and at-risk conditions—2 doses: 9 to <15 years—6 months minimum interval; 3 doses: ≥15 years and/or have certain medical conditions—0-, 2- and 6-month schedule. Only 2 doses funded on the NIP schedule unless 12–13 year old has certain medical risk factors.

(f) All people aged 70, with a 5-year catch-up program for people aged 71–79 until 31 October 2021.

(g) Single dose recommended each pregnancy, ideally between 28–32 weeks, but may be given up until delivery.

Note: The NIP schedule specifies the ages and at-risk groups for which individuals are eligible for free vaccination under the NIP. The latest version of the schedule is available at https://www.health.gov.au/health-topics/immunisation.

Source: Department of Health 2018a.

What is burden of disease?

Burden of disease analysis is a way to measure, combine and compare the impact of different diseases, conditions or injuries on a population. It uses information from a range of sources to quantify the fatal (for example, dying early from cervical cancer caused by human papillomavirus (HPV) infection) and non-fatal (for example, living with chronic liver disease caused by Hepatitis B) effects of these diseases in a consistent manner so that they can then be combined into a summary measure of health called the 'disability-adjusted life year' (DALY). A DALY combines estimates of years of life lost due to premature death (YLL) and years lived with ill health or disability (YLD) to count the total years of healthy life lost from disease and injury (Box 1.1).

The health loss that the DALY measures, represents the difference between the current health status of the population and the ideal situation where everyone lives a long life, free of disease. Burden of disease estimates capture both the quantity and quality of life, and reflect the magnitude, severity and impact of disease and injury on the population.

Burden of disease analysis is a standard method for collating data of acceptable quality on causes of health loss to produce comparable and concise policy-relevant evidence. A key strength of a burden of disease study is the ability to use data from a range of sources to construct an internally consistent measure for all diseases. Similar comparisons and rankings across different diseases or injuries cannot be produced using separate studies conducted on a disease-by-disease basis or using disparate data sources.

Box 1.1: Key terms used in this report

Burden of disease: The quantified impact of a disease or injury on a population, using the **disability-adjusted life years (DALY)** measure. Referred to as the 'burden' of the disease in this report.

DALY (disability-adjusted life years): A measure (in years) of healthy life lost, either through premature death (defined as dying before the expected potential life span remaining at the age of death) (**YLL**) or, equivalently, through living with ill health due to illness or injury (**YLD**).

Disability weight: A factor that reflects the severity of health loss from a particular health state on a scale from 0 (perfect health) to 1 (equivalent to death).

Fatal burden: The burden from dying prematurely as measured by years of life lost. Often used synonymously with **YLL** and also referred to as 'life lost'.

Health state: Consequences of diseases and conditions reflecting key differences in symptoms and functioning, with which health losses can be associated.

Incidence: The number of new cases (of an illness or injury) occurring in a defined population during a given period, often expressed as the number of new cases per 100,000 population per year.

Non-fatal burden: The burden from living with ill-health as measured by years lived with disability. Often used synonymously with **YLD** and also referred to as 'health loss'.

Prevalence: The number of current cases (new and pre-existing) of a disease or injury in a defined population at a given time, often expressed as the number of cases per 100,000 population.

Sequelae: Health consequences of diseases; for example, septicaemia due to meningococcal disease.

YLD (years lived with disability): The number of years of what could have been a healthy life but were instead spent in states of less than full health. YLD represent non-fatal burden.

YLL (years of life lost): The number of years of life lost due to premature death, defined as dying before the ideal life span. YLL represent the fatal burden.

(Refer to the Glossary for a full list of definitions.)

Types of burden estimates presented in this report

A range of statistics and estimates are presented in this report and in the accompanying material, which are useful for different purposes:

- **DALY**, **YLD** and **YLL estimates** describe the overall, non-fatal and fatal disease burden in the population being analysed. They are useful for summarising the health of that population at a point in time, for assessing health-care needs and for planning health services.
- **Crude numbers**, **proportions and rates** of DALY, YLL and YLD provide a measure of health loss against the size of the population, without taking any other features of the population into account. They are useful for measuring the relative impact in one age group compared with another by describing the amount of health loss relative to the size of the age group. They are also useful for assessing health-care needs and planning health services.
- **Age-standardised rates** of DALY, YLL and YLD also provide a measure of the health loss against the size of the population, but take into account the age structure of the

population and changes in population size and ageing over time. Age-standardised rates have little use in service provision planning, but are useful for comparing the impact of various diseases between 2 populations with different age structures (for example, Indigenous and non-Indigenous Australians) or between 2 different time points (for example, 2005 and 2015).

- **Rate ratios** and **rate differences** are used to compare groups (for example, age groups, Indigenous and non-Indigenous Australians or sub-national populations) in measures of the health gap as well as in comparisons over time (between 2005 and 2015 estimates). A rate ratio (calculated as $rate_{(group\ 1)}/rate_{(group\ 2)}$) shows the ratio of one rate of burden relative to another, while rate difference (calculated as $rate_{(group\ 1)} - rate_{(group\ 2)}$) is a straight numerical difference between one rate and another.
- **Rankings** are often used to tell the story of which disease or injury causes the biggest burden. However, rankings do not provide context of the size of each estimate, nor of the difference in size between adjacent estimates.

Overarching burden of disease methods

Two main methods are generally used in burden of disease studies:

- an incidence-based modelling approach, which uses deaths and new disease cases occurring in the reference year (incident deaths and incident illness) as inputs
- a hybrid modelling approach, which uses deaths and all disease cases existing in the reference year (incident deaths and prevalent illness) as inputs.

Other methods are available, but are rarely used in practice.

The incidence-based approach takes into account the current and future burden due to cases of disease that occur in the reference year, but does not include the burden due to cases already diagnosed in previous years. The hybrid approach takes into account the current burden of all cases existing in the reference year, regardless of when the case was first diagnosed. For conditions lasting 12 months or less, the models return the same result; the difference is in how long-term conditions, including the long-term effects of acute infections, contribute to the estimates.

Under the incidence-based approach, the resulting DALY represent the expected current and future impact of newly diagnosed cases of disease in a given year. For the hybrid approach, the resulting DALY can be thought of as an index of population health in a given year, providing a summary measure of the overall population health for that year. Both of these measures are useful in different ways:

- the incidence-based approach may provide information relevant to prevention and evaluation of preventive interventions, whereas
- the hybrid approach may be more relevant to questions about health service use, health expenditure, and evaluations of interventions aimed at existing cases.

The hybrid approach was used in the ABDS as it better reflects Australia's overall disease profile (for which the prevalence of diseases is typically used to inform health service planning, disease management and treatment programs) and aligns with disease expenditure estimates.

The analyses presented in this report used an **incidence-based** modelling approach for estimating the burden of disease. This means that, for each reference year, the analysis is based on all new cases of disease that occur in that year and the immediate and future consequences (including death) of those cases. This study thus differs from the ABDS and

the Global Burden of Disease (GBD) study—both of which use the hybrid modelling approach—but is consistent with other studies that focus on infectious diseases, such as the Burden of Communicable Diseases in Europe (BCoDE) study (Cassini et al. 2018). Results from this report should not be directly compared with those from the ABDS or GBD study.

Why use a different method to estimate burden?

At the start of the BVPD study, the intention was to remain broadly consistent with the methodology used in the ABDS, while, where possible, improving data sources, severity distributions, disease duration, sequelae included, and disability weights assigned to stages of the diseases under study.

As data and disease model work progressed for the BVPD study, it became apparent that the usual hybrid approach was not the option best suited to the purposes of the project, which were to:

- quantify the current burden of VPD and explore how it has changed over time
- identify differences by sex, age groups, for Indigenous Australians and by state and territory.

A key interest of the BVPD study is the effect of vaccination on the incidence and outcomes of new cases for each included disease. For several diseases (for example, polio) some Australians are still experiencing the long-term effects of cases acquired many years ago, before the widespread use of relevant vaccines. Including estimates of burden from these cases would make it difficult to see clearly how things have changed in the recent past, and how they may change in the future, as a result of changes in disease incidence or vaccination coverage. Using an incidence-based methodology for estimating burden helps to overcome this problem, since only new cases of diseases, and the long-term complications arising from these cases, are included in the analysis for a particular year, focusing on the burden that vaccination is aimed at preventing.

Disease model building

The BCoDE study (Cassini et al. 2018) used an incidence-based approach to estimate burden, and the group has made a tool available to support the necessary calculations (European Centre for Disease Prevention and Control 2015). Several models in this tool relate to diseases included in the BVPD study and these have been used as a starting point for disease model building. The tool requires model input estimates by sex and 5-year age group of:

- acute disease incidence, including, if relevant, the proportion developing complications
- case-fatality rates
- transition probabilities for each long-term outcome
- durations and disability weights for the acute stage and all sequelae
- the size of the population at risk
- relevant life tables.

The software allows ranges of values for disability weights, durations, case-fatality rates and transition probabilities. If ranges are used, the software randomly assigns values within the range to each case. Ranges were used in some models and this is noted in the methods for individual diseases in Appendix C.

Disease models for the BVPD study were constructed following a literature review of each disease, to ensure suitability for an Australian context. This included information on the description of symptoms, illness duration, case fatality estimates, transitional probabilities for sequelae and, where relevant, additional health states not included in the BCoDE or ABDS models. The values used for each disease are presented along with relevant evidence and contextual information in Appendix C of this report.

Main data sources

Data to develop the BVPD estimates were obtained from 5 main data sources:

- National Notifiable Diseases Surveillance System
- National Hospital Morbidity Database
- Bettering the Evaluation and Care of Health
- National Mortality Database
- Epidemiological studies.

Population estimates underpinning all estimates were sourced from the Australian Bureau of Statistics (ABS).

Details on the various data sources, including Indigenous identification considerations, are in Appendix B.

Modelling infectious diseases

Figure 1.1 presents a generic conceptual model of infectious disease, on which the models underlying estimates of the burden for each individual disease in this report were based.

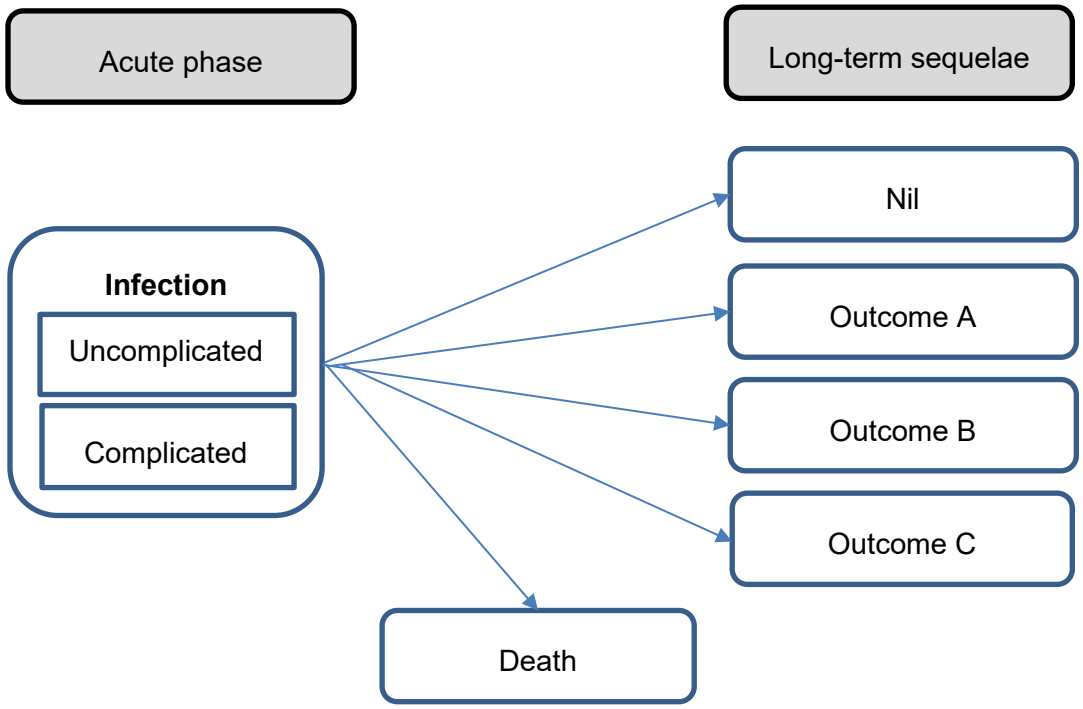
The model has 3 main parts, each of which needs to be estimated:

- the acute phase of infection, which can include complications (for example, orchitis caused by mumps) or be a simple uncomplicated case
- death following infection
- long-term sequelae following infection, which can be immediate or delayed, and may last months, years or the individual's remaining lifetime. These sequelae may also be fatal.

Note that a disability weight was not applied to the acute phase of asymptomatic infections in these models. For certain diseases, namely hepatitis B and HPV, long-term sequelae can result from asymptomatic infections; this was accounted for in the disease-specific models.

Details on the individual disease models are in Appendix C.

Figure 1.1: Generic conceptual model for infectious diseases



Additional material

A range of additional information accompanies this technical report, including:

- supplementary tables providing data underlying the figures in this report
- an 'In-focus' report summarising the key findings
- data visualisations that allow the user to explore the data.

All of these are available on the Australian Institute of Health and Welfare (AIHW) website at: https://www.aihw.gov.au/reports-data/health-welfare-services/immunisation/overview.

Fact sheets and data visualisations presenting key statistics on each of the diseases covered by vaccines under the NIP are also available at this web address.

2 National results

This chapter presents detailed results of the estimated burden of disease (Box 2.1), for each disease individually and for the 17 NIP diseases as a group, for 2005 and 2015. Estimates are provided for Australia as a whole and by age group. Estimates of burden by state and territory are also presented where the available data allowed reliable estimates to be made at this level. Separate estimates of burden of disease among Aboriginal and Torres Strait Islanders are presented in Chapter 3.

Box 2.1: Interpreting the results in this report

As this study uses an incidence-based method, the results represent the current and future burden of infections acquired in the reference year. For example, the burden of hepatitis B in 2015 is the immediate burden of acute hepatitis B infections acquired in 2015, plus the future burden due to chronic hepatitis B, liver cirrhosis and liver cancer resulting from these infections.

Using this method, the future burden associated with long-term sequelae is attributed to the age at which the person acquired their infection, not the age at which the sequelae occur. Using the earlier example, if a person was infected with hepatitis B at age 27, and then developed liver cirrhosis aged 43, the burden associated with the liver cirrhosis is attributed to the 25–29 age group, not to the 40–44 age group.

This means results differ from those for infectious diseases produced by the ABDS or GBD studies, which represent the current burden of all infections acquired in the reference year, and any deaths caused by these infections in that year. In those studies, the burden of any long-term sequelae of infectious diseases, such as liver cancer, is attributed to the age at which the sequelae occur. The ABDS and GBD studies also differ from the BVPD study in that they attribute the burden of these sequelae to the specific manifestation of disease (cancer) rather than to the initial infection that caused it (hepatitis B).

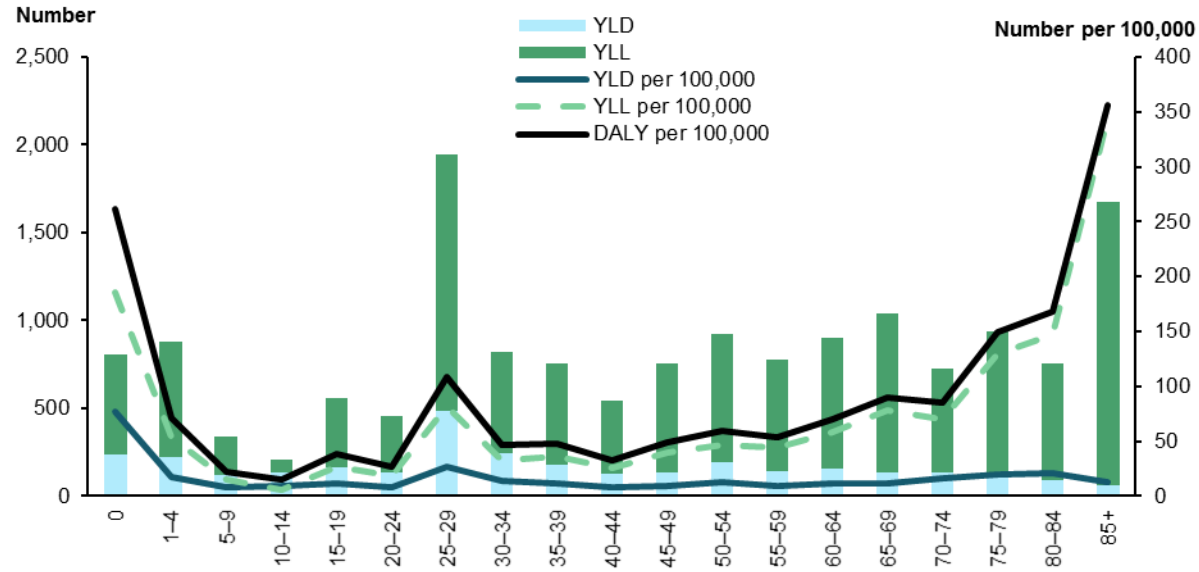
Overall burden of vaccine preventable diseases

As a group, new cases of the 17 VPD covered under the NIP schedule were responsible for almost 16,000 DALY in 2015. The majority (80%) of this burden was due to premature death (fatal burden, YLL).

Overall, the number of DALY was highest among people aged 25–29, accounting for 12% of the total burden, followed by people aged 85 and over who contributed a further 11%. The high burden among young adults is because of the potential long-term outcome of developing cervical cancer after infection with HPV.

The rate of burden was highest among infants and those aged 85 and over, at 262 and 357 DALY per 100,000 population, respectively (Figure 2.1). Almost one-third (32%) of the overall burden due to VPD occurred among people aged 65 and over.

Figure 2.1: Non-fatal (YLD), fatal (YLL) and total burden (DALY) due to VPD, by age, 2015



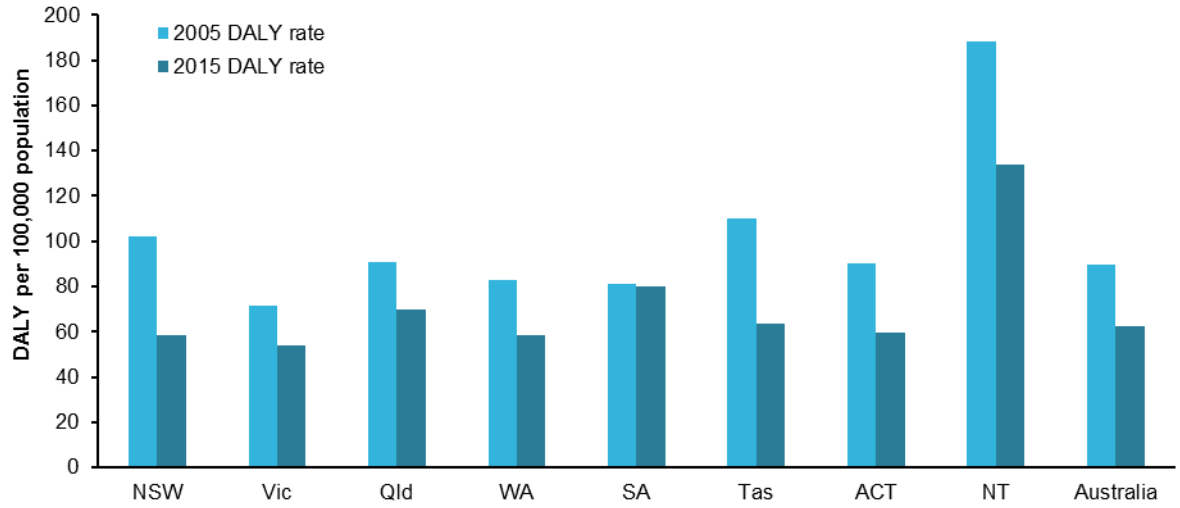
Source: This figure is based on data in Table D2.1.

States and territories

For 11 of the 17 individual VPD, the annual number of cases allowed for the estimation of the burden by states and territories. The annual number of cases or the overall burden attributed to the remaining diseases was too small to be disaggregated by individual states and territories (diphtheria, tetanus, rubella, Hib, mumps and polio).

In 2015, the rate of burden due to VPD was highest in the Northern Territory (134 DALY per 100,000 population) and South Australia (80 DALY per 100,000). Rates for the other jurisdictions ranged between 54 and 70 DALY per 100,000 in 2015. The rate of burden due to VPD decreased substantially between 2005 and 2015 in most states and territories (Figure 2.2). For more detailed results by state and territory, see Appendix A.

Figure 2.2: Burden (DALY per 100,000 population) due to VPD, by state and territory, 2005 and 2015



Notes

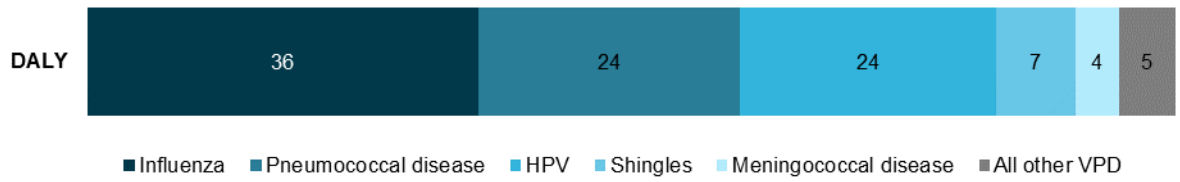
1. Includes chickenpox, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, pneumococcal disease, rotavirus, shingles and whooping cough. The annual number of cases or the overall burden attributed to diphtheria, Hib, rubella, mumps, polio and tetanus were too small to be disaggregated by individual states and territories.
2. Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.2.

Which diseases caused the most burden?

Influenza contributed more than one-third of the total burden (5,674 DALY, 36%), followed by pneumococcal disease (3,793 DALY, 24%) and HPV (3,710 DALY, 24%). Shingles contributed a further 7% to the total and meningococcal disease just over 4%. Together, these 5 diseases accounted for just under 95% of the total burden associated with diseases covered by vaccines under the NIP schedule (Figure 2.3).

Figure 2.3: Contribution of individual diseases to overall burden (DALY) due to VPD, 2015 (%)



Note: 'All other VPD' comprises hepatitis B, whooping cough, chickenpox, rotavirus, hepatitis A, measles, diphtheria, tetanus, rubella, Hib, mumps and polio.

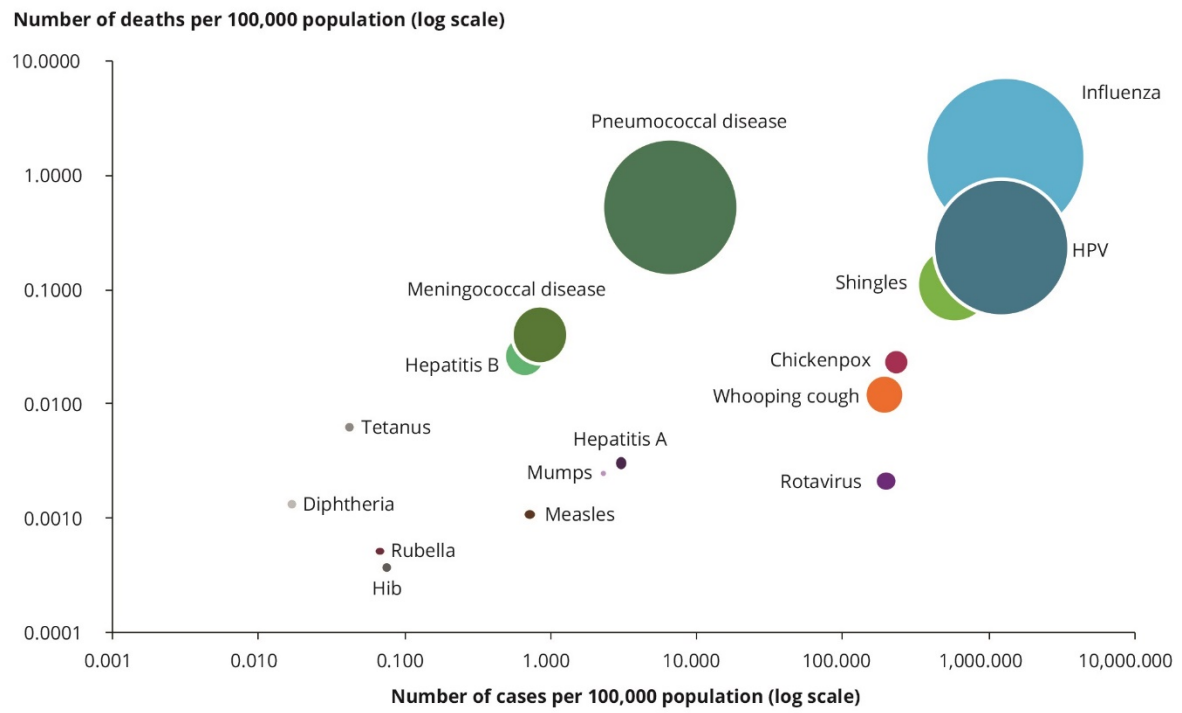
Source: This figure is based on data in Table D2.3.

Some VPD cause more severe illness and have a higher burden of disease for each person with the disease (relatively high DALY per case); some, on the other hand, may not be as severe at the individual level but, due to the large number of cases, have a greater total burden (relatively high DALY per 100,000 population, see Figure 2.4).

Despite contributing more than one-third of the total burden at the population level, influenza has a very low burden at the individual level, at 0.02 DALY per case. Several other common diseases, such as shingles, whooping cough and chickenpox, also have a very low individual burden:

- Diphtheria, while contributing only 15 DALY to the total of almost 16,000 DALY, has the highest individual burden at 3.7 DALY per case, due to the small number of cases and the high case-fatality rate for the respiratory form of the disease.
- Meningococcal disease and pneumococcal disease also have a relatively high level of individual burden, due to high case-fatality combined with the serious lifelong consequences associated with bacterial meningitis.
- Similarly, although the individual burden of rubella infection is low, the burden associated with each case of congenital rubella syndrome (CRS) is high.
- HPV, although potentially having serious long-term consequences and a high population burden, has a relatively low individual burden as the number of infections is very large, with only a fraction of these (about 1 in 700) progressing to cervical cancer.

Figure 2.4: Number of cases, deaths and population-level burden due to VPD, Australia, 2015



Notes

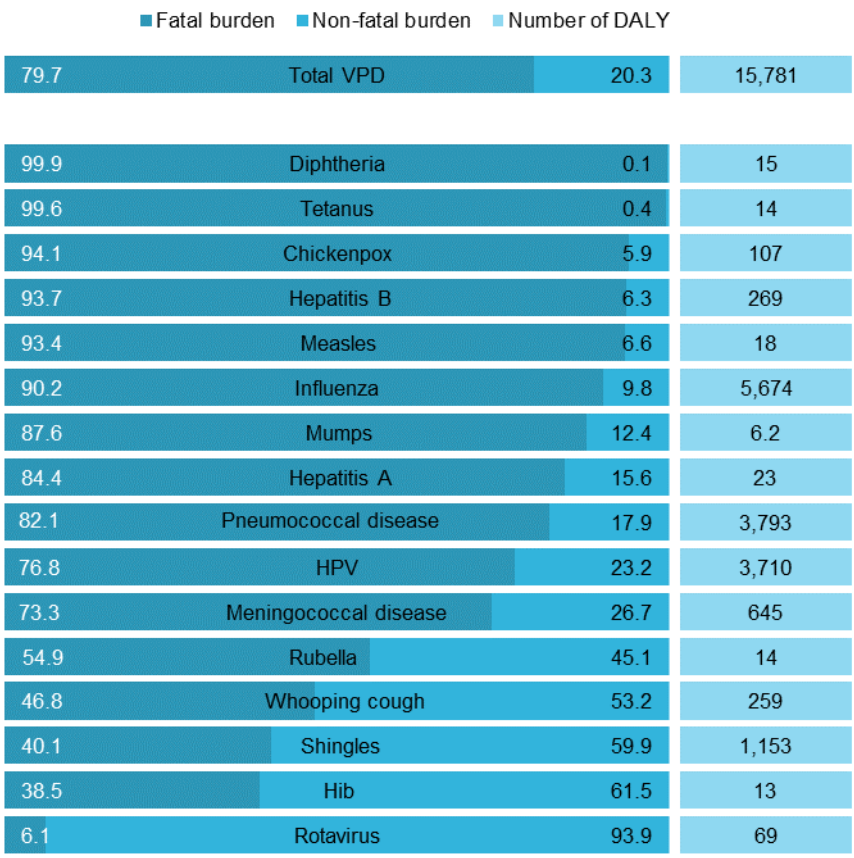
1. Size of bubbles indicates population-level burden (DALY per 100,000 population).
2. Polio is not included in the figure as the burden due to incident polio in 2015 was zero.

Source: This figure is based on data in Table D2.4.

Fatal and non-fatal burden by disease

The contribution of fatal and non-fatal outcomes to the total burden by disease varied considerably (Figure 2.5). Fatal burden contributed at least three-quarters of the total burden for most diseases; however, less than half of the total burden was fatal for whooping cough (47%), shingles (40%) and Hib (39%). Only 6% of the burden due to rotavirus was fatal.

Figure 2.5: Proportion of fatal (YLL) and non-fatal (YLD) burden, by disease, 2015

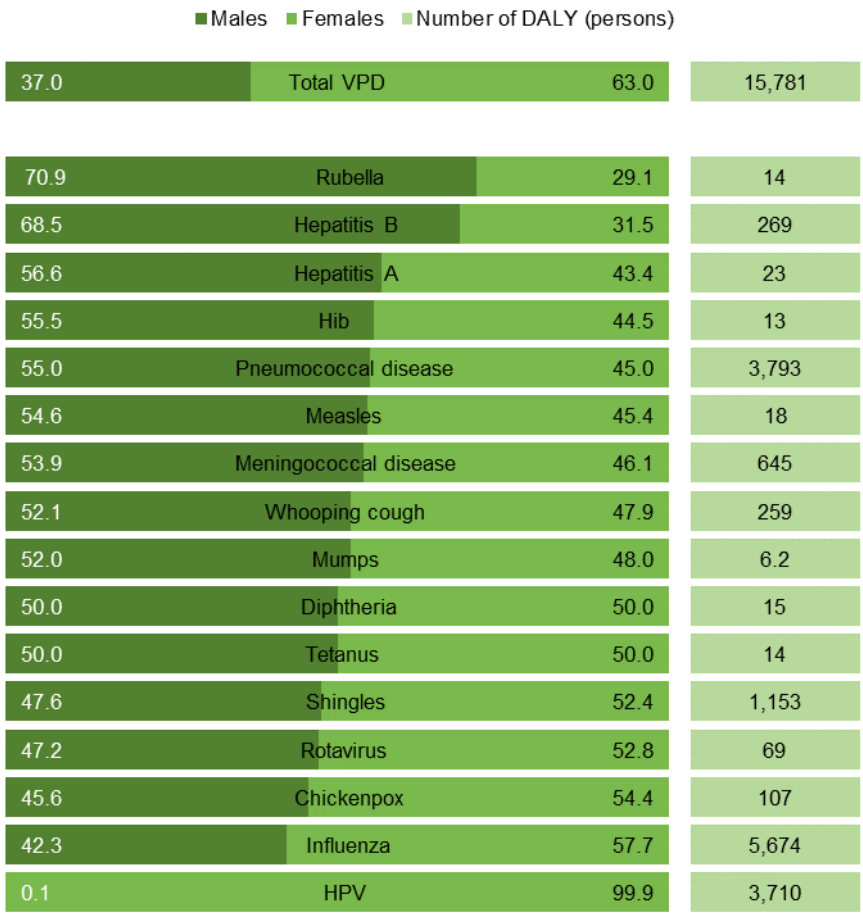


Source: This figure is based on data in Table D2.5.

Burden by disease and sex

The distribution of burden between the sexes varied by disease. Males experienced a greater share of the overall burden due to rubella (71%), hepatitis B (69%) and hepatitis A (57%), whereas females experienced a greater share of the burden due to influenza (58%) as well as more than 99% of the burden due to HPV (Figure 2.6). The higher rubella burden attributed to males was due to the higher number of CRS cases among males.

Figure 2.6: Proportion of total burden (DALY), by disease and sex, 2015



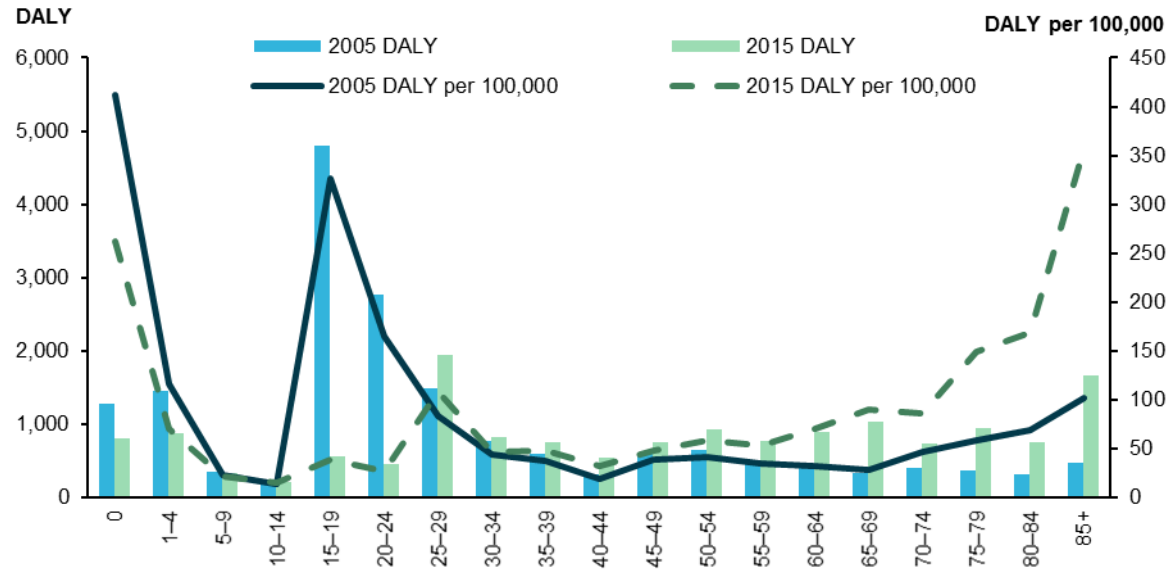
Source: This figure is based on data in Table D2.6.

Changes in the overall burden since 2005

The overall burden of VPD decreased between 2005 and 2015. The number of DALY decreased by 13% overall, and the age-standardised rate by 31%. Rates of DALY for children and mid-age adults remained fairly stable, with decreases in the rate of burden among infants, young children aged 1–4 and young adults aged 15–24, and increases in the older age groups (Figure 2.7).

Decreased burden in young children was mostly driven by declines in the incidence of rotavirus, and in pneumococcal and meningococcal diseases, while the sharp decreases for young adults were driven by declines in HPV infection. The increased burden among older adults was mainly due to the increased incidence of influenza and shingles, along with greater numbers of deaths from these 2 diseases.

Figure 2.7: Burden (DALY and DALY per 100,000 population) due to VPD, by age, 2005 and 2015



Source: This figure is based on data in Table D2.7.

When comparing results for 2005 and 2015, it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices. For example, the apparent increase in influenza cases in recent years is likely to be due to a combination of increased awareness and testing as well as to a real increase in the number of cases. Also, 2015 was an outbreak period for whooping cough, with rates twice as high among infants and 10 times as high among young children as in 2005.

Factors contributing to changes in burden for individual diseases are described in the following sections.

Burden for individual diseases

The remainder of this chapter presents detailed results for each individual disease, ordered by contribution to overall DALY. For each disease, results are provided by age group and broken down by state and territory where possible. Results by age group for 2005 are also presented to highlight changes over time. To account for differences in population age structure and size, age-standardisation has been used when comparing burden of disease estimates for 2005 and 2015.

Influenza

In 2015, there were an estimated 313,000 cases of influenza in Australia. Over the 3-year period 2014–2016, influenza caused an average of 10,613 hospitalisations and 337 deaths per year.

Between 2010 and 2018, the NIP schedule provided annual influenza vaccinations for people aged 65 and over, Indigenous Australians aged 6 months to 5 years or 15 years and over, pregnant women, and people aged over 6 months with medical risk factors. Many others purchased vaccines from health services each year.

From 2019 onwards, the NIP schedule expanded funded influenza vaccinations to all Indigenous Australians aged 6 months and over.

Burden in 2015

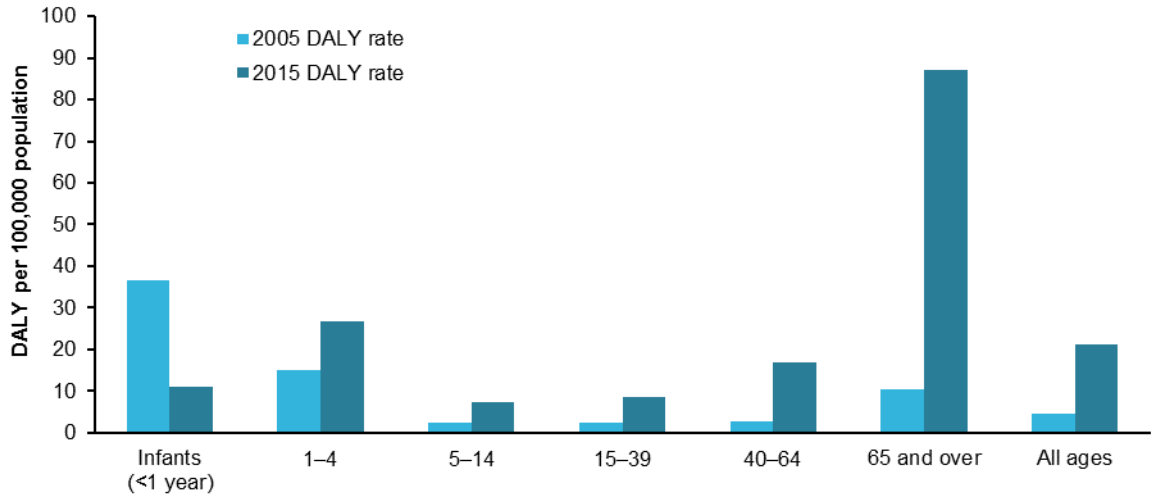
In 2015, the estimated influenza burden was 5,674 DALY, with 90% of this attributed to fatal burden. While influenza infection is mild in many cases, with a low individual burden of 0.02 DALY per case, it is relatively common, with an estimated 313,000 cases in 2015. As a result, influenza has the highest population-level burden of the diseases included in this study. In 2015, the influenza burden rate generally increased with age, although it was higher among children aged under 5 than in older children and young adults (Figure 2.8).

Change since 2005

The estimated influenza burden in 2005 was lower than in 2015 (4.6 compared with 21.1 DALY per 100,000 population), and the rate of burden was highest among infants and young children (Figure 2.8).

The substantially lower burden in 2005 is a result of a considerably smaller number of influenza cases combined with a lower case-fatality rate. The particular subtypes of the influenza virus that circulate each season affect the burden of disease, as they influence the age groups affected, the severity of illness and the effectiveness of the vaccine, as well as the overall number of cases. However, the impact of increased awareness following the 2009 pandemic, combined with the availability of PCR (polymerase chain reaction) testing on the Medicare Benefits Schedule in recent years, would also have contributed substantially to a greater number of cases being identified in 2015. Alternative data sources providing surveillance of influenza-like illnesses suggest that the magnitude of the 2015 influenza season was slightly higher than, but comparable to, that for the preceding few years and that the increase in notifications may relate to increased testing rather than to increased morbidity (Fielding et al. 2016).

Figure 2.8: Influenza burden (DALY per 100,000 population), by age, 2005 and 2015



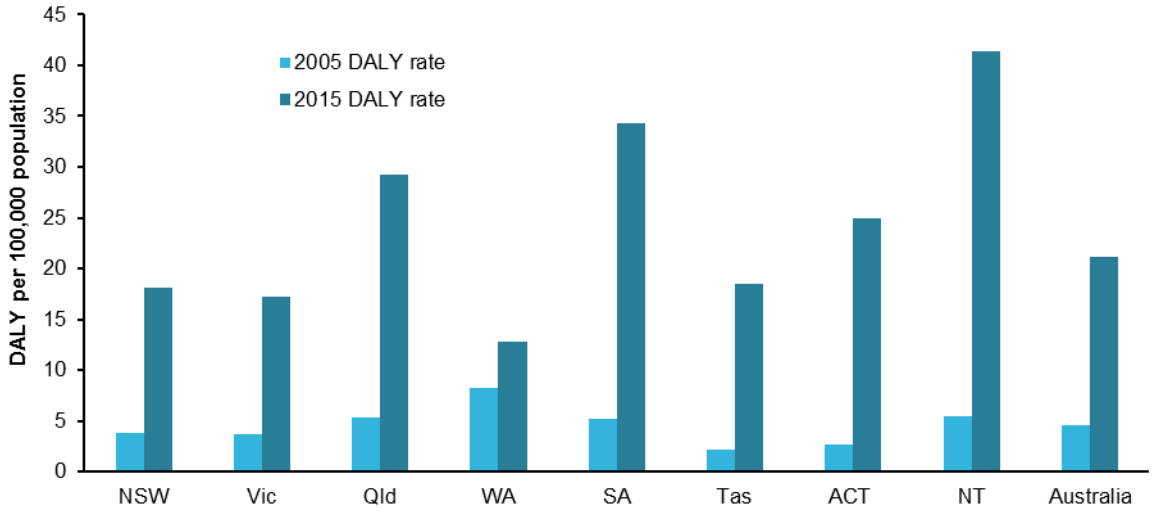
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.8.

Burden by state and territory

In 2015, the rate of influenza burden was highest in the Northern Territory and South Australia, at around 41 and 34 DALY per 100,000 population, respectively (Figure 2.9). The rate of influenza burden was higher in 2015 than in 2005 across all states and territories.

Figure 2.9: Influenza burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.9.

Pneumococcal disease (invasive)

Over the 3-year period 2014–2016, there were an average of 1,576 notifications of invasive pneumococcal disease (IPD) and 2,219 hospitalisations per year. Although around 20 deaths from IPD are registered each year, data from the enhanced pneumococcal surveillance program suggest that the number of deaths following IPD may be 5–6 times this figure.

Pneumococcal vaccination is available on the NIP schedule for infants and young children, adults aged 65 and over, and Indigenous Australians aged 50 and over. Vaccination under the NIP schedule for at-risk Indigenous adults was introduced in 1999, although subsidised vaccinations have been available under the Pharmaceutical Benefits Scheme for all people aged over 65 since February 1997. Vaccination for at-risk infants was first nationally funded under the NIP schedule in 2001, and then extended to all infants and people aged 65 and over in 2005 (NCIRS 2018b).

A large number of different types of pneumococcal bacteria (serotypes) can cause IPD. Currently, the NIP schedule provides a conjugate vaccine covering 13 serotypes (13-valent) for infants and young children, and a polysaccharide vaccine covering 23 serotypes (23-valent) for at-risk children and the elderly. The 13-valent vaccine was introduced in July 2011, replacing a 7-valent conjugate vaccine that had been used for infants and young children since 2001. After the 7-valent vaccine was introduced, the number of cases caused by serotypes not covered by this vaccine increased. This effect is known as 'serotype replacement'; it occurs because the effectiveness of the vaccine in preventing bacterial colonisation by the serotypes it covers increases the opportunity for other serotypes to colonise and cause disease (WHO 2011). Following the change to the 13-valent vaccine, there was a relatively rapid decrease in IPD due to the additional 6 serotypes it covered, but its incidence has subsequently plateaued. More recently, the number of cases due to the 11 serotypes additionally covered by the 23-valent polysaccharide vaccine, and also those serotypes not covered by either available vaccine, has been increasing steadily across all age groups.

In 2001, in IPD cases where the serotype was identified, 75% of cases were caused by serotypes covered by the 7-valent vaccine, and 93% by serotypes covered by the 23-valent vaccine (Roche et al. 2002). By 2005, these proportions had decreased to 61% and 88%, respectively (Roche et al. 2007). In 2015, 34% of IPD cases with known serotype were caused by serotypes covered by the 13-valent vaccine and 65% by serotypes covered by the 23-valent vaccine (NNDSS Annual Report Writing Group 2019).

Burden in 2015

In 2015, the estimated IPD burden was 3,795 DALY, with four-fifths (82%) of this attributed to fatal burden. Nearly all of the IPD non-fatal burden was due to long-term disability resulting from meningitis. Infection is severe in most cases, reflected in the high individual burden of 2.4 DALY per case.

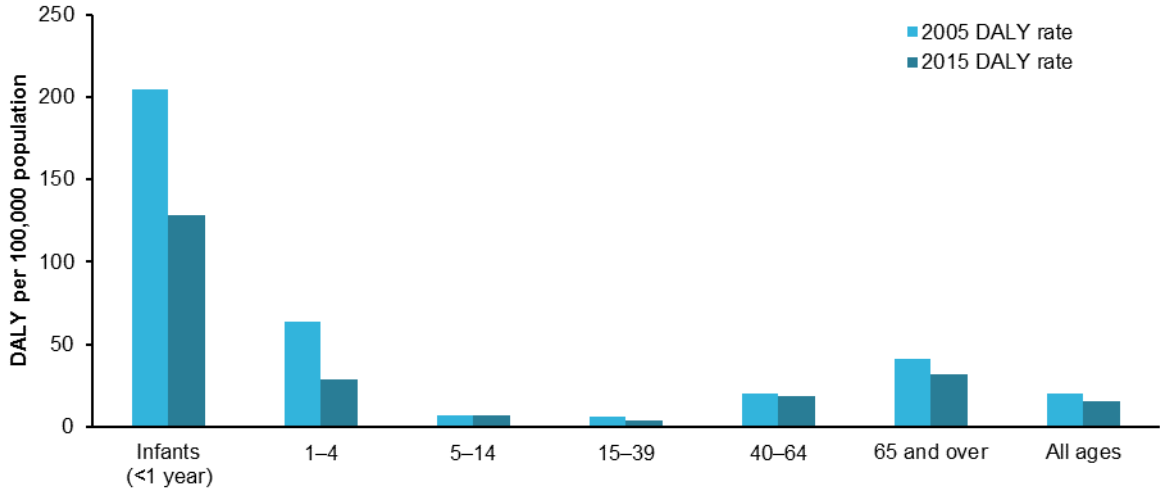
The rate of burden was highest among infants at 128 DALY per 100,000 population (Figure 2.10). This age group accounts for 10% of the total DALY due to IPD, including 24% of the non-fatal burden and 7% of the fatal burden.

Change since 2005

Vaccination of all infants against pneumococcal disease with a 7-valent conjugate vaccine was funded under the NIP schedule in 2005, extending a targeted program that had covered vaccination for at-risk infants since 2001.

The estimated IPD burden in 2005 was higher than in 2015 (20.4 compared with 15.1 DALY per 100,000 population) (Figure 2.10). In 2005, the IPD burden rate was highest among infants (204 DALY per 100,000) and children aged 1–4 (64 DALY per 100,000). Rates in both of these age groups were substantially lower in 2015.

Figure 2.10: IPD burden (DALY per 100,000 population), by age, 2005 and 2015



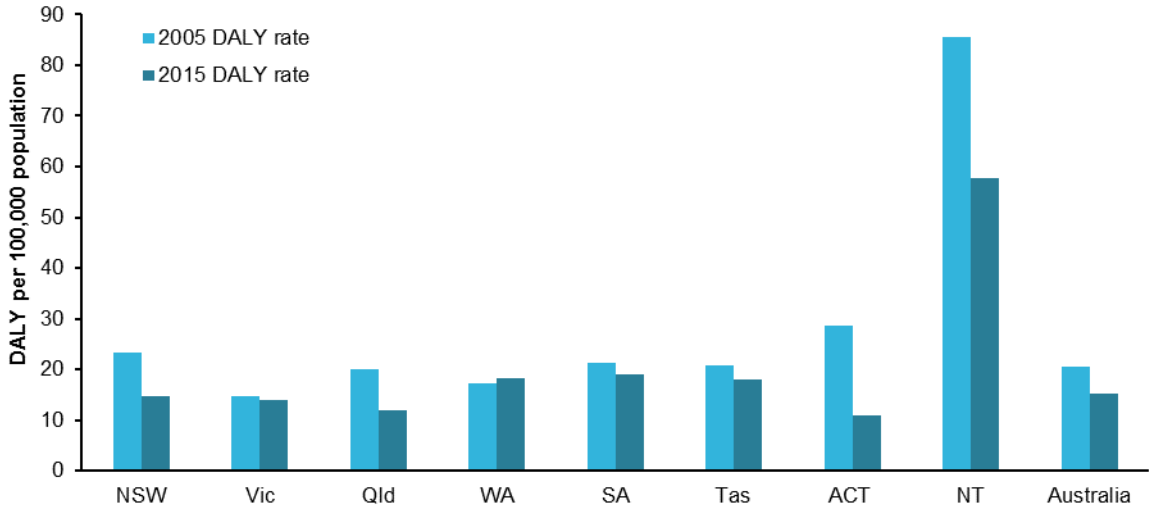
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.10.

Burden by state and territory

In 2005 and 2015, the rate of IPD burden was highest in the Northern Territory (85.6 and 57.7 per 100,000 population, respectively) (Figure 2.11). This reflects the higher notification rate for IPD in the Northern Territory compared with the other jurisdictions.

Figure 2.11: IPD burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.11.

Human papillomavirus

Infection with human papillomavirus (HPV) is very common. While most infections resolve spontaneously, in a very small number of women, the infection persists and may lead to precancerous cervical abnormalities. If not detected and treated, these abnormalities may then progress to cervical cancer in around 10–20 years (AIHW 2018b).

In 2015, there were over 16,000 high-grade cervical abnormalities detected, over 800 diagnoses of cervical cancer and an estimated 230 deaths due to cervical cancer among Australian women (AIHW 2018b). These all resulted from HPV infections acquired many years previously.

There were estimated to be over 291,000 new HPV infections in Australia in 2015. In this study, these new infections were projected to lead to around 15,000 high-grade cervical abnormalities, 400 cervical cancers and 56 deaths due to cervical cancer in future years. This study models and describes the future burden due to these results of HPV infections acquired in 2015. It also includes the burden due to genital warts in both males and females.

HPV vaccination for girls was first included on the NIP schedule in 2007, with vaccination for boys added in 2013. The NIP schedule provides vaccination for adolescents aged 12–13 through state and territory school vaccination programs. In 2018, the vaccine covered by the NIP was updated to a new type that protects against 9 strains of HPV, which together cause over 90% of cervical cancers occurring in Australia.

Burden in 2015

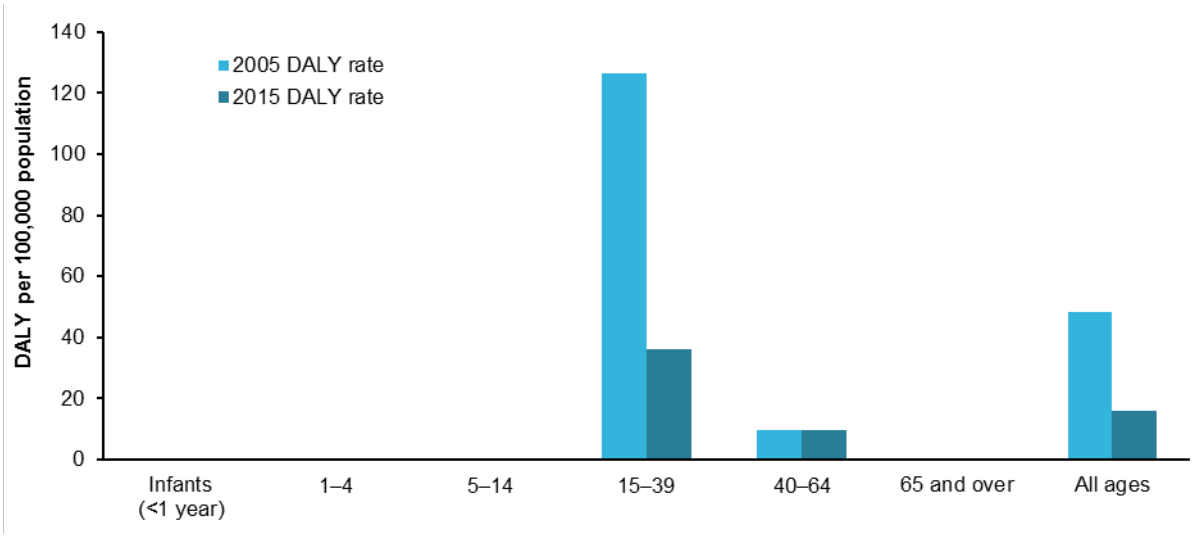
In 2015, the estimated HPV burden was 3,710 DALY, with over three-quarters (77%) of this attributed to fatal burden resulting from cervical cancer. The rate of burden was highest among people aged 15–39, with the vast majority of the overall burden being in females.

HPV has a low individual burden of 0.01 DALY per case, with a large number of cases occurring each year.

Change since 2005

The estimated HPV burden in 2005 was considerably greater than the burden in 2015 (48.2 compared with 15.8 DALY per 100,000 population) (Figure 2.12). The substantially higher burden in 2005 is a result of a considerably larger number of estimated HPV cases (more than 545,000 in 2005, compared with 291,000 in 2015), with the resulting higher numbers of high-grade cervical abnormalities and cervical cancer sequelae.

Figure 2.12: HPV burden (DALY per 100,000 population), by age, 2005 and 2015



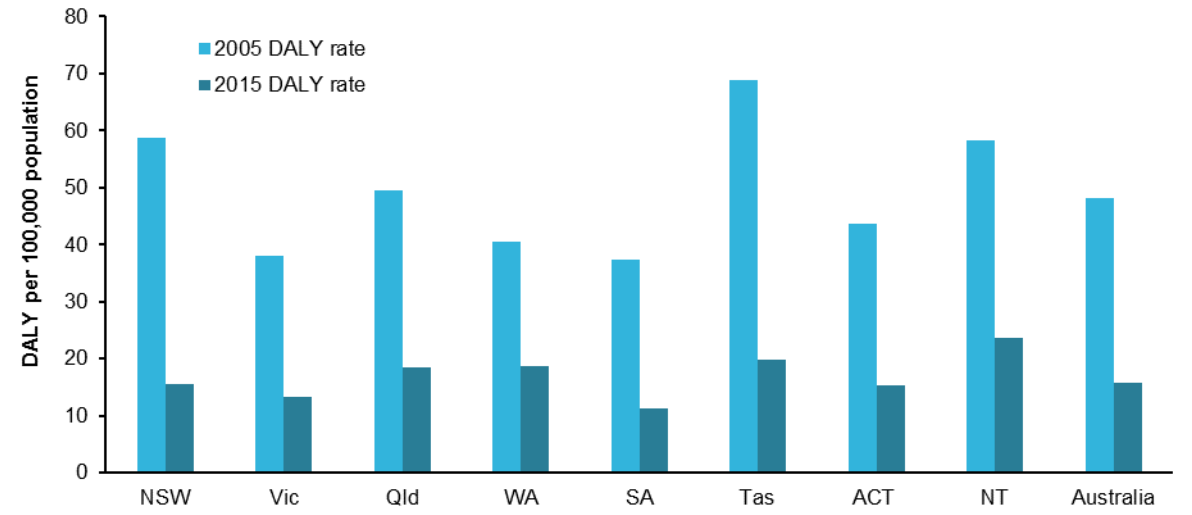
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.12.

Burden by state and territory

The HPV burden dropped considerably in all states and territories between 2005 and 2015. In 2015, the rate of HPV burden was highest in the Northern Territory (23.6 DALY per 100,000 population) (Figure 2.13).

Figure 2.13: HPV burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.13.

Shingles

In 2015, there were an estimated 140,000 cases of shingles (herpes zoster) in Australia. Over the 3-year period 2014–2016, shingles caused an average of 2,473 hospitalisations and 28 deaths per year.

A shingles vaccine for people aged 70 (with a catch-up dose for people aged 71–79 until October 2021) was added to the NIP schedule in November 2016. The impact of vaccination is expected to become more evident as more vulnerable people are vaccinated.

Burden in 2015

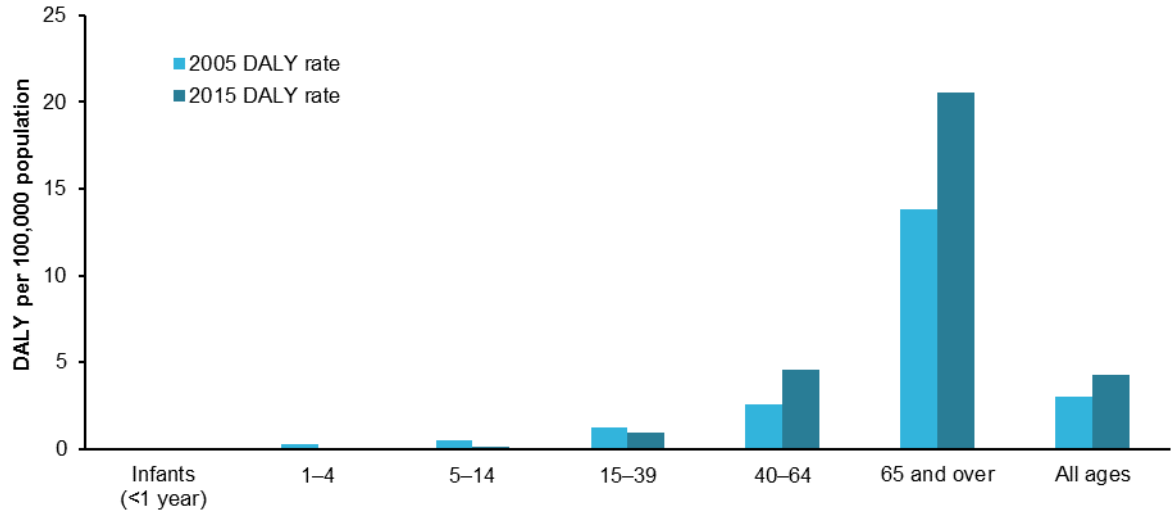
In 2015, the estimated shingles burden was 1,152 DALY, with three-fifths (60%) of this attributed to non-fatal burden. More than half (55%) of the non-fatal burden due to shingles was a result of post-herpetic neuralgia. Although acute shingles infection has a moderate impact, with potential for sequelae lasting several months, the individual burden is low at just under 0.01 DALY per case. Shingles burden increased with age (Figure 2.14). In 2015, people aged 65 and over accounted for 44% of shingles cases, but almost all of the deaths.

Change since 2005

The estimated shingles burden in 2005 was lower than in 2015 (3.0 compared with 4.3 DALY per 100,000 population) (Figure 2.14). There were considerably fewer estimated shingles cases in 2005 than in 2015 (98,100 and 139,500, respectively), along with fewer deaths, which contributed to the smaller burden in 2005.

The increasing burden of shingles over time, both in Australia and overseas, has been reported previously (MacIntyre et al. 2015). It has been suggested that exposure to varicella boosts immunity to the zoster virus (thereby preventing the reactivation of the virus that results in shingles) and that countries with universal childhood varicella immunisation would experience an increased incidence of shingles (for example, see Guzzetta et al. 2016). However, the increasing trend of shingles in Australia was apparent before the introduction of the varicella vaccine, and so the impact of the varicella vaccination program is unclear.

Figure 2.14: Shingles burden (DALY per 100,000 population), by age, 2005 and 2015



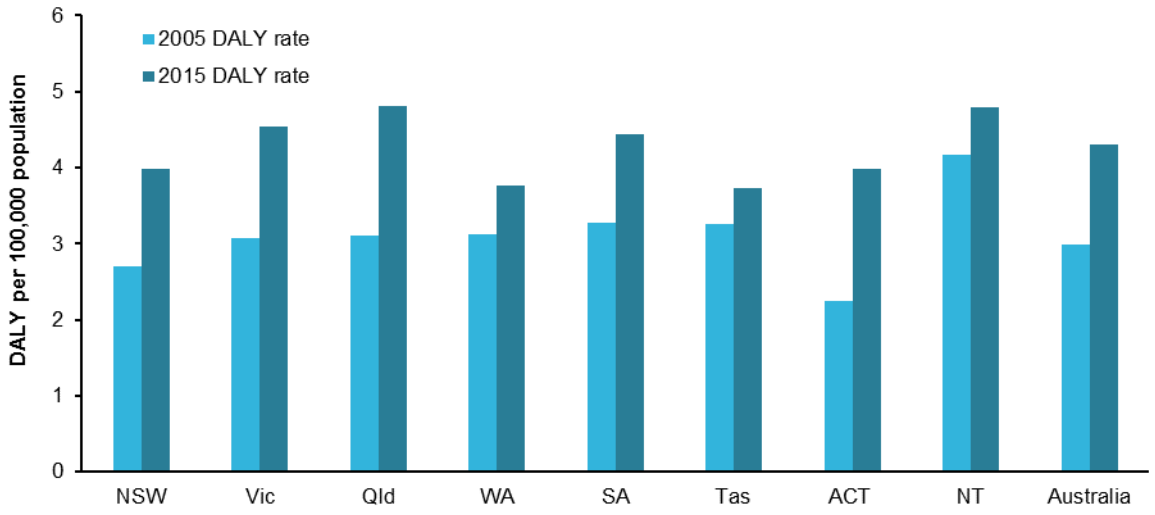
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.14.

Burden by state and territory

In 2015, the rate of shingles burden was highest in Queensland and the Northern Territory, with each at around 4.8 DALY per 100,000 population (Figure 2.15). The rate of shingles burden was higher in 2015 than in 2005 across all states and territories.

Figure 2.15: Shingles burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.15.

Meningococcal disease (invasive)

Over the 3-year period 2014–2016, there was an average of 201 invasive meningococcal disease (IMD) cases per year in Australia. Over the same period, meningococcal disease caused an average of 197 hospitalisations and 10 deaths per year.

Several different types of meningococcal bacteria (serogroups) can cause IMD, with the most common being serogroups A, B, C, W and Y. Historically, serogroups B and C have been the major causes of IMD in Australia, accounting for 44% and 32% of IMD notifications, respectively, in 2002. After the meningococcal serogroup C vaccination was included on the NIP schedule in 2003, the proportion of IMD cases caused by serogroup C decreased from 29% in 2003 to 12% in 2005 and 1% in 2015 (NNDSS Annual Report Writing Group 2005, 2007, 2019). From July 2018, the NIP has provided vaccination against meningococcal serogroups A, C, W and Y for all infants. From April 2019, it also provides adolescents with vaccination against these 4 serogroups.

Burden in 2015

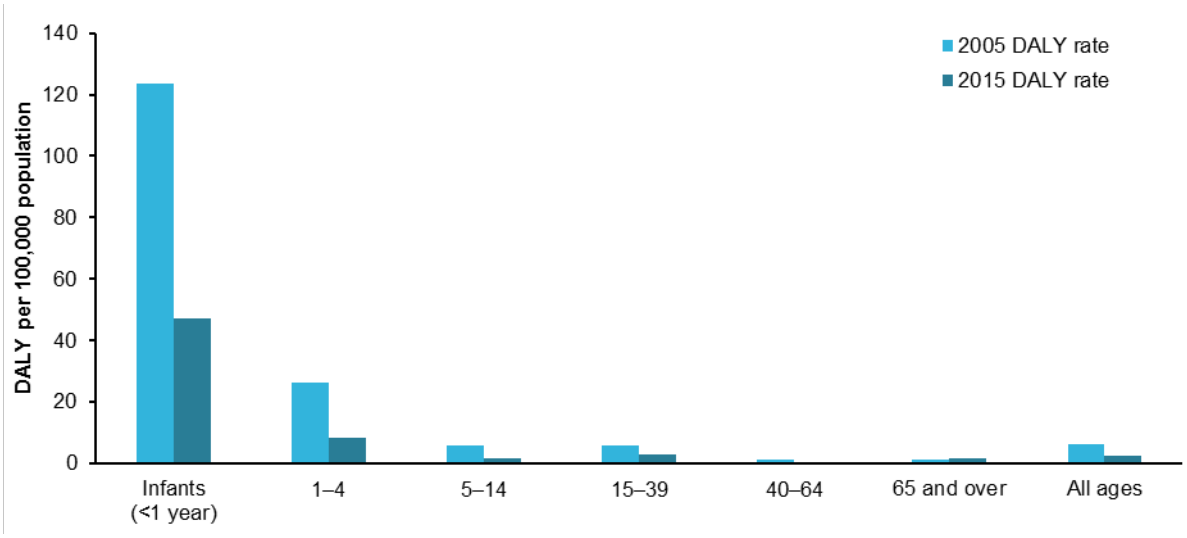
In 2015, the estimated IMD burden was 645 DALY, with almost three-quarters (73%) of this attributed to fatal burden. Nearly all of the non-fatal burden was due to long-term disability resulting from meningitis. Despite being rare, infection is severe in most cases, reflected in the high individual burden of 3.2 DALY per case.

The rate of burden was highest among infants (47 DALY per 100,000 population) and children aged 1–4 (8.4 DALY per 100,000) (Figure 2.16).

Change since 2005

The estimated IMD burden in 2005 was more than twice the estimated burden in 2015 (6.5 compared with 2.7 DALY per 100,000 population). The substantially higher burden in 2005 is a result of twice as many cases of IMD in 2005 than in 2015. In 2005 and 2015, the IMD burden rate was highest among infants and children aged 1–4 (Figure 2.16).

Figure 2.16: IMD burden (DALY per 100,000 population), by age, 2005 and 2015



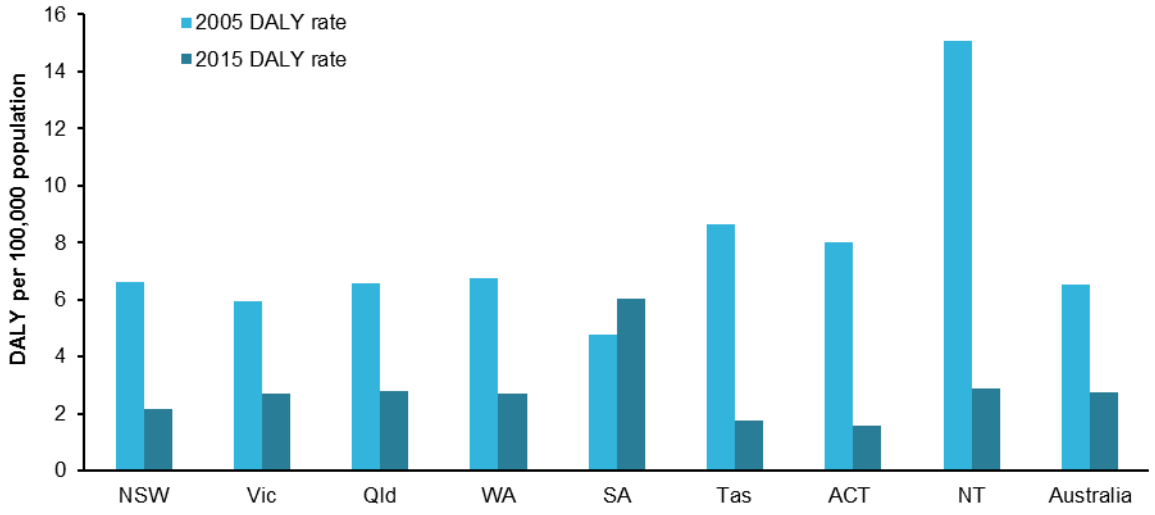
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.16.

Burden by state and territory

The rate of IMD burden in 2015 was highest in South Australia (6.0 DALY per 100,000 population) (Figure 2.17), and was higher in 2005 than in 2015 across all states and territories except South Australia.

Figure 2.17: IMD burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.17.

Hepatitis B

Over the 3-year period 2014–2016, there were an average of 158 notifications of newly acquired hepatitis B each year in Australia. During this period, hepatitis B was recorded as the cause of an average of 84 hospitalisations and 26 deaths per year. However, as some cases of liver cancer or cirrhosis in this period would have been the result of chronic hepatitis B, the actual number of hospitalisations and deaths attributable to hepatitis B infection would have been greater than this.

Chronic hepatitis B is believed to account for up to 1 in 4 cases of liver cancer in developed countries (Maucort-Boulch et al. 2018); The Kirby Institute estimated that, in Australia, 419 deaths were attributable to hepatitis B in 2015 (The Kirby Institute 2016).

Vaccination against hepatitis B in Australia began in the early 1980s. Free infant vaccination started in 1990 in the Northern Territory and was rolled out nationally in 2000. A school-based adolescent 'catch-up' program operated from the late 1990s until 2013. The NIP schedule currently provides routine vaccination against hepatitis B at birth and during infancy.

It is estimated that over 95% of new cases of chronic hepatitis B diagnosed in Australia are attributable to migration (MacLachlan et al. 2013); these cases cannot be prevented through local vaccination initiatives.

When asymptomatic cases are accounted for, it is estimated that in 2015 there were around 340 new infections of hepatitis B in Australia. In this study, these new infections were projected to lead to 29 chronic infections, 16 cases of liver cancer and 6 deaths in future years. This study models and describes the future burden due to these results of hepatitis B infections acquired in 2015. It does not account for the large number of overseas-acquired infections, which account for the majority of the burden of chronic hepatitis B in Australia.

Burden in 2015

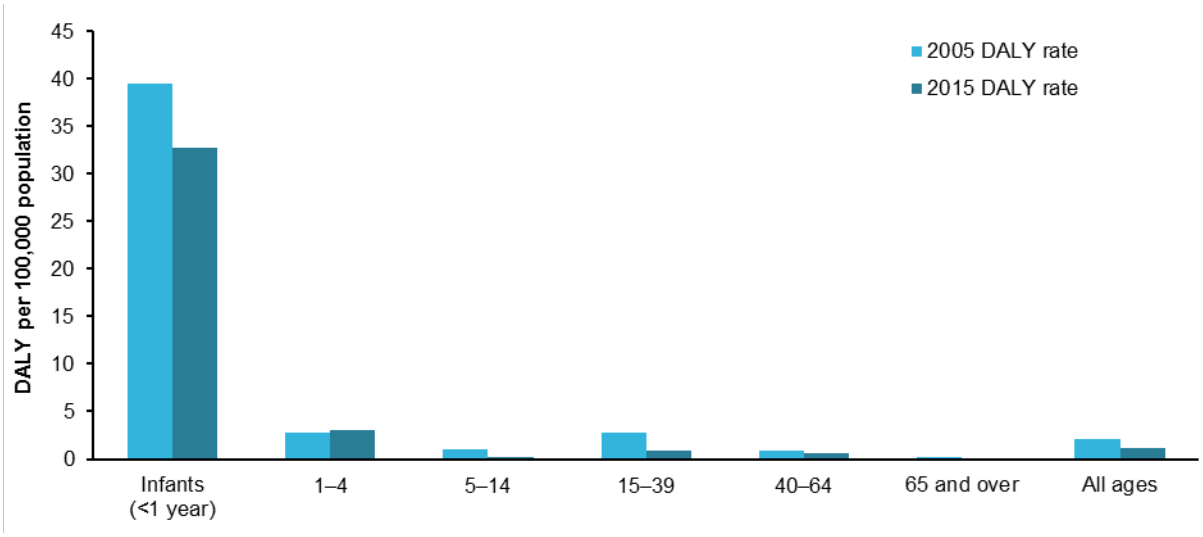
The estimated burden of acute hepatitis B infections acquired in 2015 was 269 DALY, with the majority (94%) of this attributed to fatal burden, mostly from liver cancer. The rate of burden was highest among infants (Figure 2.18). Although less than 2% of cases occur among infants, people infected at this age are much more likely to develop chronic hepatitis and resulting long-term sequelae.

Hepatitis B has a relatively high individual burden of 1.5 DALY per case, mostly associated with the long-term sequelae resulting from chronic cases.

Change since 2005

The estimated burden of acute hepatitis B infections acquired in 2005 was higher than for those acquired in 2015 (2.1 compared with 1.2 DALY per 100,000 population) (Figure 2.18). In 2005, there were an estimated 580 new acute hepatitis B infections, compared with an estimated 340 in 2015.

Figure 2.18: Hepatitis B burden (DALY per 100,000 population), by age, 2005 and 2015



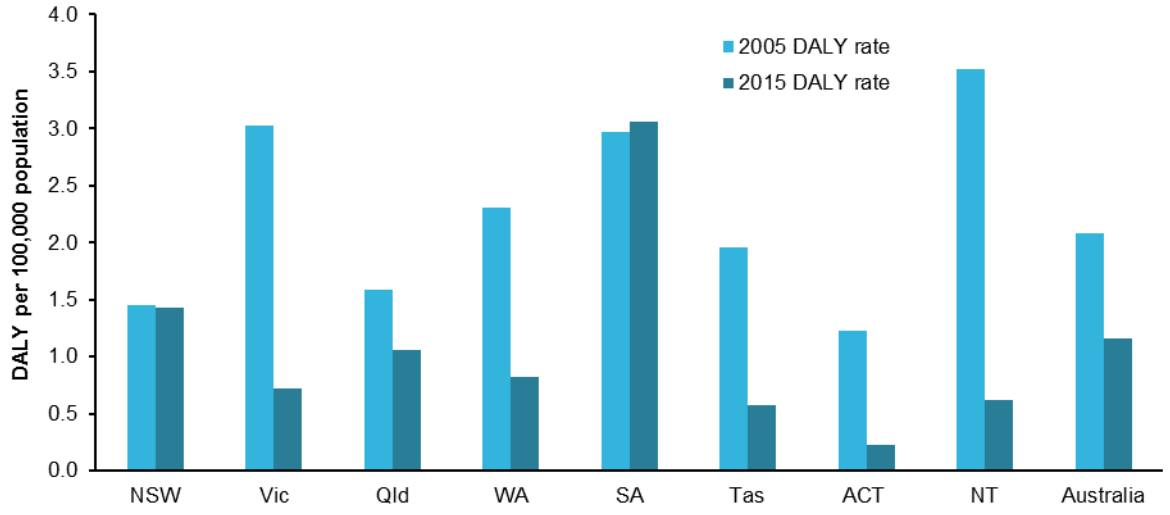
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.18.

Burden by state and territory

In 2015, the rate of hepatitis B burden was highest in South Australia (3.1 DALY per 100,000 population), followed by New South Wales (1.4 DALY per 100,000) (Figure 2.19). These 2 states recorded 7 of the 8 notifications of hepatitis B among children aged under 5 in the period 2014–2016. The rate of hepatitis B burden was higher in 2005 than in 2015 across all states and territories except New South Wales and South Australia, where the rates were similar in the 2 years.

Figure 2.19: Hepatitis B burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.19.

Whooping cough

In 2015, there were an estimated 46,400 cases of whooping cough (pertussis) in Australia, including 302 notifications of whooping cough among infants aged under 6 months. Over the 3-year period 2014–2016, whooping cough caused an average of 415 hospitalisations and 3 deaths per year. Cyclic epidemics of whooping cough occur in many countries including Australia, with outbreaks every few years.

Whooping cough vaccination began in Australia in the early 1940s, and the vaccine type, number of doses and age at vaccination has varied over time to optimise protection. The NIP schedule provides whooping cough vaccination for infants and young children, and is provided through state and territory school vaccination programs for adolescents. The current schedule includes a primary course of pertussis vaccinations at 2, 4 and 6 months of age. Infants under 6 months of age are at the greatest risk of severe illness and death from whooping cough.

For various periods between 2009 and 2015, several jurisdictions funded additional vaccination of parents (and, in some cases, grandparents and carers) of infants under a strategy known as 'cocooning' (for details see NCIRS 2018a). This strategy was aimed at indirectly protecting newborn babies by reducing their risk of exposure to the virus while they were too young to be vaccinated. Australian studies showed varying results as to the effectiveness of cocooning (Carcione et al. 2015; Rowe et al. 2018), suggesting that vaccination of pregnant women offers the best protection against severe disease in newborns (Campbell et al. 2018; Saul et al. 2018; Swamy & Wheeler 2014). Since July 2018, the NIP schedule has also provided whooping cough vaccination for pregnant women during each pregnancy, to help protect newborns until they are old enough to be vaccinated.

Burden in 2015

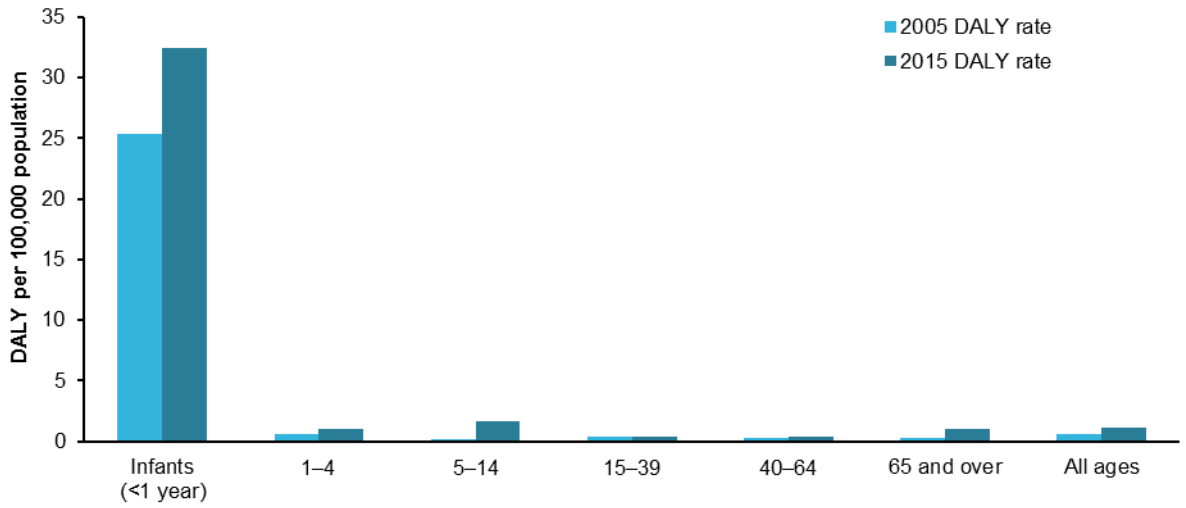
In 2015, the estimated whooping cough burden was 259 DALY, split almost equally between non-fatal burden due to acute infection (53%) and fatal burden (47%). Infants had by far the highest rate of burden at 32 DALY per 100,000 population (Figure 2.20).

While whooping cough is mild in most cases, with a low individual burden of less than 0.01 DALY per case, whooping cough infection is relatively common and so the overall population burden is greater than for many other VPD. Vaccination against whooping cough is targeted at reducing the severity of illness and preventing hospitalisations and deaths, as well as at protecting infants and other vulnerable people by reducing transmission.

Change since 2005

The estimated whooping cough burden in 2005 was lower than in 2015 (0.6 compared with 1.1 DALY per 100,000 population) (Figure 2.20). The higher burden in 2015 is associated with an outbreak of whooping cough that began in 2015 and extended into 2016. Although the outbreak affected jurisdictions at differing times, the annual average number of cases reported overall was almost twice that usually seen in non-outbreak years.

Figure 2.20: Whooping cough burden (DALY per 100,000 population), by age, 2005 and 2015



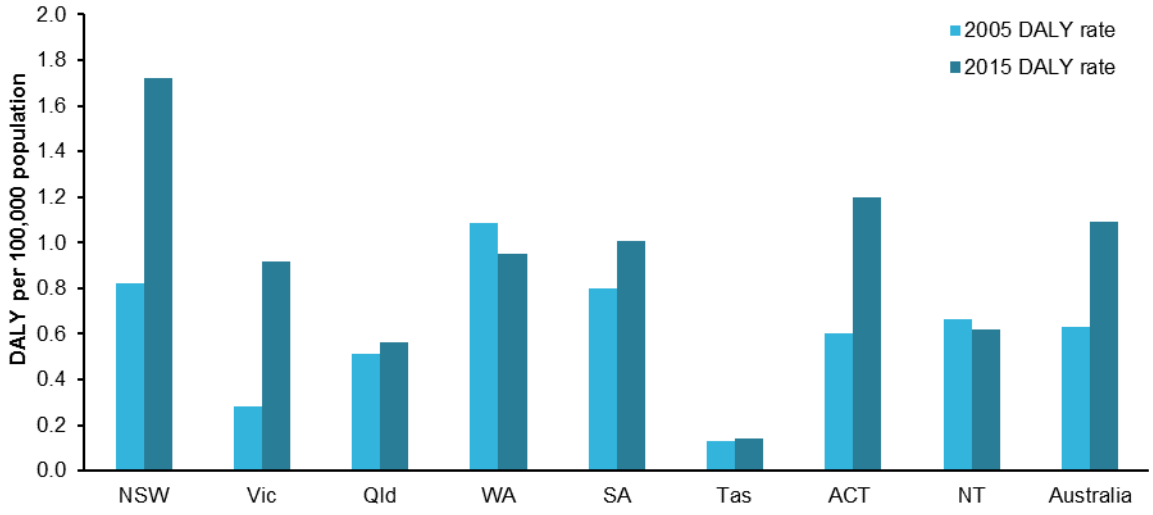
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.20.

Burden by state and territory

In 2015, the rate of whooping cough burden was highest in New South Wales and the Australian Capital Territory, at 1.7 and 1.2 DALY per 100,000 population, respectively (Figure 2.21). In 2005, the burden was highest in Western Australia (1.1 DALY per 100,000) and New South Wales (0.8 DALY per 100,000).

Figure 2.21: Whooping cough burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.21.

Notification of whooping cough in Australia is heavily reliant on laboratory confirmation of the disease, and so notification rates are affected by factors such as the ease and reliability of testing, and the likelihood of doctors to request testing. Kaczmarek (2016) found that the advent of polymerase chain reaction testing in 2005 (which allowed better case detection) and increased use of testing by health professionals are likely to have increased the

recorded incidence of whooping cough in Australia over the last decade. Follow-up of notified cases to alert potentially exposed contacts may also prompt diagnosis and notification of cases that may otherwise not have been detected. The extent and types of cases routinely followed up by public health units varies between jurisdictions and may affect comparisons of burden between states and territories.

Chickenpox

In 2015, there was an estimated 55,300 cases of chickenpox (varicella) in Australia. Over the 3-year period 2014–2016, chickenpox caused an average of 379 hospitalisations and 5 deaths per year.

Vaccination against chickenpox was first included on the NIP schedule in 2005. The NIP schedule currently provides a combined measles-mumps-rubella-varicella (MMR-V) vaccine for young children aged 18 months.

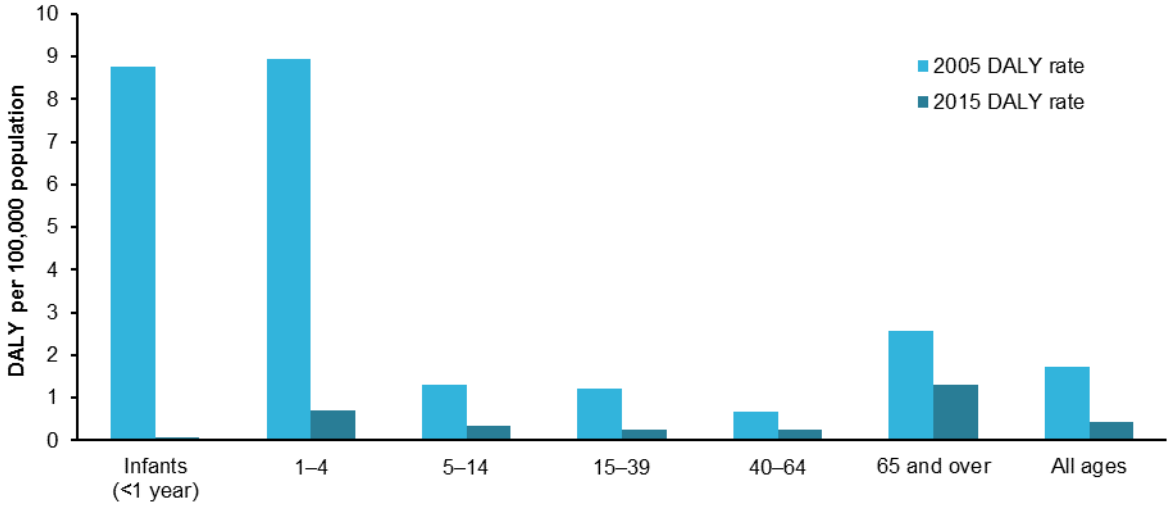
Burden in 2015

In 2015, the estimated chickenpox burden was 107 DALY, with 94% of this attributed to fatal burden. Chickenpox infection is generally mild, with a low individual burden of 0.002 DALY per case. The rate of chickenpox burden is highest among children aged under 5—who account for around one-fifth (21%) of all incident cases—and those aged 65 and over—who account for relatively few cases but most of the deaths (Figure 2.22).

Change since 2005

The estimated chickenpox burden in 2005 was higher than in 2015 (1.7 compared with 0.4 DALY per 100,000 population) (Figure 2.22). There was a substantially higher number of cases of chickenpox in 2005 than in 2015 (95,200 and 55,300 cases, respectively), resulting in greater burden, particularly in the young. The reduction in burden between 2005 and 2015 is likely to be associated with the introduction of the funded national vaccination against chickenpox, which commenced in November 2005 for children aged 18 months.

Figure 2.22: Chickenpox burden (DALY per 100,000 population), by age, 2005 and 2015



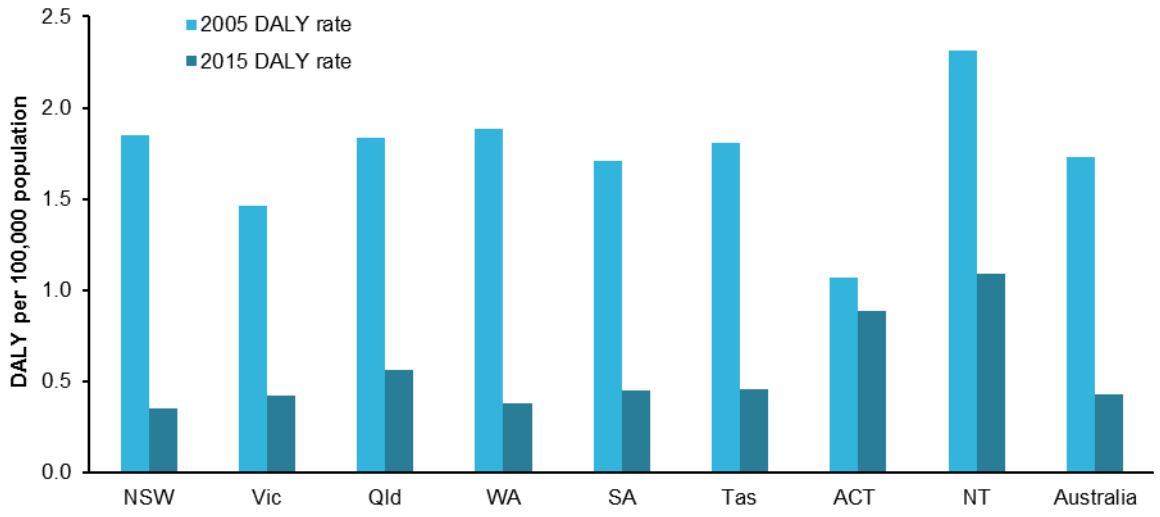
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.22.

Burden by state and territory

In both 2005 and 2015, the burden due to chickenpox was highest in the Northern Territory (2.3 DALY per 100,000 population in 2005; 1.1 DALY per 100,000 in 2015) (Figure 2.23). The rate of chickenpox burden was higher in 2005 than in 2015 across all states and territories.

Figure 2.23: Chickenpox burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.23.

Rotavirus

In 2015, there were an estimated 47,700 cases of rotavirus in Australia. Over the 3-year period 2014–2016, rotavirus caused an average of 647 hospitalisations and less than 1 death per year.

Vaccination against rotavirus was first included on the NIP schedule in 2007. Rotavirus vaccination is available on the NIP schedule for young infants.

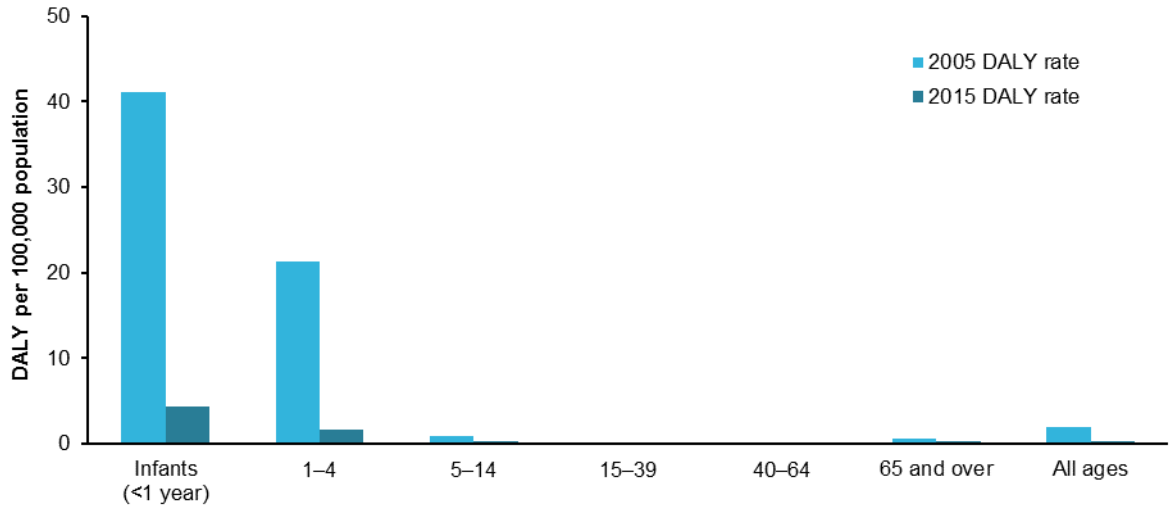
Burden in 2015

In 2015, the estimated rotavirus burden was 69 DALY, with 94% of this attributed to non-fatal burden. Infants and young children had the highest rates of burden (Figure 2.24). Rotavirus has a low individual burden of less than 0.001 DALY per case.

Change since 2005

The estimated rotavirus burden in 2005 was higher than in 2015 (1.9 compared with 0.3 DALY per 100,000 population) (Figure 2.24). There was a substantially larger number of cases of rotavirus in 2005 than in 2015 (estimated at 241,000 and 47,700 cases, respectively), resulting in a greater burden, particularly among the young. Funded national infant vaccination against rotavirus began in 2007.

Figure 2.24: Rotavirus burden (DALY per 100,000 population), by age, 2005 and 2015



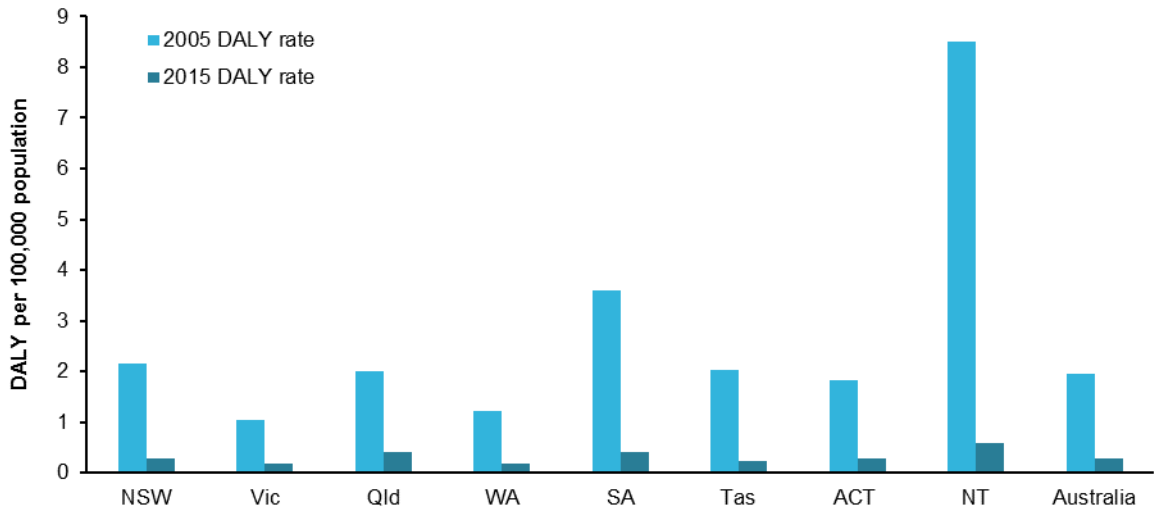
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.24.

Burden by state and territory

In both 2005 and 2015, the burden due to rotavirus was highest in the Northern Territory (8.5 DALY per 100,000 population in 2005; 0.6 DALY per 100,000 in 2015) (Figure 2.25). The rate of rotavirus burden was considerably higher in 2005 than in 2015 across all states and territories.

Figure 2.25: Rotavirus burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.25.

Hepatitis A

In 2015, there were an estimated 727 cases of hepatitis A in Australia. Over the 3-year period 2014–2016, hepatitis A caused an average of 100 hospitalisations and 1 death per year.

Vaccination against hepatitis A was made available to Indigenous children in North Queensland in 1999. From 2005, the NIP schedule provided hepatitis A vaccination for young Indigenous children living in Queensland, Western Australia, South Australia and the Northern Territory.

Most hepatitis A cases now diagnosed in Australia are among people exposed overseas, or are associated with occasional foodborne outbreaks.

Burden in 2015

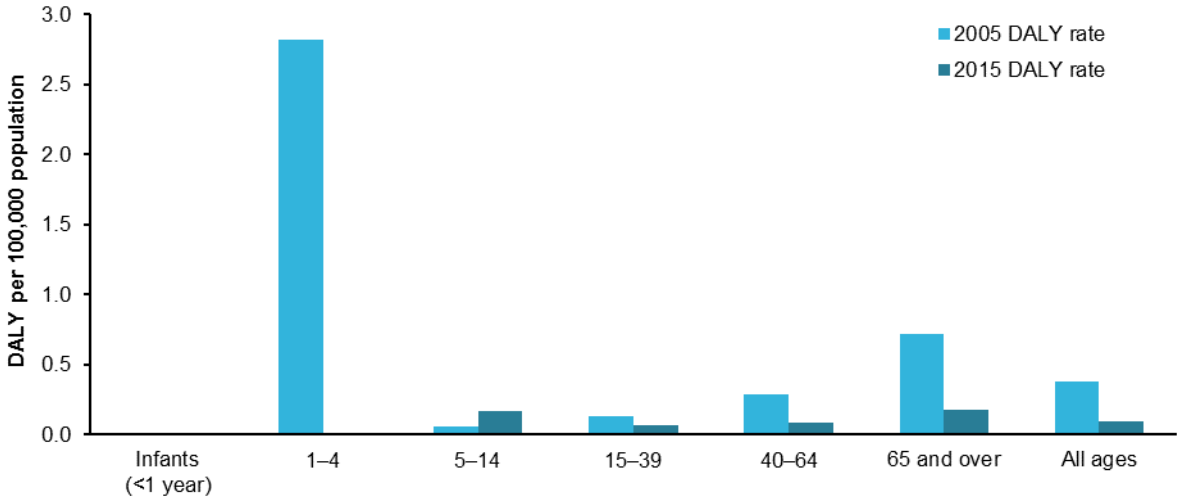
In 2015, the estimated hepatitis A burden was 23 DALY, with the majority (84%) of this attributed to fatal burden. The rate of burden was highest among children aged 1–4, with a second peak in older people (Figure 2.26). Hepatitis A has a low individual burden of 0.03 DALY per case.

Change since 2005

The estimated hepatitis A burden in 2005 was higher than in 2015 (0.4 compared with 0.1 DALY per 100,000 population) (Figure 2.26). The estimated number of hepatitis A cases in 2005 was substantially higher than that in 2015 (around 1,200 and 700 cases, respectively), which contributed to the greater burden in 2005.

The number of hepatitis A cases, and the death rate, dropped considerably after funded vaccinations were introduced for Indigenous infants in Queensland, Western Australia, South Australia and the Northern Territory in 2005, extending a program introduced in North Queensland in 1999. This has substantially reduced the burden associated with the disease, particularly among young children.

Figure 2.26: Hepatitis A burden (DALY per 100,000 population), by age, 2005 and 2015



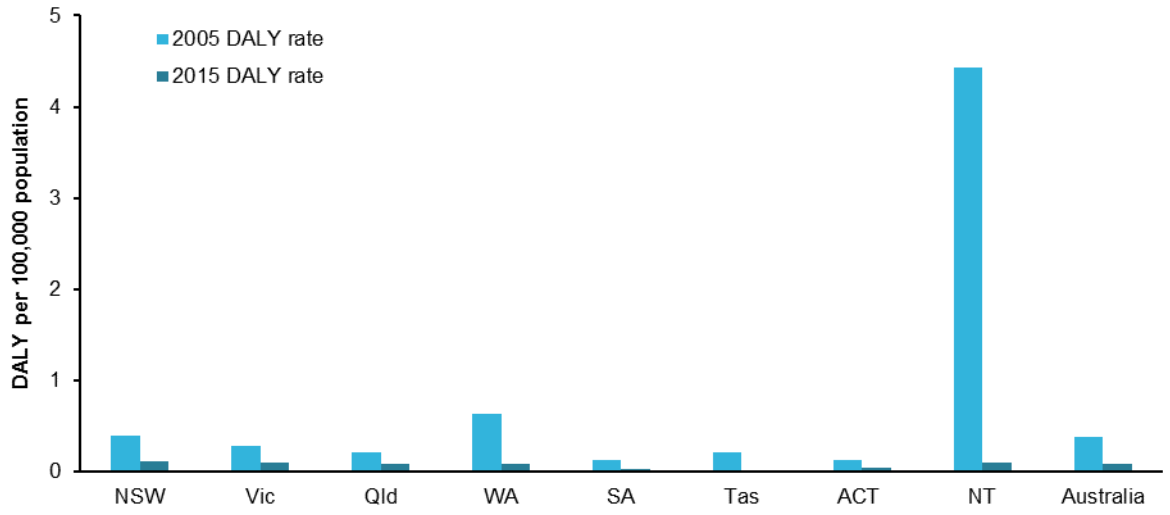
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.26.

Burden by state and territory

The rate of hepatitis A burden was higher in 2005 than in 2015 across all states and territories (Figure 2.27). In 2005, the burden of hepatitis A was highest in the Northern Territory (4.4 DALY per 100,000 population).

Figure 2.27: Hepatitis A burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.27.

Measles

Between 2014 and 2016, there were an average 171 notifications of measles per year in Australia. Measles caused an average of 64 hospitalisations per year over this period. Between 2007 and 2016, there were only 2 deaths due to measles.

The NIP schedule has included a measles vaccination since the mid-1970s. It first included a combined measles-mumps-rubella (MMR) vaccine in 1989, with a second dose of MMR for school-aged children introduced in late 1992. The NIP currently provides MMR vaccine for infants and a combined MMR-varicella (MMR-V) vaccine for young children.

In March 2014, the WHO announced that Australia had achieved measles elimination (Department of Health 2014). This means that there is no local strain of measles circulating in the community and that Australia has well-performing surveillance systems to rapidly detect and respond to cases. Most measles cases now diagnosed in Australia are found among infants too young to be vaccinated and young adults who were unvaccinated, or only partially vaccinated in childhood (in accordance with the vaccination schedule at the time). The majority of cases can be traced back to a person who became infected overseas (imported measles or import-related measles).

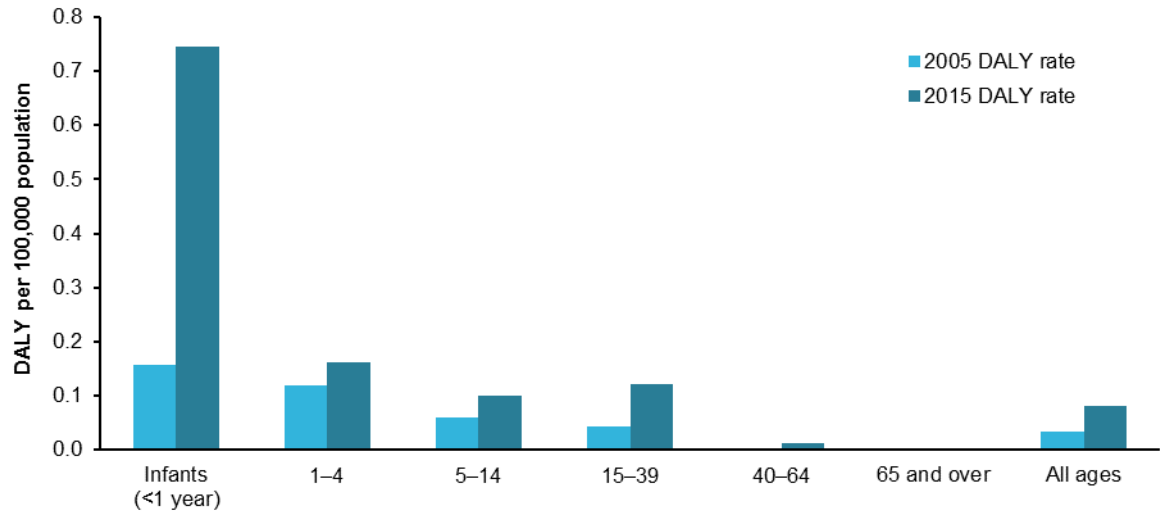
Burden in 2015

In 2015, the estimated measles burden was 18 DALY, with nearly all of this attributed to fatal burden (93%). The rate of burden was highest among infants, but the greatest number of DALY were among the younger adult age group (15–39 years, 10.1 DALY), where the number of cases was highest. People in this age group are more likely to travel overseas, including to countries where measles is common, and are also likely to have received only 1 dose of measles vaccine in childhood. Measles has a modest individual burden of 0.1 DALY per case.

Change since 2005

The estimated measles burden in 2005 was lower than in 2015 (0.03 compared with 0.08 DALY per 100,000 population), due to a smaller number of cases. The 2005 rates were lower across all age groups compared with 2015, with the largest differences among infants and younger adults aged 15–39 (Figure 2.28).

Figure 2.28: Measles burden (DALY per 100,000 population), by age, 2005 and 2015



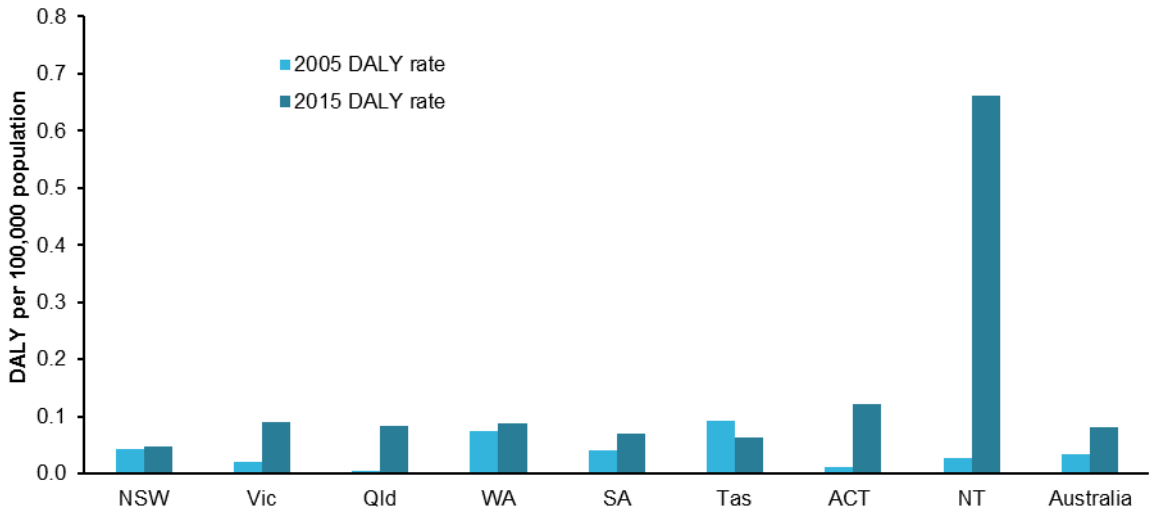
Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.28.

Burden by state and territory

In 2015, the rate of measles burden was highest in the Northern Territory (0.66 DALY per 100,000 population) and the Australian Capital Territory (0.12 DALY per 100,000) (Figure 2.29). It was also higher in 2015 than in 2005 across all states and territories except Tasmania, which was the only jurisdiction to have a higher average number of cases in the earlier period.

Figure 2.29: Measles burden (DALY per 100,000 population), by state and territory, 2005 and 2015



Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.29.

Diphtheria

Over the 3-year period 2014–2016, there was an average of 4 diphtheria notifications per year in Australia. Between 2007 and 2016, there were a total of 16 hospitalisations and 2 deaths due to diphtheria.

Widespread vaccination against diphtheria began in Australia in 1932. Diphtheria vaccination has been part of the NIP schedule since 1975, providing vaccination for infants and young children, and for adolescents through state and territory school vaccination programs.

Burden in 2015

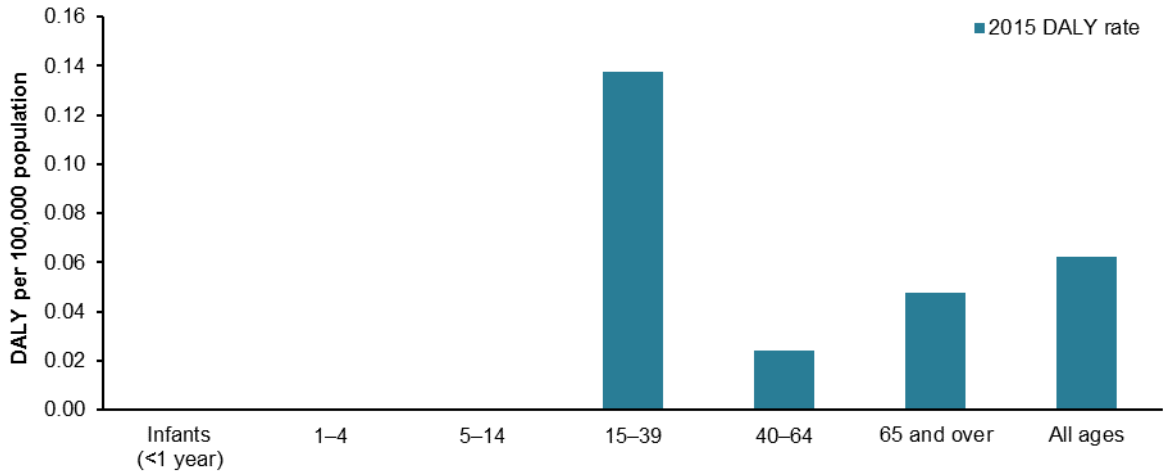
In 2015, the estimated diphtheria burden was 15 DALY (0.06 per 100,000 population), with more than 99% of this attributed to fatal burden. The rate of burden was greatest among adolescents and younger adults, mirroring the distribution of cases (Figure 2.30).

Despite being rare, respiratory diphtheria infection is severe in most cases, reflected in the high individual burden of 3.7 DALY per case.

Change since 2005

No cases of diphtheria were notified to Australian health authorities between 2004 and 2006. The burden for 2005 is therefore zero.

Figure 2.30: Diphtheria burden (DALY per 100,000 population), by age, 2015



Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.30.

Burden by state and territory

The average annual number of diphtheria cases was too small to allow disaggregation of the burden by individual states and territories.

Tetanus

Over the 3-year period 2014–2016, there was an average of 4 notified tetanus cases and 10 tetanus hospitalisations per year in Australia. Between 2007 and 2016, there were 7 deaths due to tetanus.

Widespread vaccination against tetanus was introduced in Australia from 1953. The NIP schedule currently provides tetanus vaccination for infants and young children, and for adolescents through state and territory school vaccination programs.

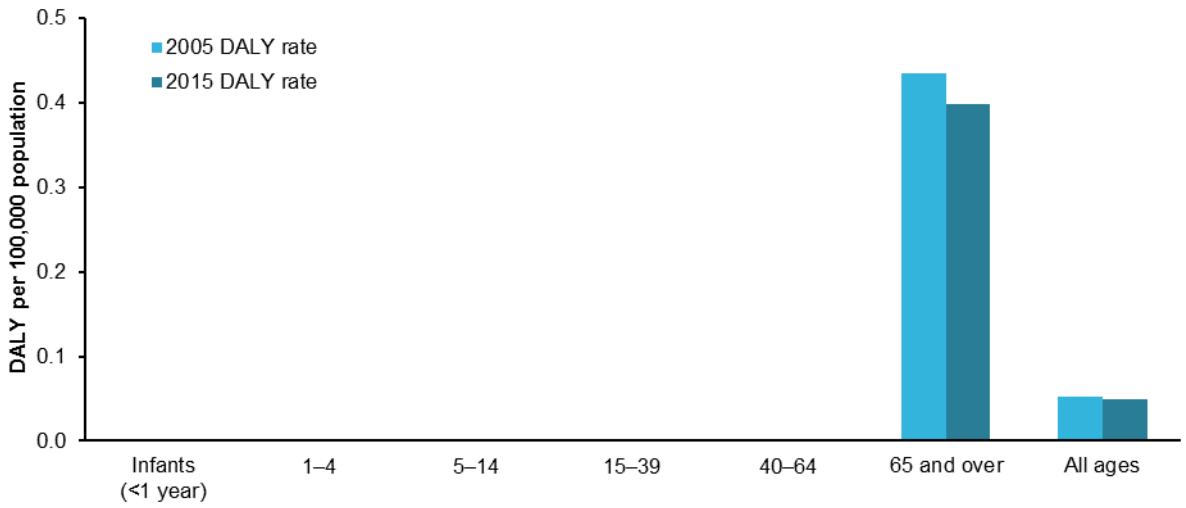
Burden in 2015

In 2015, the estimated tetanus burden was 14.2 DALY (0.05 per 100,000 population), with more than 99% of this attributed to fatal burden. The vast majority of the burden occurred among the oldest age groups, with all deaths from tetanus over the past 10 years having occurred in people aged 75 and over (Figure 2.31). Despite being rare, tetanus infection is severe in most cases, reflected in the high individual burden of 1.4 DALY per case.

Change since 2005

The estimated tetanus burden in 2005 was similar to the burden in 2015 (0.05 DALY per 100,000 population) (Figure 2.31). As in 2015, nearly all the tetanus burden in 2005 was attributed to fatal burden and occurred almost entirely among people aged 65 and over.

Figure 2.31: Tetanus burden (DALY per 100,000 population), by age, 2005 and 2015



Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.31.

Burden by state and territory

The burden associated with tetanus was too small to be disaggregated by individual states and territories.

Rubella and Congenital Rubella Syndrome

Over the 3-year period 2014–2016, there was an average of 16 rubella notifications and 0.3 congenital rubella syndrome (CRS) cases per year in Australia. Between 2007 and 2016, there was a total of 41 hospitalisations and 10 deaths due to rubella and CRS.

Widespread vaccination against rubella for schoolgirls and non-immune women was introduced in Australia in 1971. The NIP schedule first included a combined measles-mumps-rubella (MMR) vaccine in 1989. The NIP currently provides an MMR vaccine for infants and a combined MMR-varicella (MMR-V) vaccine for young children.

Burden in 2015

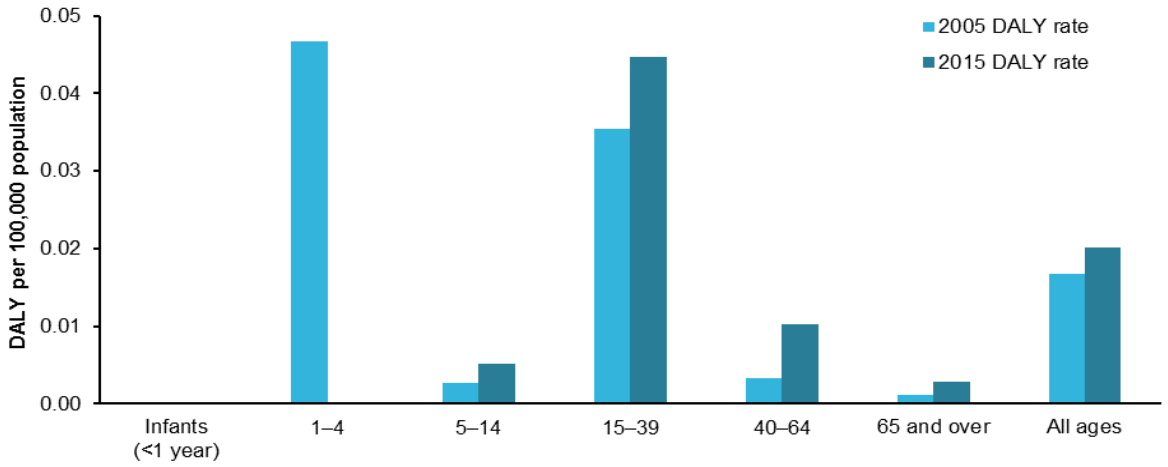
Acute (postnatal) rubella infection generally causes only mild illness in the infected person, at 0.3 DALY per case. In 2015, the rate of rubella burden was highest in the younger adult age group (15–39 years, 3.7 DALY per 100,000 population), where the number of cases was highest.

In 2015, the estimated CRS burden was almost twice the estimated acute rubella burden (9.1 and 4.7 DALY, respectively). Around one-third (31%) of the CRS burden was attributed to fatal burden, compared with over 99% of the rubella burden. The mortality and long-term disability resulting from CRS has a greater impact than acute rubella, at 27.3 DALY per case. All CRS burden occurs among infants, at a rate of 3.0 DALY per 100,000 infants in 2015.

Change since 2005

The estimated burden of CRS among infants in 2005 was higher than in 2015 (10.6 compared with 3.0 DALY per 100,000 infants). The higher CRS burden in 2005 was the result of a higher number of CRS cases between 2004 and 2006 than between 2014 and 2016. The estimated burden of acute rubella in 2005 was slightly lower than in 2015 (Figure 2.32).

Figure 2.32: Rubella (excl. CRS) burden (DALY per 100,000 population), by age, 2005 and 2015



Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.32.

Burden by state and territory

The burden associated with CRS and rubella were too small to be disaggregated by individual states and territories.

Haemophilus influenzae type b

Over the 3-year period 2014–2016, there was an average of 18 *Haemophilus influenzae* type b (Hib) notifications per year in Australia. Between 2007 and 2016, there were 187 hospitalisations and 1 death due to Hib.

Vaccination against Hib was first included on the NIP schedule in 1993. It is available on the NIP for infants and young children.

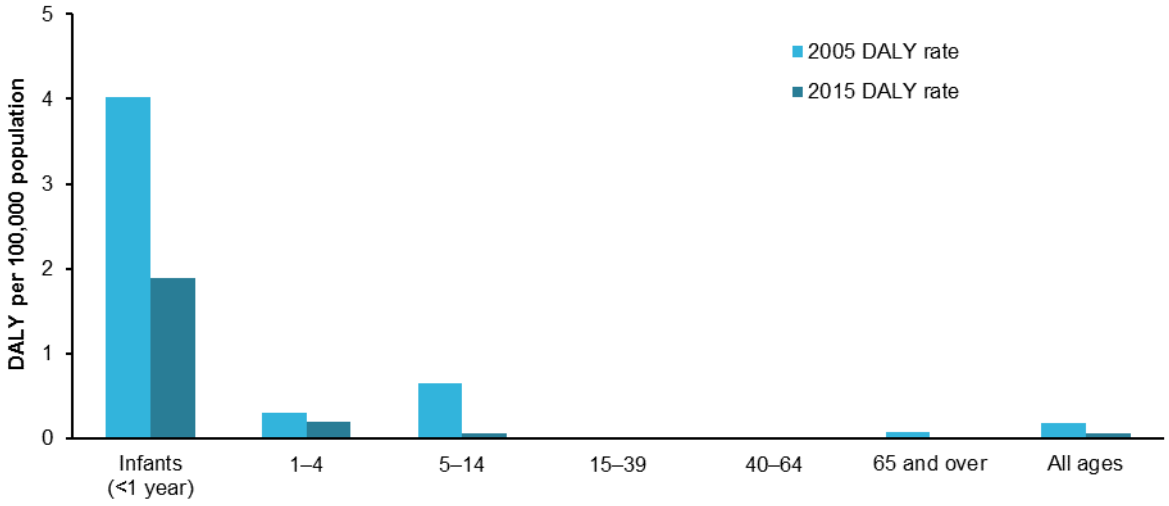
Burden in 2015

In 2015, the estimated Hib burden was 13 DALY, with three-fifths (61%) of this attributed to non-fatal burden due to the long-term disability resulting from meningitis. Despite being rare, infection is severe in most cases, reflected in a high individual burden of 0.75 DALY per case. In 2015, the rate of burden was highest among infants and children aged under 5 (Figure 2.33).

Change since 2005

The estimated Hib burden in 2005 was higher than in 2015 (0.2 compared with 0.1 DALY per 100,000 population) (Figure 2.33). Although the number of cases in 2005 and 2015 were similar, the case-fatality rate was higher in the earlier period, leading to a larger number of YLL.

Figure 2.33: Hib burden (DALY per 100,000 population), by age, 2005 and 2015



Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.33.

Burden by state and territory

The burden associated with Hib was too small to be disaggregated by individual states and territories.

Mumps

Over the 3-year period 2014–2016, there was an average of 545 mumps notifications and 80 mumps hospitalisations per year in Australia. Between 2007 and 2016, there were only 3 deaths due to mumps in Australia.

Mumps vaccination was introduced in Australia in the early 1980s. The NIP schedule first included a combined MMR vaccine in 1989; it currently provides an MMR vaccine for infants and a combined MMR-V vaccine for young children.

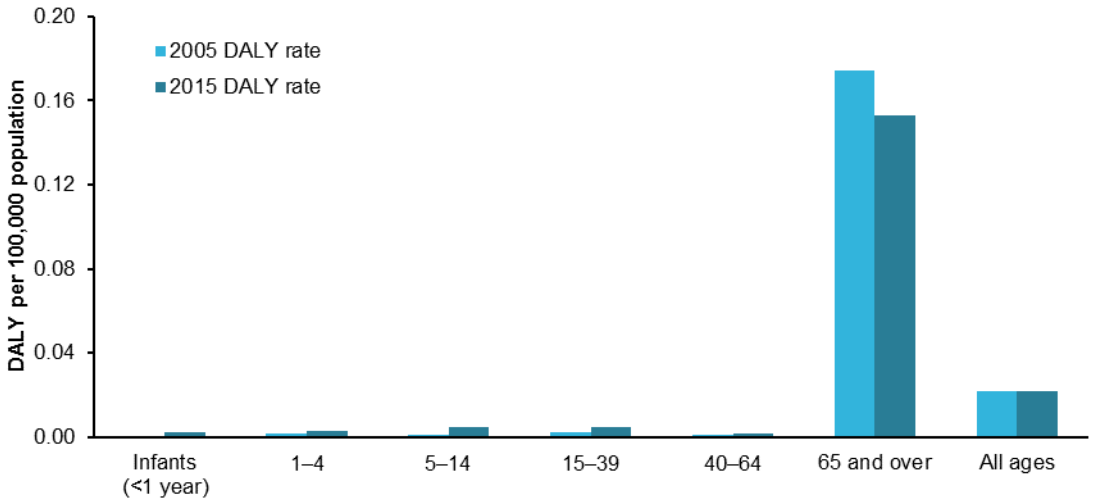
Burden in 2015

In 2015, the estimated mumps burden was 6.2 DALY, with 88% of this attributed to fatal burden. The fatal burden occurs only among the oldest age groups and is responsible for almost all the burden among people aged 65 and over (Figure 2.34). The majority of the non-fatal burden falls among the young adult age groups. Mumps is a relatively mild disease, with a low individual burden of 0.01 DALY per case.

Change since 2005

In 2005, the estimated burden due to mumps was 4.8 DALY, with most (94%) of this attributed to fatal burden. The number of notified mumps cases in 2015 was around twice that in 2005, with an outbreak having begun in 2015 in Western Australia.

Figure 2.34: Mumps burden (DALY per 100,000 population), by age, 2005 and 2015



Note: 'All ages' rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in Table D2.34.

Burden by state and territory

The burden associated with mumps was too small to be disaggregated by individual states and territories.

Poliomyelitis

Australia was declared polio-free by the World Health Organization in 2000, with no known local transmission of the polio virus in Australia since 1972. The last imported case of wild polio virus in Australia was reported in 2007. Historical data show that there were 2,206 cases of polio diagnosed in Australia in 1950 and 116 recorded deaths.

Widespread vaccination against polio was introduced in Australia in the mid-1950s and polio vaccination was included on the NIP schedule in 1975. Polio vaccination is available on the NIP for infants and young children.

Burden in 2005 and 2015

There were no new cases of polio in Australia in 2005 or 2015; therefore, the burden of incident polio in these years is zero.

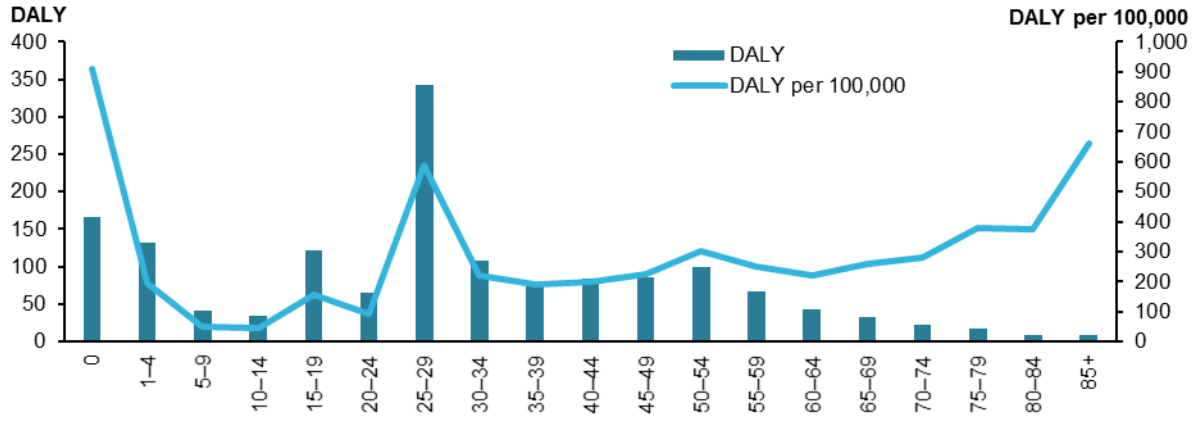
3 Indigenous Australians

Due to the very small number of cases of some VPD, it was not possible to produce estimates for Aboriginal and Torres Strait Islanders of the burden for all the diseases included in the previous chapter. This chapter provides estimates of the burden among Indigenous Australians for 13 diseases: chickenpox, hepatitis A, hepatitis B, Hib, HPV, influenza, measles, meningococcal disease, mumps, pneumococcal disease, rotavirus, shingles and whooping cough. Estimates of burden among Indigenous Australians are included for 2005 and 2015, and comparisons between Indigenous and non-Indigenous Australians are presented for 2015.

Overall burden among Indigenous Australians

As a group, the 13 VPD noted earlier were responsible for 1,552 DALY among Indigenous Australians in 2015 (237 DALY per 100,000 population). Premature loss of life accounted for 85% of the total burden of VPD among Indigenous Australians in 2015. Among Indigenous Australians, the number of DALY was highest among young adults aged 25–29, and accounted for 22% of the total DALY, with infants accounting for a further 11% (Figure 3.1). The rate of burden was highest among infants (911 DALY per 100,000) and among those aged 85 and over (663 DALY per 100,000).

Figure 3.1: Burden (DALY and DALY per 100,000 population) due to VPD, by age, Indigenous Australians, 2015



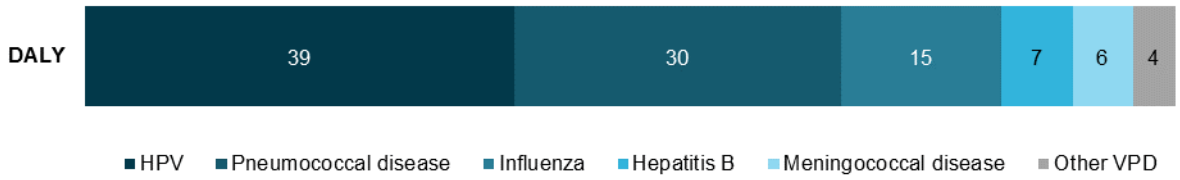
Note: Includes chickenpox, Hib, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, mumps, pneumococcal disease, rotavirus, shingles and whooping cough. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.

Source: This figure is based on data in Table D3.1.

Which diseases caused the most burden?

HPV contributed the greatest proportion of the VPD burden among Indigenous Australians in 2015 (39% of total DALY, 81 DALY per 100,000 population), followed by pneumococcal disease (30%, 78 DALY per 100,000) and influenza (15%, 49 DALY per 100,000) (Figure 3.2). Hepatitis B contributed a further 7% and meningococcal disease 6%. The remaining diseases together accounted for 4% of the total burden.

Figure 3.2: Contribution of individual diseases to overall burden (DALY) due to VPD, Indigenous Australians, 2015 (%)



Notes

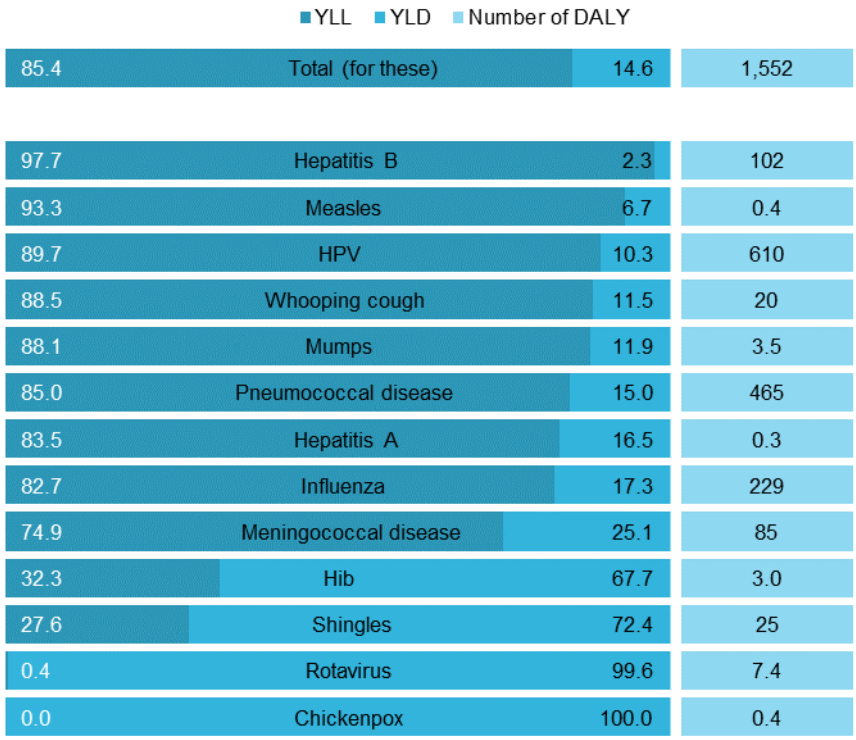
1. Includes chickenpox, Hib, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, mumps, pneumococcal disease, rotavirus, shingles and whooping cough. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
2. 'Other VPD' comprises shingles, whooping cough, rotavirus, mumps, Hib, measles, chickenpox and hepatitis A.

Source: This figure is based on data in Table D3.2.

Fatal and non-fatal burden by disease

The contribution of fatal and non-fatal outcomes to the total burden by disease among Indigenous Australians varied considerably (Figure 3.3). For 9 of the 13 diseases, fatal burden (premature death) contributed at least three-quarters of the total burden. However, more than two-thirds, or all, of the burden for Hib (68%), shingles (72%), rotavirus (more than 99%) and chickenpox (100%) was non-fatal.

Figure 3.3: Proportion of fatal (YLL) and non-fatal (YLD) burden by disease, Indigenous Australians, 2015



Note: Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
Source: This figure is based on data in Table D3.3.

Changes in burden since 2005

Among Indigenous Australians, the overall burden due to the 13 specified VPD decreased between 2005 and 2015. The number of DALY decreased by 45%, and the age-standardised rate by 41%.

The overall rate of burden decreased from 400 to 237 per 100,000 population, largely due to a decrease in the burden due to HPV, which fell from 263 to 81 per 100,000. Decreases in the rate of burden between 2005 and 2015 were also seen for hepatitis A (98% decrease), rotavirus (95% decrease), Hib (81% decrease), meningococcal disease (53% decrease), hepatitis B (52% decrease) and chickenpox (44% decrease). Vaccines for some of these diseases were added to, or vaccine eligibility extended on, the NIP schedule during the past 20 years: meningococcal disease in 2003, chickenpox and hepatitis A in 2005, and rotavirus in 2007. Hepatitis B vaccination in Australian began in the 1980s, but free infant vaccination was nationally implemented in 2000.

There were increases in the rate of burden among Indigenous Australians for several diseases, including influenza (where the rate more than quadrupled, from 11 to 49 DALY per 100,000 population), shingles (91% increase), whooping cough (56% increase) and pneumococcal disease (16% increase) (Table 3.1). The increase in burden due to mumps was the result of a large mumps outbreak over 2015–2016.

Table 3.1: Burden (DALY per 100,000 population) due to VPD, Indigenous Australians, 2005 and 2015

	DALY		DALY per 100,000 population		
Disease	**2005**	**2015**	**2005**	**2015**	**% change**
HPV	1,925	610	263.4	81.0	–69
Pneumococcal disease	333	465	67.5	78.3	16
Influenza	59	229	11.4	49.4	334
Hepatitis B	179	102	19.5	9.3	–52
Meningococcal disease	161	85	15.4	7.2	–53
Shingles	12	25	3.6	6.9	91
Mumps	<0.1	3.5	<0.1	2.6	—[(a)]
Whooping cough	10	20	1.0	1.5	56
Rotavirus	110	7.4	12.9	0.7	–95
Hib	8.3	3.0	1.3	0.2	–81
Hepatitis A	10	0.3	4.0	0.1	–98
Measles	0.4	0.4	0.1	0.1	—
Chickenpox	0.7	0.4	0.1	<0.1	—
Total burden due to 13 VPD	**2,807**	**1,552**	**400.0**	**237.3**	**–41**

(a) Due to the extremely low rate for mumps in 2005 compared with the outbreak in 2015, a reliable value for change over time could not be calculated.

Notes

1. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
2. Rates age-standardised to the 2001 Australian population.

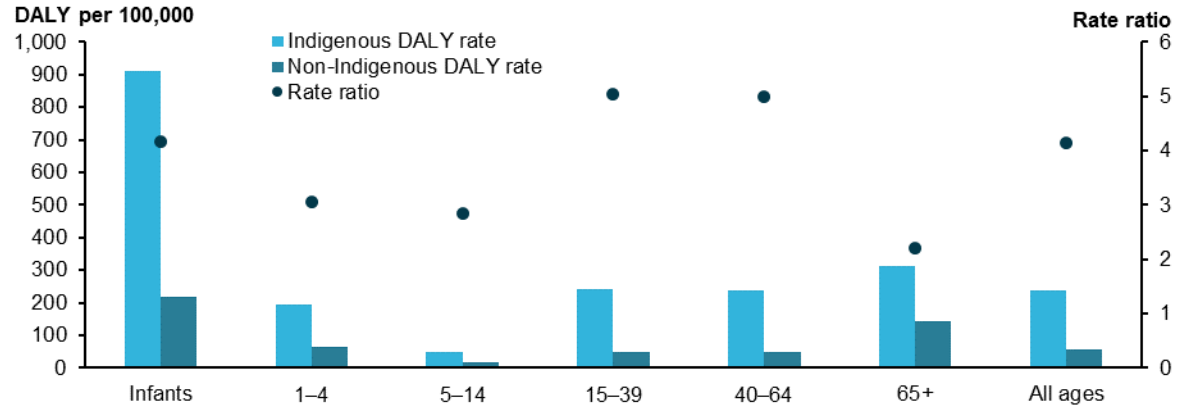
Gap in burden

In 2015, VPD among Indigenous Australians accounted for 10% of the total burden due to the 13 specified VPD. After adjusting for differences in population age structure, the burden among Indigenous Australians was 4.1 times the rate for non-Indigenous Australians.

Rate differences and rate ratios are presented as measures of the gap in burden between Indigenous and non-Indigenous Australians. Rate differences provide a measure of the absolute gap (or difference), while rate ratios are a measure of the relative gap (or difference) between the 2 populations.

Across all age groups, Indigenous Australians had higher rates of burden than non-Indigenous Australians (Figure 3.4). The largest absolute difference in VPD burden rates was between Indigenous and non-Indigenous infants. The largest relative differences were for people aged 15–39 and 40–64, where the rates among Indigenous Australians were 5 times the rates for non-Indigenous Australians.

Figure 3.4: Burden rates (DALY per 100,000 population) and rate ratios, by age, Indigenous and non-Indigenous Australians, 2015



Notes

1. Includes chickenpox, Hib, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, mumps, pneumococcal disease, rotavirus, shingles and whooping cough. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
2. 'All ages' rates age-standardised to the 2001 Australian population.

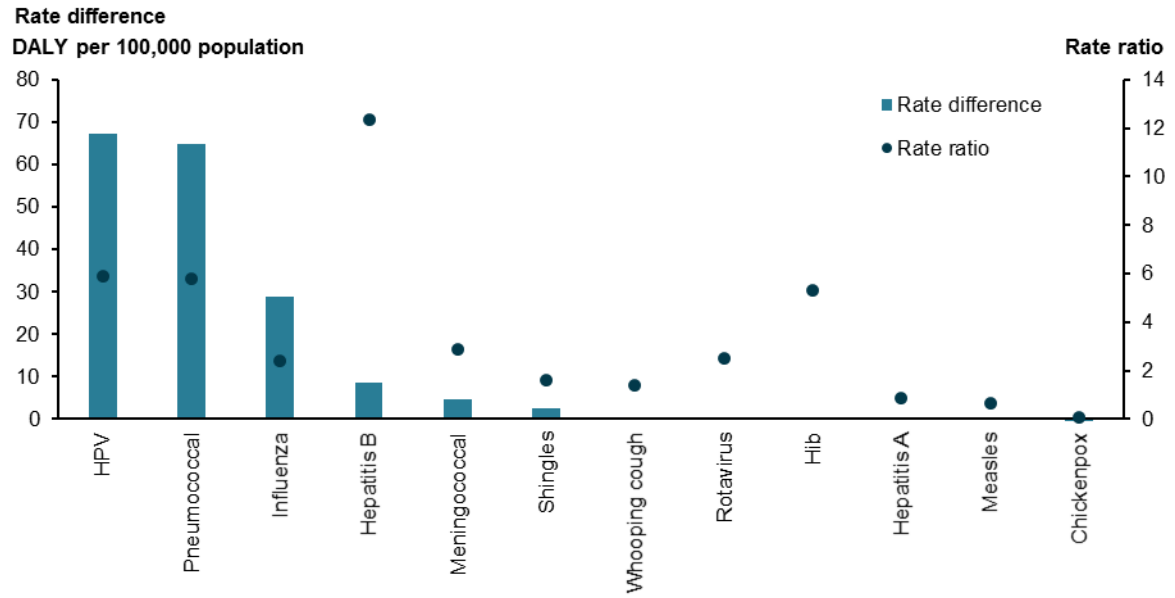
Source: This figure is based on data in Table D3.4.

How does the gap vary by disease?

In 2015, HPV and pneumococcal disease had the largest absolute differences between Indigenous and non-Indigenous rates, at 67.3 and 64.7 DALY per 100,000 population, respectively. These diseases also had large relative differences, with rate ratios of 5.9 and 5.8, respectively (Figure 3.5). Although HPV infection rates are similar for Indigenous and non-Indigenous women, the higher incidence of cervical cancer and poorer survival rates among Indigenous women result in a greater burden of long-term sequelae from HPV.

Hepatitis B showed the largest relative difference between Indigenous and non-Indigenous Australians (Figure 3.5). The rate of hepatitis B burden among Indigenous Australians was 12.4 times the rate for non-Indigenous Australians (9.3 and 0.8 DALY per 100,000 population, respectively), reflecting the higher disease incidence among Indigenous Australians as well as relatively poor liver cancer survival rates.

Figure 3.5: Burden rate ratios and rate differences between Indigenous and non-Indigenous Australians, by disease, 2015



Notes

1. Rate ratios and rate differences calculated using age-standardised rates.
2. A reliable rate ratio for mumps could not be calculated due to the very low rate of burden in the non-Indigenous population.
3. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.

Source: This figure is based on data in Table D3.5.

How does the gap vary over time?

The overall gap in VPD burden between Indigenous and non-Indigenous Australians decreased between 2005 and 2015 (rate differences of 322 and 180 per 100,000 population; rate ratios of 5.1 and 4.1, respectively) (Table 3.2).

Over the period 2005–2015, the health gap between Indigenous and non-Indigenous Australians (as measured by the rate difference) decreased for most VPD, and more than halved for several diseases (Table 3.2). The largest decrease in the gap was seen for HPV (rate difference declining from 223 to 67 DALY per 100,000 population), followed by rotavirus and hepatitis B.

Increases in the gap were seen for influenza and pneumococcal disease, with a small increase also for shingles.

Which diseases contribute most to the gap?

HPV was the largest contributor to the gap in VPD burden in both 2005 and 2015 (as measured by the rate difference); however, HPV was responsible for a much smaller proportion of the gap in 2015 than in 2005 (37% compared with 69%) (Figure 3.6).

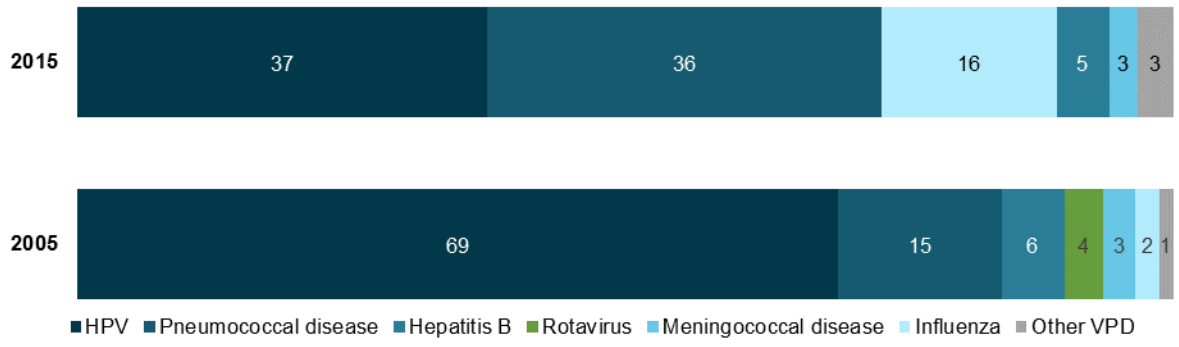
Table 3.2: Gap measures of VPD burden (rates and rate differences per 100,000 population), by disease, 2005 and 2015

Disease	2005 Indigenous rate	2005 Non-Indigenous rate	2005 Gap (rate difference)	2015 Indigenous rate	2015 Non-Indigenous rate	2015 Gap (rate difference)	Direction of change in gap
HPV	263.4	40.0	223.4	81.0	13.7	67.3	↓
Pneumococcal disease	67.5	19.4	48.1	78.3	13.5	64.7	↑
Influenza	11.4	4.4	7.0	49.4	20.6	28.9	↑
Hepatitis B	19.5	1.2	18.3	9.3	0.8	8.5	↓
Meningococcal disease	15.4	6.0	9.4	7.2	2.5	4.7	↓
Shingles	3.6	3.0	0.7	6.9	4.2	2.7	↑
Whooping cough	1.0	0.6	0.3	1.5	1.1	0.4	–
Rotavirus	12.9	1.5	11.5	0.7	0.3	0.4	↓
Hib	1.3	0.1	1.2	0.2	<0.1	0.2	↓
Hepatitis A	4.0	0.3	3.6	<0.1	<0.1	—	↓
Total for 13 VPD	**400.0**	**78.3**	**321.6**	**237.3**	**57.3**	**180.0**	↓

Notes

1. Data for chickenpox and measles are not presented due to very low rates of burden. Data for mumps are not presented due to an outbreak in the later period that affected mostly Indigenous Australian communities in Western Australia and the Northern Territory.
2. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
3. Rates age-standardised to the 2001 Australian population.
4. Rate difference is calculated as Indigenous age-standardised rate minus non-Indigenous age-standardised rate.

Figure 3.6: Contribution of individual diseases to the gap in VPD burden between Indigenous and non-Indigenous Australians (based on DALY rate differences), 2005 and 2015 (%)



Notes

1. Includes chickenpox, Hib, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, mumps, pneumococcal disease, rotavirus, shingles and whooping cough. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
2. Rotavirus contributed 0.2% to the gap in 2015.
3. 'Other VPD' comprises shingles, whooping cough, mumps, Hib, measles, chickenpox and hepatitis A.

Source: This figure is based on data in Table D3.6.

4 Discussion

This study presents estimates of the burden of 17 VPD in Australia. An incidence-based approach was adopted to calculate the burden of disease using the DALY measure; this allowed future disability arising from infections acquired in the reference year to be incorporated.

While the burden of disease methodology enables selected diseases to be compared, and over time, an incidence-based approach allows the impact of interventions—in this case, changes to the standard vaccination schedule—to be examined. This is because the burden arising from each incident case is counted in the year that the case occurs, so the impact of long-term sequelae of cases occurring before an intervention does not contribute to the burden in the post-intervention years.

A comparison of results of studies using incidence-based and hybrid methods to calculate the burden of VPD is provided later in this chapter.

Burden of vaccine preventable diseases in 2015

The overall burden of new cases of the 17 diseases covered under the NIP schedule was estimated to be almost 16,000 DALY (62 per 100,000 population) in 2015, with 80% of this being attributed to fatal burden (YLL). As is common in burden of disease studies relating to infectious diseases, the burden from premature death drives most of the estimates and the position of diseases relative to each other.

Included in the list of diseases with the highest individual burden were a number of common pathogens with a relatively high case-fatality rate. However, the long-term disability from bacterial meningitis makes a substantial contribution to the burden of Hib (61% of the Hib burden), as well as to IMD (26%) and IPD (18%).

The overall burden, in terms of number of DALY, was relatively large among infants and young children compared with older children, but then generally increased with age, apart from a peak among younger adults aged 25–29. The high burden among young adults aged 25–29 is due to the potential long-term outcome of developing cervical cancer after infection with HPV. The rate of burden (DALY per 100,000 population) followed a similar shape, being highest among infants and among those aged 85 and over, but with a secondary peak among the 25–29 age group.

Of the VPD included in this study, influenza had the highest overall burden in 2015, with 5,674 DALY. There was a particularly high number of influenza cases notified in the 3-year period 2014–2016, with more than twice the observed number of deaths than in the periods 2011–2013 and 2008–2010. As noted in Chapter 2, some of this increase is related to heightened awareness of influenza, along with increased propensity for testing—meaning that influenza cases and influenza-related deaths are more likely to be identified. It is difficult, though, to clarify how much of the increase in notifications is due to increased awareness and testing and how much is due to a real increase in the number of cases occurring.

IPD had the second highest burden at 3,793 DALY in 2015, with a relatively high case-fatality rate when using the enhanced surveillance data collection to identify pneumococcal-related deaths. Over 80% of the total pneumococcal disease DALY were attributed to fatal burden, with most of the remaining DALY being the non-fatal burden associated with long-term effects of bacterial meningitis.

The next greatest contributor was HPV at 3,710 DALY. HPV infection is generally asymptomatic, with only certain HPV types causing genital warts. The majority of the HPV burden results from the potential long-term outcome of developing cervical cancer following infection with HPV; although only a small proportion of infections progress to cancer, the large number of cases (estimated at 291,000 in 2015) and the severity of the outcome result in a relatively high number of DALY at a population level.

The burden of disease was noticeably small (fewer than 20 DALY) for a number of diseases for which vaccines have been widely available for many years, such as diphtheria (15 DALY), measles (18 DALY) and rubella (14 DALY). The latter 2 diseases have been declared eliminated in Australia. However, the remaining burden of these diseases, which relates for the most part to infections acquired overseas or contacts of these cases, shows the importance of maintaining high levels of vaccination coverage within the Australian population to avoid increases in burden in the future.

Changes in burden over time

Table 4.1 summarises the results from 2005 and 2015 for each disease. For 2 diseases—influenza and shingles—the rate of burden was considerably higher in 2015 than in 2005.

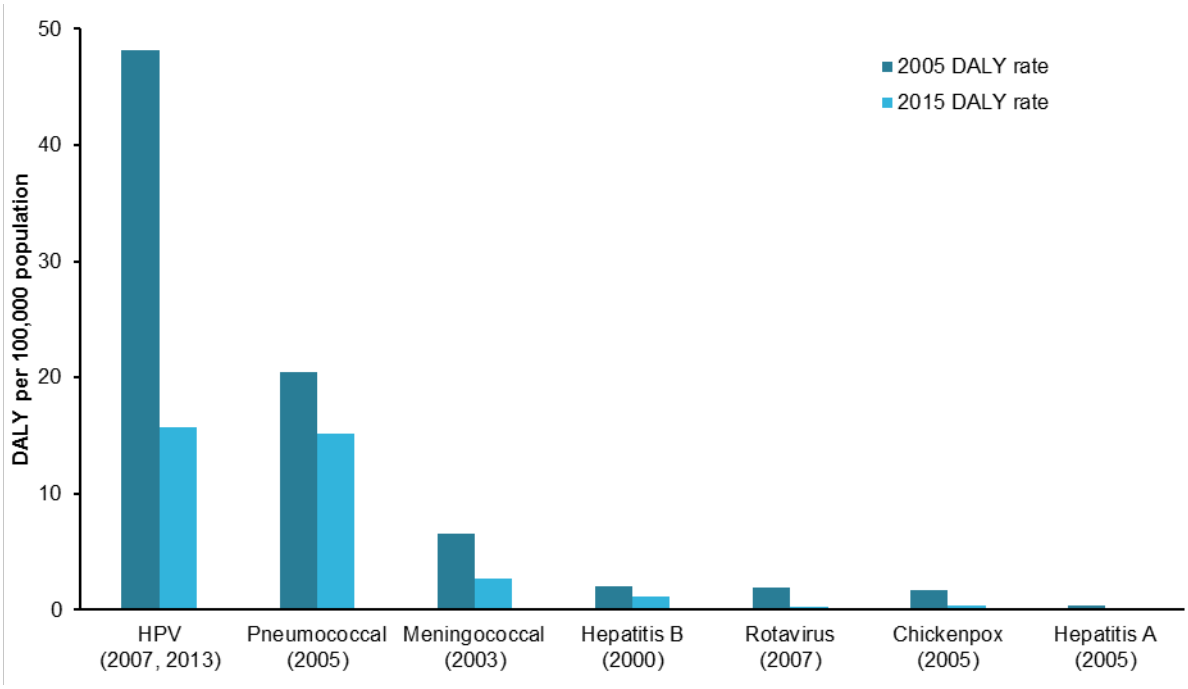
- For influenza, increased awareness (both in the medical community and among the general public) and more accessible testing have contributed to a greater number of notified cases in recent years. This would have contributed to the change in burden.
- For shingles, information from a range of sources suggested increased incidence of shingles in older people over the past decade, both in Australia and overseas (see ‘Shingles’ in Chapter 2). In late 2016, shingles vaccination for people aged 70 was introduced under the NIP, with a catch-up vaccination program for people aged 71–79 until October 2021. This is expected to result in reduced incidence and burden from shingles in the future.

Impacts of recently introduced vaccines

Comparing 2 time points of 2015 and 2005, this study has shown a reduction in the burden for a number of diseases for which vaccines have been added to, or vaccine eligibility extended on, the NIP schedule during the past 20 years—such as HPV, chickenpox, hepatitis A, hepatitis B, meningococcal disease, pneumococcal disease and rotavirus.

The introduction of vaccines appears to have reduced both the number of cases and the overall disease burden associated with these diseases (Figure 4.1; Table 4.1).

Figure 4.1: Burden (DALY per 100,000 population) due to selected VPD, Australia, 2005 and 2015



Notes

1. The number in brackets after the disease name is the year vaccination for all children (all Indigenous children in high-risk jurisdictions, for hepatitis A) was added to the NIP.
2. Rates are age-standardised to the 2001 Australian estimated resident population.

Source: Table 4.1.

Table 4.1: Summary of burden results by disease, 2005 and 2015

Disease	Year widespread vaccination introduced	Burden in 2005			Burden in 2015			% change in DALY per 100,000 population
		Cases[a]	DALY	DALY per 100,000 population[b]	Cases[a]	DALY	DALY per 100,000 population[b]	
Chickenpox (varicella)	2005	95,200	346	1.7	55,300	107	0.4	–75
Diphtheria	1932	0	0	0.0	4	15	<0.1	. .
Hepatitis A	2005	1,200	77	0.4	720	23	<0.1	–75
Hepatitis B	Early 1980s for at-risk groups, 2000 for all infants	580	411	2.1	340	269	1.2	–44
Hib	1993	18	34	0.2	18	13	<0.1	–67
HPV	2007 for girls, 2013 for boys	545,600	9,634	48.2	291,000	3,710	15.8	–67
Influenza	2010 for at-risk only	220,600	934	4.6	313,200	5,674	21.1	362
Measles	1970	60	7	<0.1	171	18	<0.1	139
Meningococcal disease	2003	369	1,285	6.5	201	645	2.7	–58
Mumps	Early 1980s	206	5	<0.1	549	6	<0.1	1
Pneumococcal disease	2001 for at-risk infants, 2005 all infants and those aged 65 and over	1,824	4,156	20.4	1,576	3,795	15.1	–26
Polio	Mid-1950s	0	0	0.0	0	0	0.0	. .
Rotavirus	2007	241,000	378	1.9	47,700	69	0.3	–85
Rubella (incl. congenital)	1971	41	30	0.2	16	14	<0.1	–62
Shingles (herpes zoster)	2016 for 70–79 years	98,100	627	3.0	139,500	1,153	4.3	44
Tetanus	1953	8	11	<0.1	10	14	<0.1	–4
Whooping cough	Early 1940s	20,500	126	0.6	46,400	259	1.1	73

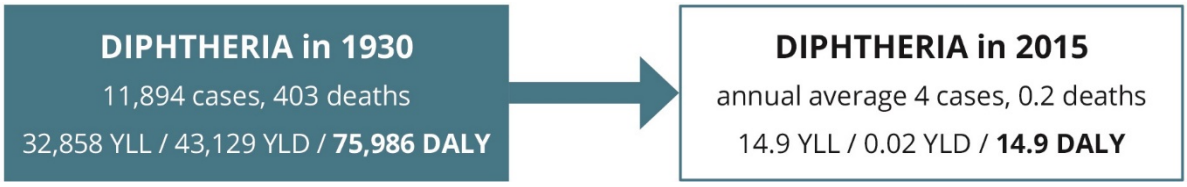
(a) Represents either the average annual number of notified cases over the 3 years centred on the reference year or, if notification data were not available or not representative, the estimated number of cases occurring in the reference year based on other data sources as described in Appendix C.

(b) Age-standardised to the 2001 Australian population.

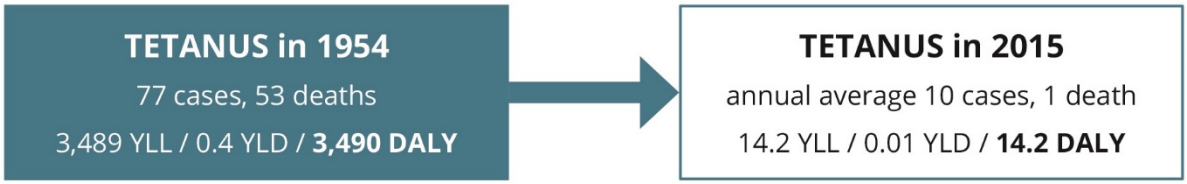
Historical comparisons

Historical notification data show the impact of long-term widespread vaccination in Australia. Diseases such as diphtheria (widespread vaccination introduced in 1932), tetanus (1953), rubella (1971) and Hib (1991) appear to be well controlled and have remained at low levels over recent decades.

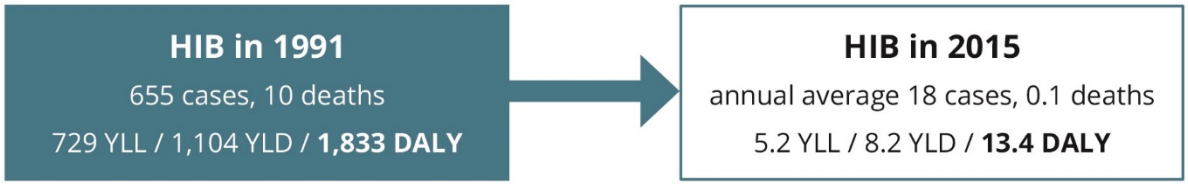
The burden of diphtheria in Australia in 1930 (before widespread vaccination, but after the advent of bacteriological diagnosis and anti-toxin treatment) was estimated at almost 76,000 DALY, with 43% of this attributed to fatal burden. This resulted from almost 12,000 cases and around 400 deaths, mostly among children. By comparison, the burden of diphtheria in 2015 was estimated to be 15 DALY, occurring among adults and mostly relating to people exposed overseas or their contacts.



Tetanus also saw a dramatic reduction in burden following the advent of widespread vaccination in the 1950s. In 1954, the estimated burden of tetanus was 3,490 DALY (almost entirely attributed to fatal cases, and mostly among children), compared with 14 DALY in 2015. Though a handful of cases still occur each year, there are few deaths, and those that do occur are among older people who may have been vaccinated many years previously, if at all.



Similarly, the burden associated with Hib in 1991 (before the introduction of widespread vaccination) was estimated at 1,833 DALY, with 60% of this attributed to YLD due to the long-term impacts of meningitis. The majority of burden was among infants and young children. By 2015, the burden had decreased to 13 DALY. In the late 1980s, Hib was the predominant cause of bacterial meningitis in Australia, accounting for up to 70% of cases. An estimated 40–50% of children with Hib developed meningitis, with the subsequent long-term complications affecting cognition, hearing, vision and other functions (Hanna & Wild 1991; McIntyre et al. 1991; McIntyre et al. 1993; Thomas 1992). The number of Hib cases in Australia declined substantially after vaccination of infants under the NIP began in 1993.

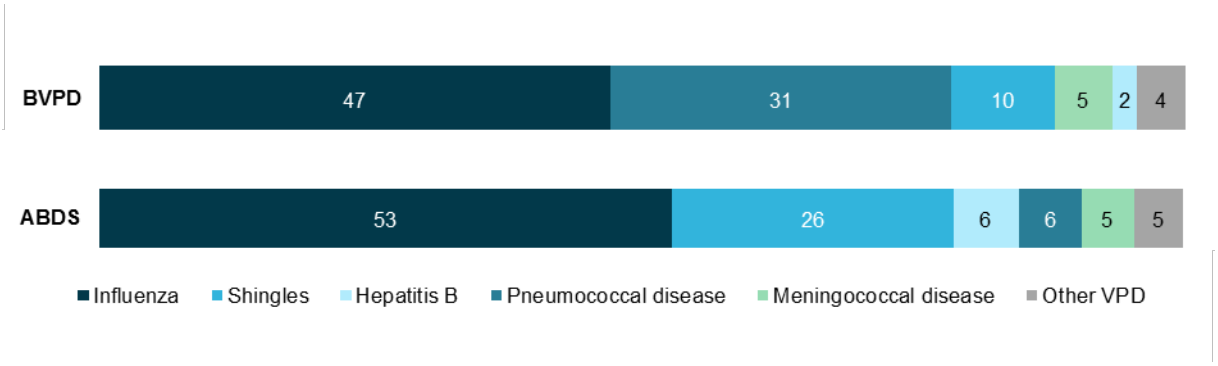


Comparison with ABDS 2015 results

The ABDS uses a hybrid burden of disease methodology, which takes as inputs all prevalent cases and all deaths occurring in the reference year. This methodology assigns the burden due to long-term disabilities to the body system affected (for example, hearing, vision or mental/behavioural disorders) rather than to the originating condition. This means that, in contrast to the incidence-based approach used in the BVPD study, the ABDS estimates for VPD do not include the burden of long-term sequelae. Hence, the estimates for diseases such as Hib, IMD, IPD and hepatitis B are considerably different. Furthermore, HPV was not a stand-alone disease in the ABDS; therefore, the burden due to HPV was captured in the relevant health states under 'other reproductive conditions' (for genital warts and cervical abnormalities) and 'cervical cancer'. Although the methodological differences mean that the results of the 2 studies are not strictly comparable, it is useful to consider the 2 sets of results and understand the reasons for the differences between them.

Excluding HPV, the overall VPD burden was 15% higher in the BVPD study than in the ABDS 2015 (12,071 DALY compared with 10,540 DALY). The same 5 diseases accounted for 95% of the VPD burden in both studies, although the positions within the top 5 differed between the studies. Influenza was the top-ranked VPD in both studies, accounting for just over half of the VPD burden (53%) in the ABDS and just under half (47%) of the non-HPV total in the BVPD study. Pneumococcal disease was the second highest ranked disease in the BVPD study, but it ranked fourth in the ABDS 2015 (Figure 4.2).

Figure 4.2: Contribution of total VPD burden (DALY) excluding HPV, top 5 VPD, BVPD study and ABDS, 2015 (%)



Note: 'Other VPD' includes chickenpox, diphtheria, hepatitis A, Hib, measles, mumps, rotavirus, rubella, tetanus and whooping cough.

Sources: AIHW BVPD study; AIHW 2019b.

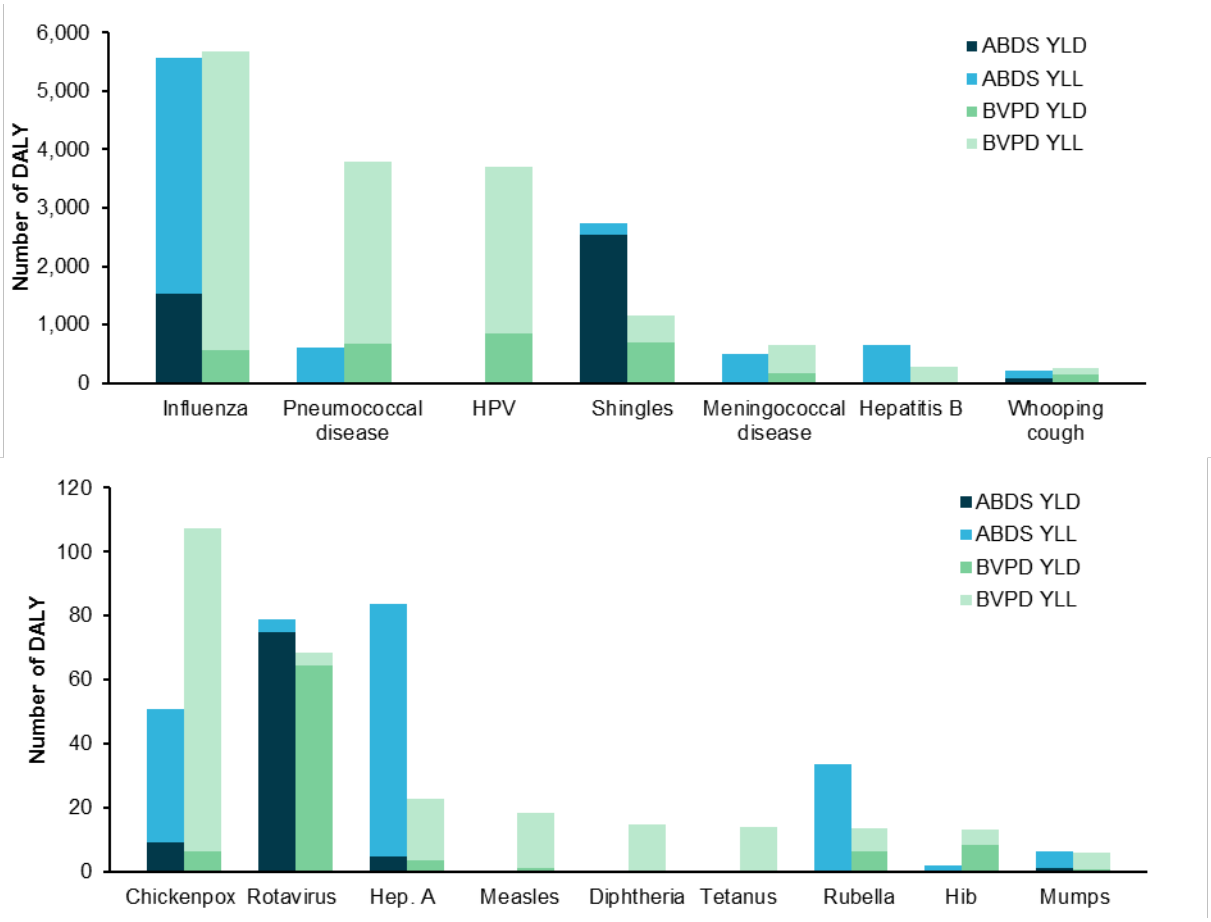
The burden estimates for influenza, whooping cough and mumps were similar across the 2 studies (Figure 4.3). These are all acute infections with no, or very rare, long-term sequelae. However, the BVPD study estimated a smaller burden than the ABDS 2015 for hepatitis A, hepatitis B, rotavirus, rubella and shingles, and a larger burden for chickenpox, diphtheria, Hib, measles, meningococcal disease, pneumococcal disease and tetanus.

Apart from the differences resulting from the inclusion of long-term sequelae in the BVPD study, the underlying reason for many of the remaining differences is variation in the methods used to derive input data in the 2 studies. The BVPD study used average notifications and hospitalisations data over 3 years, and deaths data over up to 10 years, to account for year-to-year fluctuations in case numbers and to ensure a representative age distribution, especially for less common diseases. In contrast, the ABDS used data only for 2015. This variation in inputs can, in some cases, result in substantial differences in outputs, particularly for YLL where, for example, a difference of a single death at age 65 would lead to

a difference of 20 YLL. Running the BVPD incidence models with only 2015 deaths data results in very similar results to the ABDS estimates for several of the diseases, including diphtheria, measles and tetanus.

For pneumococcal disease, there is a large difference in the YLL estimates between the 2 studies—the result of the BVPD study's using the enhanced pneumococcal surveillance program data to identify pneumococcal disease deaths. This results in more than 5 times as many deaths being included in the BVPD model than in the ABDS model, which used only deaths data from the National Mortality Database (NMD). As the ABDS distributed all deaths during the reference year to a cause group based on the underlying cause of death recorded on the NMD, it would not be possible to use the enhanced surveillance data to reallocate NMD deaths to the pneumococcal disease cause without undertaking data linkage. Estimates of YLD for pneumococcal disease are also larger in the BVPD study than in the ABDS due to the inclusion of burden resulting from the long-term sequelae of bacterial meningitis.

Figure 4.3: Estimates of fatal (YLL) and non-fatal (YLD) burden due to VPD from the ABDS and BVPD study, 2015



Note: The ABDS 2015 did not produce a stand-alone estimate of HPV burden; the burden due to HPV was captured in the relevant health states under 'other reproductive conditions' and 'cervical cancer'.

Sources: AIHW BVPD study; AIHW 2019b.

The other major difference in inputs between the 2 studies relates to the conditions estimated in the BVPD study using sources other than National Notifiable Diseases Surveillance System (NNDSS) data—namely influenza, chickenpox and shingles. For these diseases, the ABDS did not have access to Bettering the Evaluation and Care of Health (BEACH) data on

general practitioner (GP) encounters for 2015 and therefore applied GP:hospitalisation or GP:notification ratios from 2011 to the relevant data for 2015 to estimate the 2015 GP numbers. However, the actual BEACH estimates of GP encounters for 2015 for each of these diseases were considerably lower than the numbers estimated using these ratios, so the YLD estimated in the BVPD study for these 3 diseases are considerably smaller than those from the ABDS.

For rotavirus, the ABDS and the BVPD study used the same source as a base for rotavirus incidence in Australia (Kirk et al. 2014), but applied different methods to project the data to 2015. The ABDS applied the proportional change in notification rates between 2011 and 2015 to the community-level incidence rates for 2011 to estimate 2015 incidence. The BVPD study refined this method by fitting a trend line to notification rates between 2010 and 2015 and applying the estimated amount of change to the 2010 community-level estimates to derive 2015 estimates.

Comparison with other incidence-based studies

Results from this study can be compared with other international studies that used an incidence-based approach.

The Burden of Communicable Diseases in Europe (BCoDE) study included several of the same diseases as in the BVPD study. Of these, influenza (81.8 DALY per 100,000 population), pneumococcal disease (30.1 per 100,000), hepatitis B (7.9 per 100,000) and Hib (5.2 per 100,000) were the highest ranked (Table 4.2). The estimates of burden for each of these diseases were considerably greater in the BCoDE study than in the BVPD study, reflecting their substantially higher incidence in Europe. (HPV was not included in the list of diseases for the BCoDE study.)

The Ontario Burden of Infectious Disease Study (ONBOIDS) also ranked influenza, pneumococcal disease, hepatitis B and Hib among the top 5 diseases of a comparable list, but in a different order. HPV was included and ranked second of the comparable diseases in terms of burden. Unlike the BVPD study, the Ontario study used prevalent cases of HPV-related cancers to measure the burden associated with HPV, leading to its higher burden.

Table 4.2: Comparison of the top 5 VPD in selected burden of disease studies

	Incidence-based models			Hybrid model
Ranking	**BVPD (Australia)**	**BCoDE (Europe)**	**ONBOIDS (Canada)**	**ABDS (Australia) 2015**
1	Influenza	Influenza	Pneumococcal disease	Influenza
2	Pneumococcal disease	Pneumococcal disease	HPV[(a)]	Shingles
3	HPV	Hepatitis B	Hepatitis B	Hepatitis B
4	Shingles	Hib	Influenza	Pneumococcal disease
5	Meningococcal disease	Whooping cough	Hib	Meningococcal disease

(a) The ONBOIDS used prevalent cases of HPV-related cancers to measure the burden.

Sources: AIHW 2019b for ABDS; Cassini et al. 2018 for BCoDE, Kwong et al. 2012 for ONBOIDS.

Cancer-causing pathogens such as hepatitis B and HPV feature prominently in the top 5 diseases of the other incidence-based models.

Australia was one of the first countries in the world to introduce the HPV vaccine. Australia already had some of the lowest cervical cancer incidence rates in the world, attributed to the introduction of organised cervical screening. The introduction of the vaccine, in combination with changes to the cervical screening program, has led to an ambitious plan to eliminate cervical cancer. The early impacts can already be seen in the reduced rates of high-grade abnormalities and pre-cancerous lesions among younger women who were eligible for the vaccine after its introduction in 2007.

Infant vaccination for hepatitis B was rolled out nationally in Australia in 2000. There has since been a dramatic reduction in the number of new hepatitis B infections acquired in Australia, resulting in decreased burden. Most newly diagnosed chronic hepatitis B cases in Australia now are the result of infections acquired overseas, particularly in high-prevalence countries. Contributing to immunisation initiatives in other countries through the WHO and other channels is a strategic priority in the *National Immunisation Strategy for Australia 2019–2024* (Department of Health 2018b), with hepatitis B control being one of the focus areas of the WHO Western Pacific Regional Office Expanded Programme on Immunization (WHO 2019b).

A notable difference between the results of the Australian studies and others is the lower position of Hib in Australia. It has a small burden in Australia when measured in DALY, despite the high individual burden per case. As noted earlier, Hib has been considerably less common in Australia since vaccination was introduced in 1993, with a substantial reduction in DALY. In 2015, an estimated 72% of Canadian children aged 2 were fully vaccinated against Hib (Public Health Agency of Canada 2017) compared with around 90% of Australian 2-year-olds (Department of Health 2019).

Limitations

The incidence data used in the BVPD study included for most diseases an average number of notifications or estimated cases over 3 years, which removed some of the fluctuations from year to year. Despite this, there were 2 conditions (mumps and whooping cough) for which the later reference period included a large outbreak lasting 2 years or more. Attempts were made to smooth this out by using a longer time period to calculate input incidence rates. However, due to the size of the outbreaks compared with the average non-outbreak level of disease, this had little effect on the estimates of burden.

The under-notification of VPD continues to be an issue, particularly for diseases such as chickenpox, shingles, rotavirus, hepatitis A and influenza. Notifications data represent only cases for which health care was sought, a test conducted and a diagnosis made, followed by a notification to health authorities (referred to as the ‘notified fraction’). The notified fraction varies by disease, jurisdiction and over time due to the influence of several factors, including disease severity, care-seeking behaviour, available diagnostics and changing case definitions, as well as differences in testing and reporting practices between primary care practices, hospitals and pathology laboratories.

For influenza and rotavirus, only laboratory-confirmed cases are notifiable, which means that a large proportion of cases are not notified each year. There would also be a substantial proportion of (likely mild) cases where the person did not seek medical attention. The advent of improved and more readily available tests, along with increased awareness among health professionals and individuals, has likely increased the notified fraction of influenza cases in recent years but the size of the impact is not clear. Alternative data sources providing surveillance of influenza-like illnesses suggest that the 2015 influenza season was comparable to those for the preceding few years and that much of the increase in

notifications between 2010 and 2015 likely relates to increased testing rather than to increased numbers of cases (Fielding et al. 2016).

The incidence of hepatitis B is also difficult to establish because many cases are asymptomatic in the acute phase. Cases may be detected only after many years, once they become chronic. In this study, following consultation with the Doherty Institute, 'newly diagnosed' hepatitis B notifications were assumed to represent incident acute infections, but this may underestimate actual incidence and therefore the burden due to long-term complications.

For analyses by Indigenous status, the under-identification of Aboriginal and Torres Strait Islanders in many administrative data sets, particularly the NNDSS, continues to be an issue. For the diseases included in this study, completeness of Indigenous identification in notifications data ranged from around 40% up to 100%. Although the inputs for this study were derived using data from jurisdictions with completeness of Indigenous status of at least 50%, and the majority of data met this threshold, the lack of complete data means that there is uncertainty around the 'true' incidence of these diseases among Indigenous Australians, and in the resulting estimates of disease burden.

This study used BEACH data in conjunction with notifications and hospitalisation data to estimate the number of cases of influenza, chickenpox, shingles, rotavirus and whooping cough. However, the BEACH survey is no longer conducted, and so an alternative source of data, or a method for modelling case numbers using available data, will need to be found in the future. The National Primary Health Care Data Asset, currently being developed by the Australian Institute of Health and Welfare, is a potential future source of relevant information. For further information, see https://consultation.aihw.gov.au/phcdu/national-primary-health-care-data-asset/.

Appendix A: Individual state/territory results

The results presented in this appendix relate to the 11 VPD for which sub-national estimates were derived. The 11 diseases are chickenpox, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, pneumococcal disease, rotavirus, shingles and whooping cough. All comparisons to 'total Australian burden' in this appendix are for these 11 diseases only. The annual number of cases or the overall burden attributed to the remaining 6 diseases was too small to be disaggregated by individual states and territories (diphtheria, Hib, mumps, polio, rubella and tetanus). The state and territory results are available in the supplementary tables on the Australian Institute of Health and Welfare (AIHW) website at https://www.aihw.gov.au/reports-data/health-welfare-services/immunisation/overview.

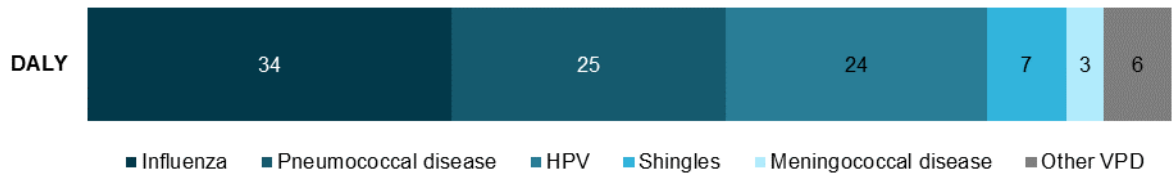
New South Wales

In 2015, New South Wales accounted for almost one-third (31%, 4,794 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in New South Wales (58.6 DALY per 100,000 population) was lower than the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Five diseases accounted for most (94%) of the VPD burden in New South Wales in 2015 (Figure A1). Influenza contributed more than one-third (34%) of the total VPD burden, followed by pneumococcal disease (25%) and HPV (24%).

Figure A1: Contribution of individual diseases to overall VPD burden (DALY), New South Wales, 2015 (%)



Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A1.

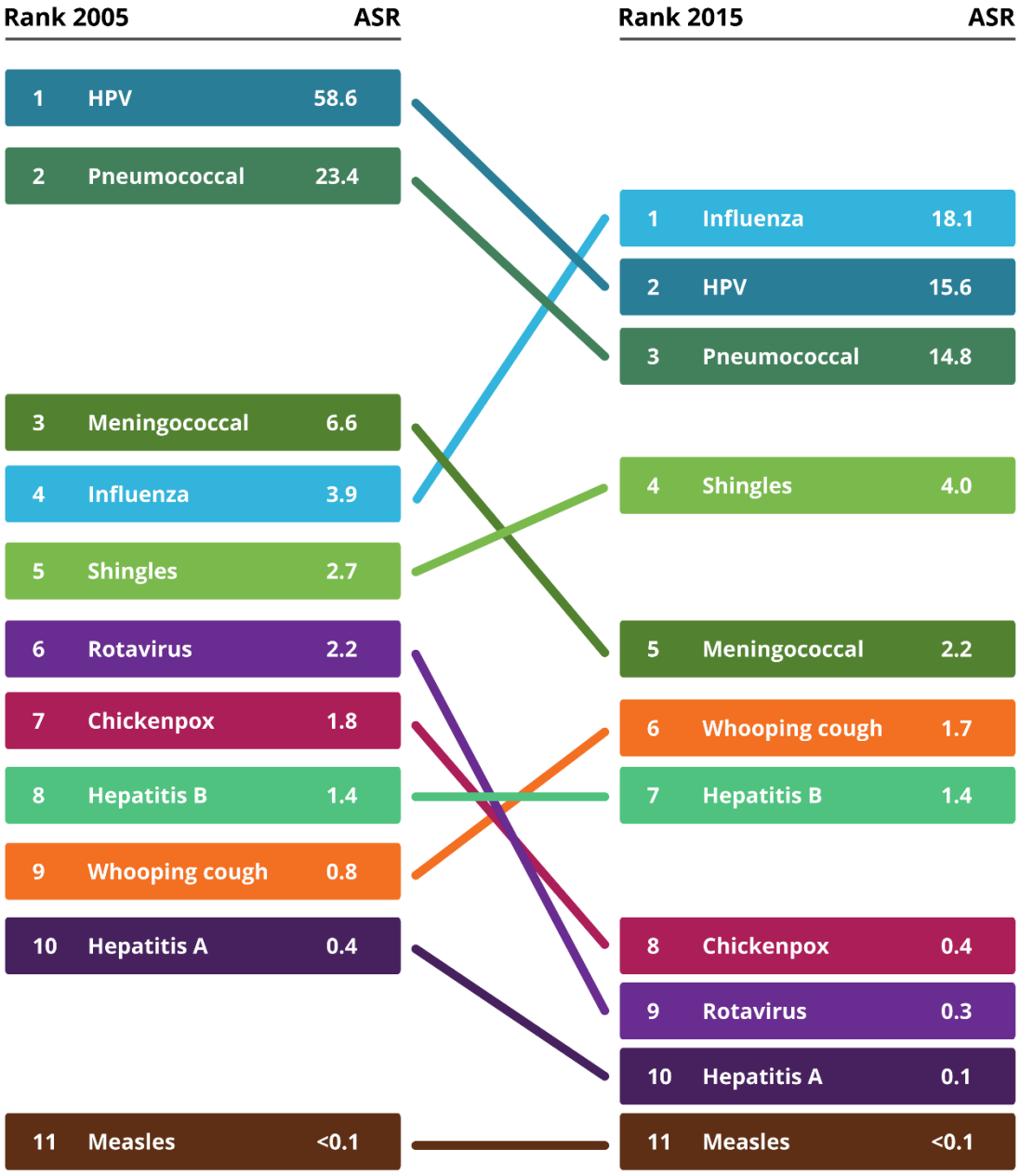
Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In New South Wales, there was a considerable decrease (of 42%) in the VPD burden rate between 2005 and 2015 (from 101.9 to 58.6 DALY per 100,000 population). There were decreases in the burden due to pneumococcal and meningococcal diseases, a large decrease in the burden due to HPV and an increase in the burden due to influenza (Figure A2).

Between 2005 and 2015, there was some movement in the rankings of individual VPD in New South Wales: for example, influenza increased from fourth in 2005 to first in 2015, meningococcal disease went from third in 2005 to fifth in 2015 and whooping cough rose from ninth in 2005 to sixth in 2015.

Figure A2: Individual VPD burden (DALY per 100,000 population) and rankings, New South Wales, 2005 and 2015



ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A2.

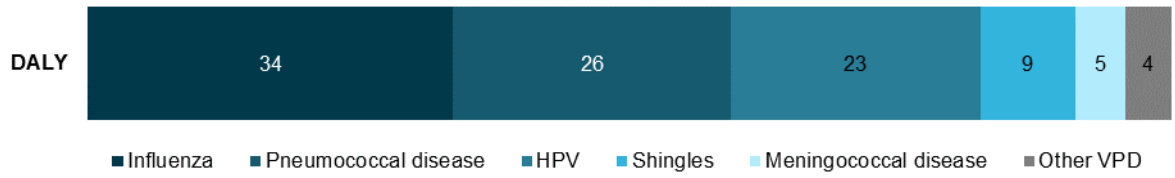
Victoria

In 2015, Victoria accounted for more than one-fifth (22%, 3,502 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in Victoria (54.2 DALY per 100,000 population) was lower than the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Five diseases accounted for most (96%) of the VPD burden in Victoria in 2015 (Figure A3). Influenza contributed more than one-third of the total burden (34%), followed by pneumococcal disease (26%) and HPV (23%).

Figure A3: Contribution of individual diseases to overall VPD burden (DALY), Victoria, 2015 (%)



Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A3.

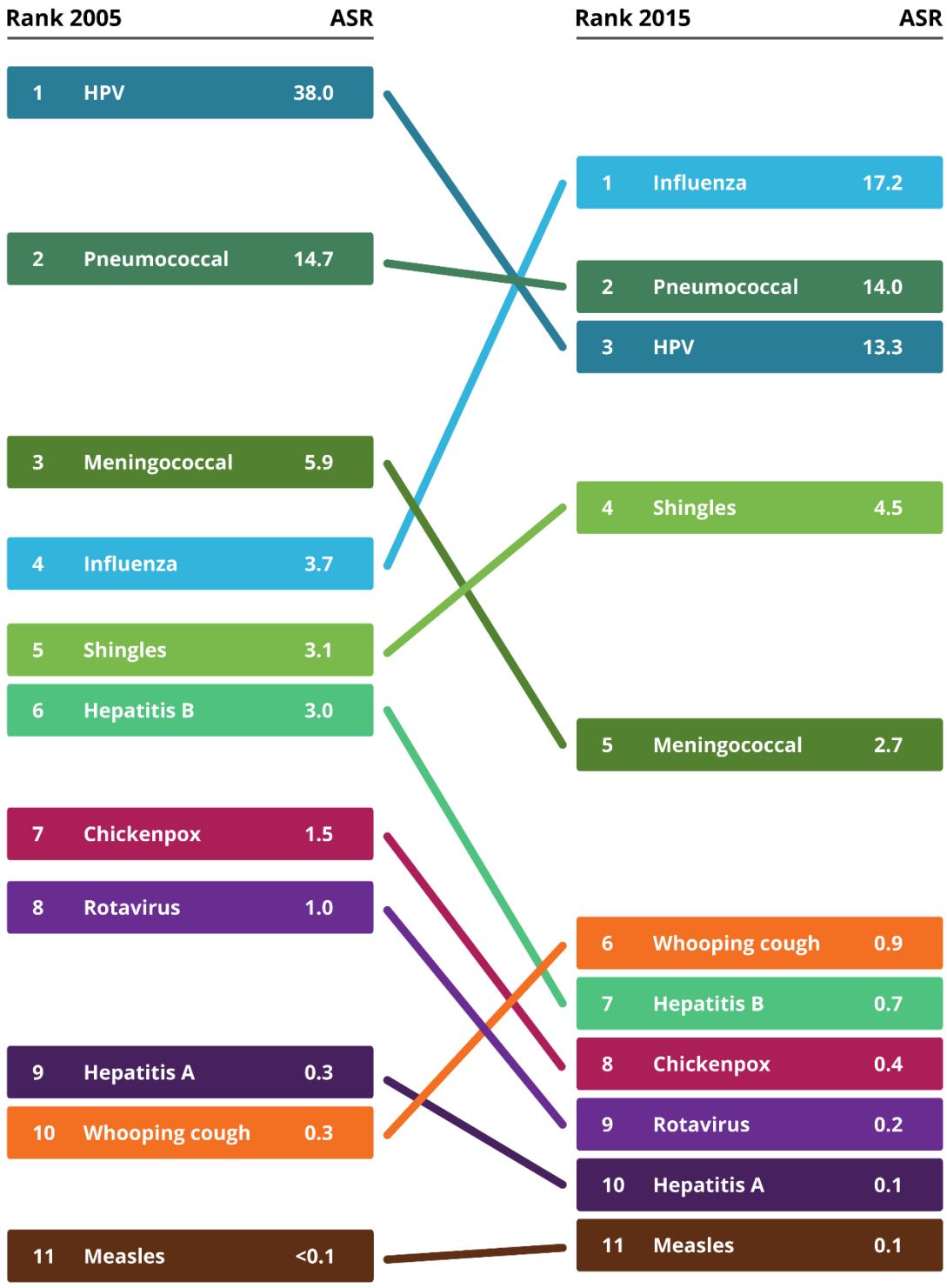
Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In Victoria, the VPD burden rate decreased by 24% between 2005 and 2015 (from 71.5 to 54.2 DALY per 100,000 population). Although there was a considerable increase in the burden due to influenza, this was exceeded by a substantial decrease in the burden due to HPV, along with decreases in the burden due to hepatitis B and meningococcal disease (Figure A4).

Between 2005 and 2015, there was some movement in the rankings of individual VPD in Victoria: for example, influenza increased from fourth in 2005 to first in 2015, HPV went from first in 2005 to third in 2015 and whooping cough increased from 10th in 2005 to sixth in 2015.

Figure A4: Individual VPD burden (DALY per 100,000 population) and rankings, Victoria, 2005 and 2015



ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A4.

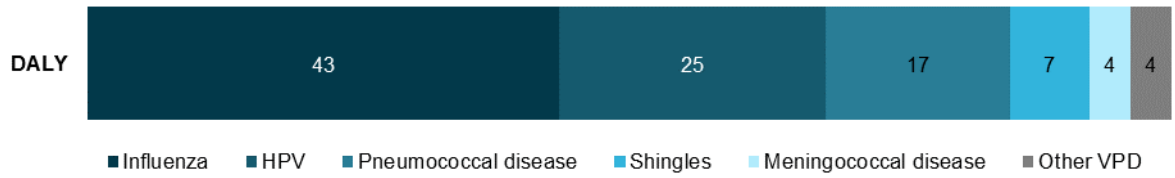
Queensland

In 2015, Queensland accounted for more than one-fifth (22%, 3,455 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in Queensland (69.8 DALY per 100,000 population) was higher than the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Five diseases accounted for most (96%) of the VPD burden in Queensland in 2015 (Figure A5). Influenza contributed more than two-fifths of the total burden (43%), followed by HPV (25%) and pneumococcal disease (17%).

Figure A5: Contribution of individual diseases to overall VPD burden (DALY), Queensland, 2015 (%)



Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A5.

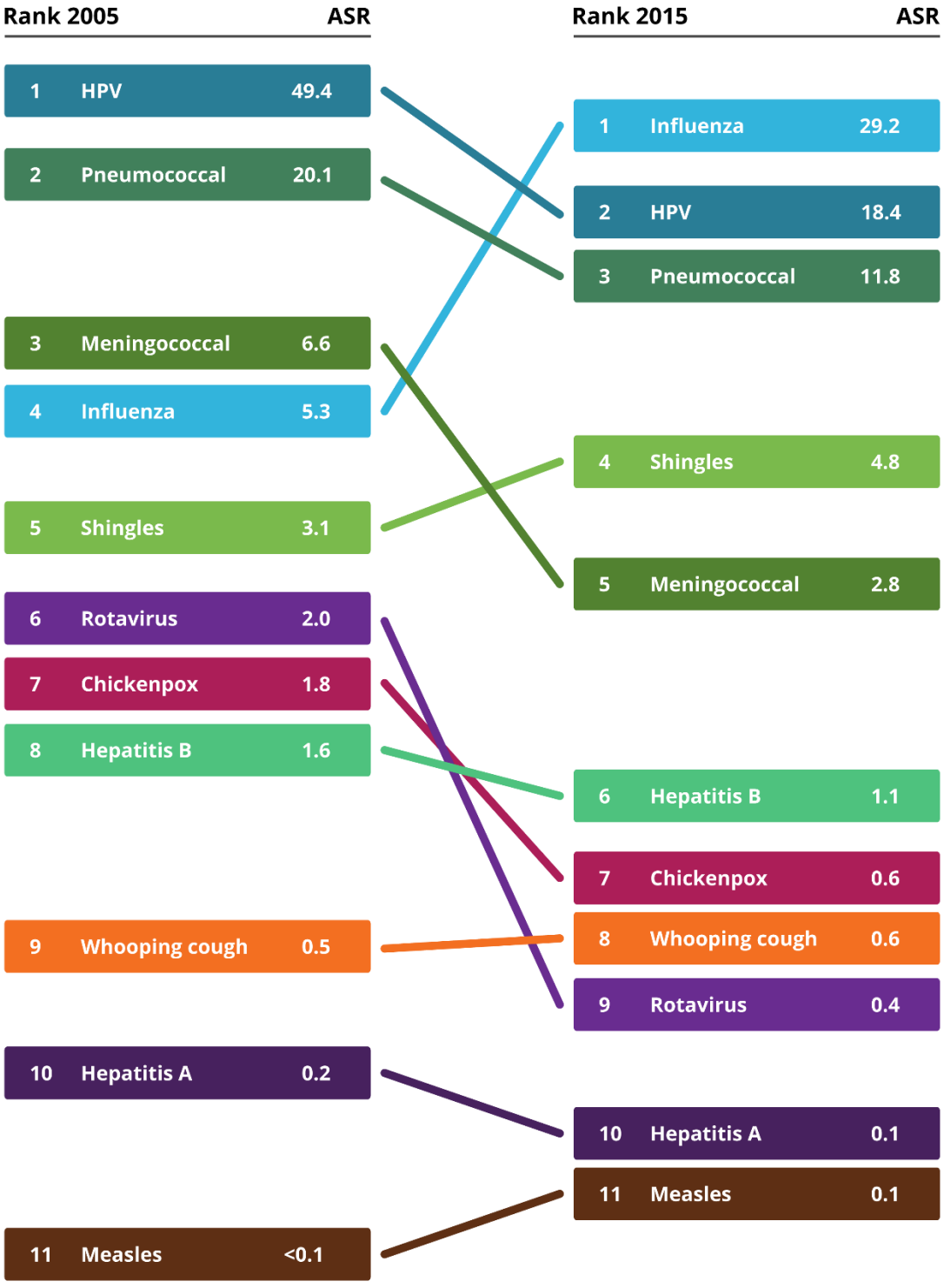
Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In Queensland, the VPD burden rate decreased by 23% between 2005 and 2015 (from 90.7 to 69.8 DALY per 100,000 population). Although there was a large rise in the influenza burden, this was exceeded by a considerable drop in the HPV burden along with decreases in the pneumococcal and meningococcal disease burden (Figure A6).

Between 2005 and 2015, there was some movement in the rankings of individual VPD in Queensland: for example, influenza increased from fourth in 2005 to first in 2015, meningococcal disease went from third in 2005 to fifth in 2015 and rotavirus went from sixth in 2005 to ninth in 2015.

Figure A6: Individual VPD burden (DALY per 100,000 population) and rankings, Queensland, 2005 and 2015



ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A6.

Western Australia

In 2015, Western Australia accounted for around 10% (1,534 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in Western Australia (58.6 DALY per 100,000 population) was lower than the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Five diseases accounted for most (96%) of the VPD burden in Western Australia in 2015 (Figure A7). HPV contributed almost one-third of the total burden (32%), followed by pneumococcal disease (31%) and influenza (22%).

Figure A7: Contribution of individual diseases to overall VPD burden (DALY), Western Australia, 2015 (%)

Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A7.

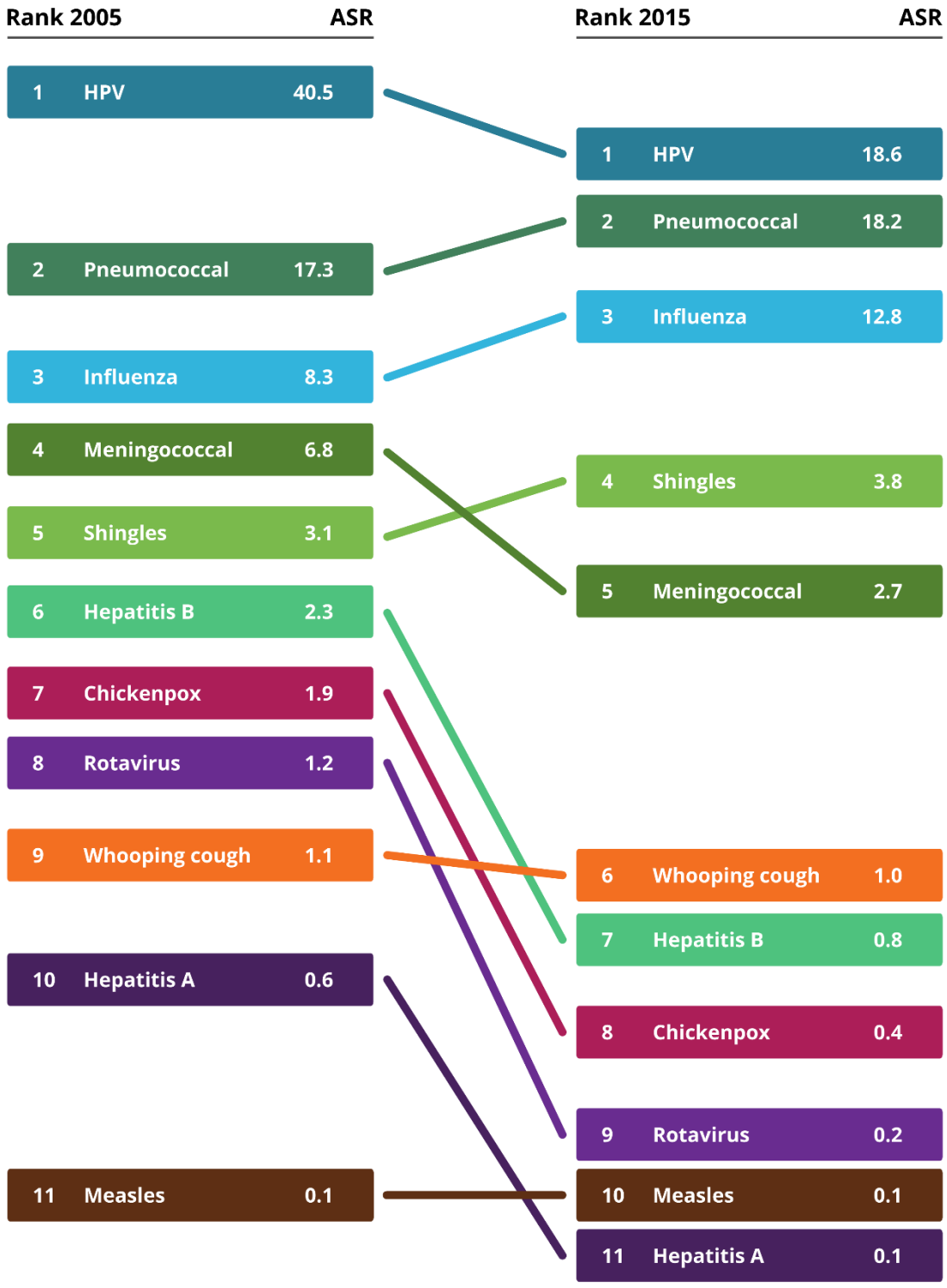
Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In Western Australia, the VPD burden rate fell by 29% between 2005 and 2015 (from 83.1 to 58.6 DALY per 100,000 population). Unlike other jurisdictions, Western Australia had a comparatively modest rise in the rate of burden due to influenza, but still had decreases in the burden due to HPV, meningococcal disease and hepatitis B (Figure A8).

Between 2005 and 2015, there was less movement in the rankings of individual VPD in Western Australia compared with other jurisdictions, but still some changes: for example, hepatitis B moved from sixth in 2005 to seventh in 2015 and whooping cough rose from ninth in 2005 to sixth in 2025.

Figure A8: Individual VPD burden (DALY per 100,000 population) and rankings, Western Australia, 2005 and 2015



ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A8.

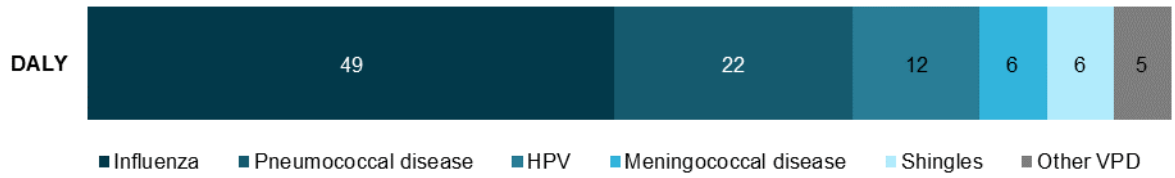
South Australia

In 2015, South Australia accounted for around 10% (1,536 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in South Australia (80.3 DALY per 100,000 population) was greater than the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Five diseases accounted for most (95%) of the VPD burden in South Australia in 2015 (Figure A9). Influenza contributed almost one-half of the total burden (49%), followed by pneumococcal disease (22%) and HPV (12%).

Figure A9: Contribution of individual diseases to overall VPD burden (DALY), South Australia, 2015 (%)



Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A9.

Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In South Australia, there was little change (1% decrease) in the VPD burden rate between 2005 and 2015 (from 81.0 to 80.3 DALY per 100,000 population). Although there were decreases in the burden due to pneumococcal disease, rotavirus and HPV, this was balanced out by a very large increase in the burden due to influenza (Figure A10).

Between 2005 and 2015, there was some movement in the rankings of individual VPD in South Australia: for example, influenza increased from third in 2005 to first in 2015, rotavirus went from fifth in 2005 to ninth in 2015 and HPV went from first in 2005 to third in 2015.

Figure A10: Individual VPD burden (DALY per 100,000 population) and rankings, South Australia, 2005 and 2015

ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A10.

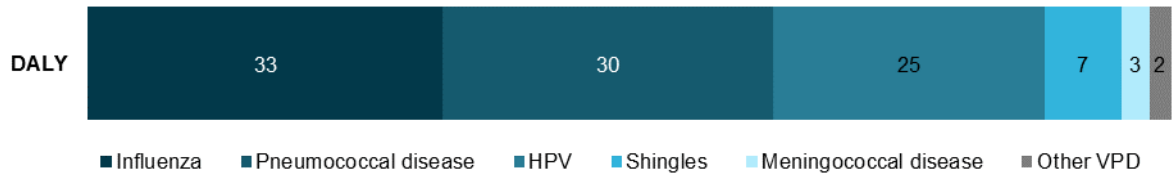
Tasmania

In 2015, Tasmania accounted for 2% (348 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in Tasmania (63.4 DALY per 100,000 population) was similar to the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Five diseases accounted for almost all (98%) of the VPD burden in Tasmania in 2015 (Figure A11). Influenza contributed one-third of the total burden (33%), followed by pneumococcal disease (30%) and HPV (25%).

Figure A11: Contribution of individual diseases to overall VPD burden (DALY), Tasmania, 2015 (%)



Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A11.

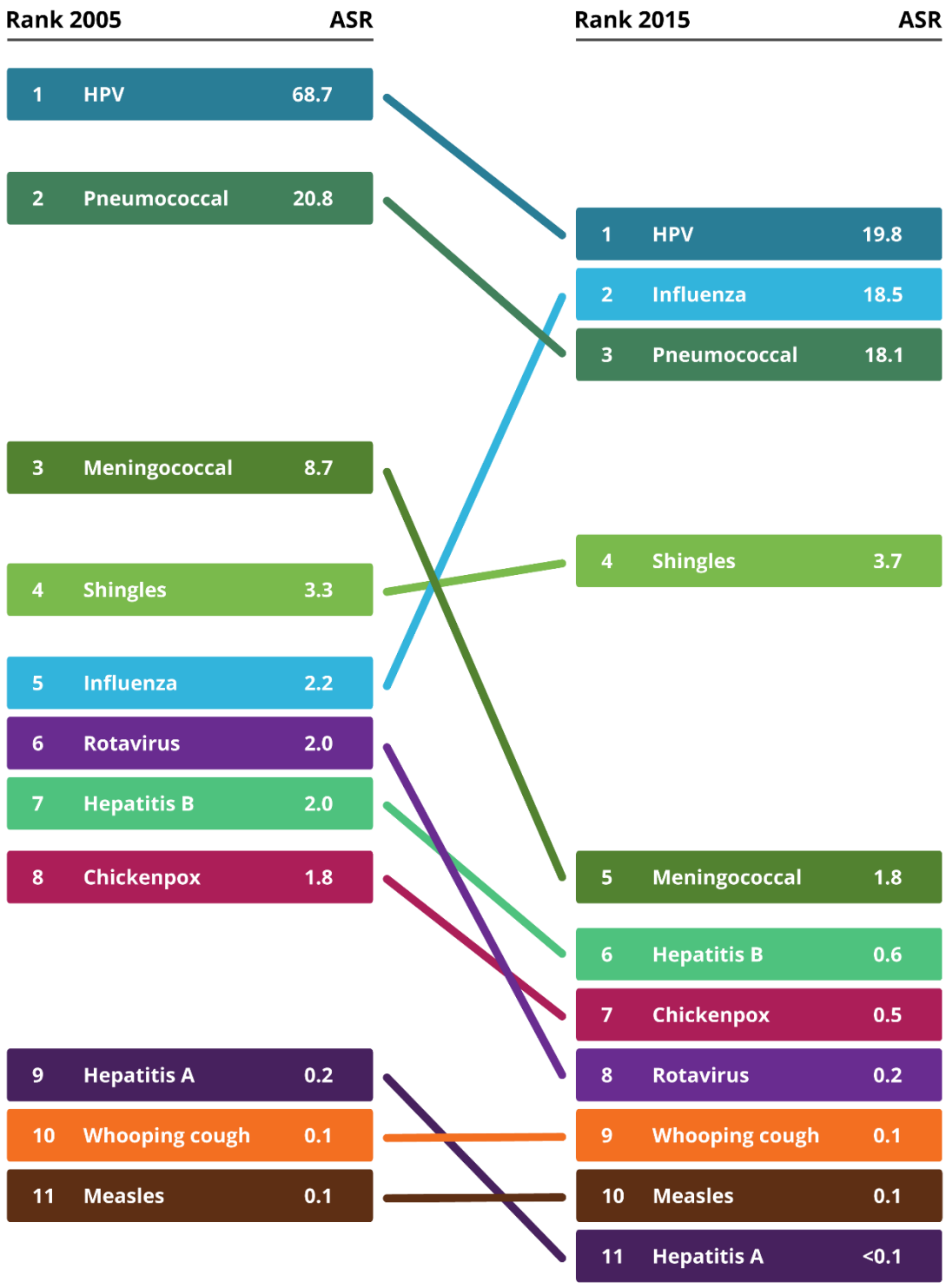
Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In Tasmania, there was a 42% decrease in the VPD burden rate between 2005 and 2015 (from 109.9 to 63.4 DALY per 100,000 population). Although there was a large increase in the burden due to influenza, this was exceeded by a decrease in the burden due to HPV, along with decreases in the burden due to pneumococcal and meningococcal diseases, rotavirus and chickenpox (Figure A12).

Between 2005 and 2015, there was some movement in the rankings of individual VPD in Tasmania: for example, influenza increased from fifth in 2005 to second in 2015, meningococcal disease went from third in 2005 to fifth in 2015, and rotavirus went from sixth in 2005 to eighth in 2015.

Figure A12: Individual VPD burden (DALY per 100,000 population) and rankings, Tasmania, 2005 and 2015



ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A12.

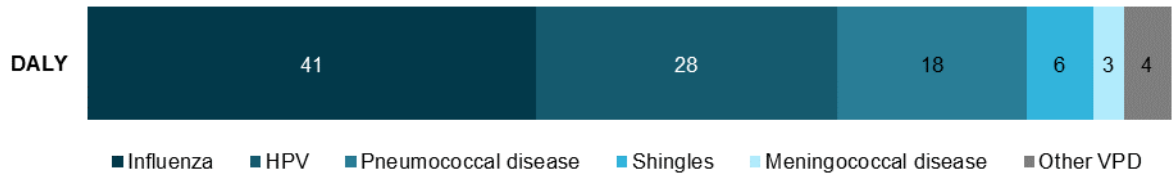
Australian Capital Territory

In 2015, the Australian Capital Territory accounted less than 2% (238 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in the Australian Capital Territory (59.7 DALY per 100,000 population) was a little lower than the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Five diseases accounted for most (96%) of the VPD burden in the Australian Capital Territory in 2015 (Figure A13). Influenza contributed more than two-fifths of the total burden (41%), followed by HPV (28%) and pneumococcal disease (18%).

Figure A13: Contribution of individual diseases to overall VPD burden (DALY), Australian Capital Territory, 2015 (%)



Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A13.

Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In the Australian Capital Territory, there was a 34% decrease in the VPD burden rate between 2005 and 2015 (from 90.0 to 59.7 DALY per 100,000 population). Although, as in most jurisdictions, there was a large increase in the burden due to influenza, this was exceeded by decreases in the burden due to HPV, pneumococcal and meningococcal diseases (Figure A14).

Between 2005 and 2015, there was some movement in the rankings of individual VPD in the Australian Capital Territory: for example, influenza increased from fourth in 2005 to first in 2015, meningococcal disease went from third in 2005 to fifth in 2015, and whooping cough rose from ninth in 2005 to sixth in 2015.

Figure A14: Individual VPD burden (DALY per 100,000 population) and rankings, Australian Capital Territory, 2005 and 2015

ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A14.

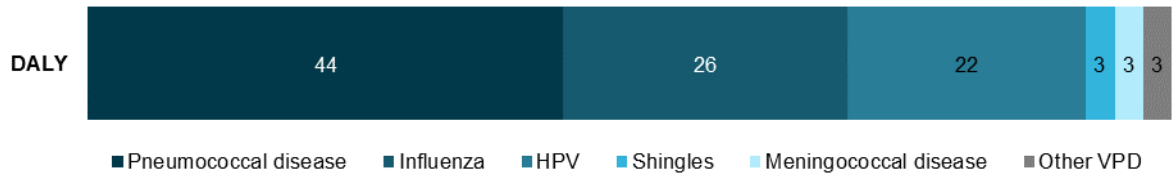
Northern Territory

In 2015, the Northern Territory accounted for 2% (312 DALY) of the burden attributed to the 11 VPD able to be disaggregated by jurisdiction. The overall burden rate in the Northern Territory (134.0 DALY per 100,000 population) was more than double the total Australian rate for these diseases (62.2 DALY per 100,000).

Which diseases caused the most burden?

Three diseases accounted for most (92%) of the VPD burden in the Northern Territory in 2015 (Figure A15). Pneumococcal disease contributed over two-fifths of the total burden (44%), followed by influenza (26%) and HPV (22%).

Figure A15: Contribution of individual diseases to overall VPD burden (DALY), Northern Territory, 2015 (%)



Note: 'Other VPD' comprises whooping cough, hepatitis B, chickenpox, rotavirus, hepatitis A and measles.

Source: This figure is based on data in a supplementary table available online—Table A15.

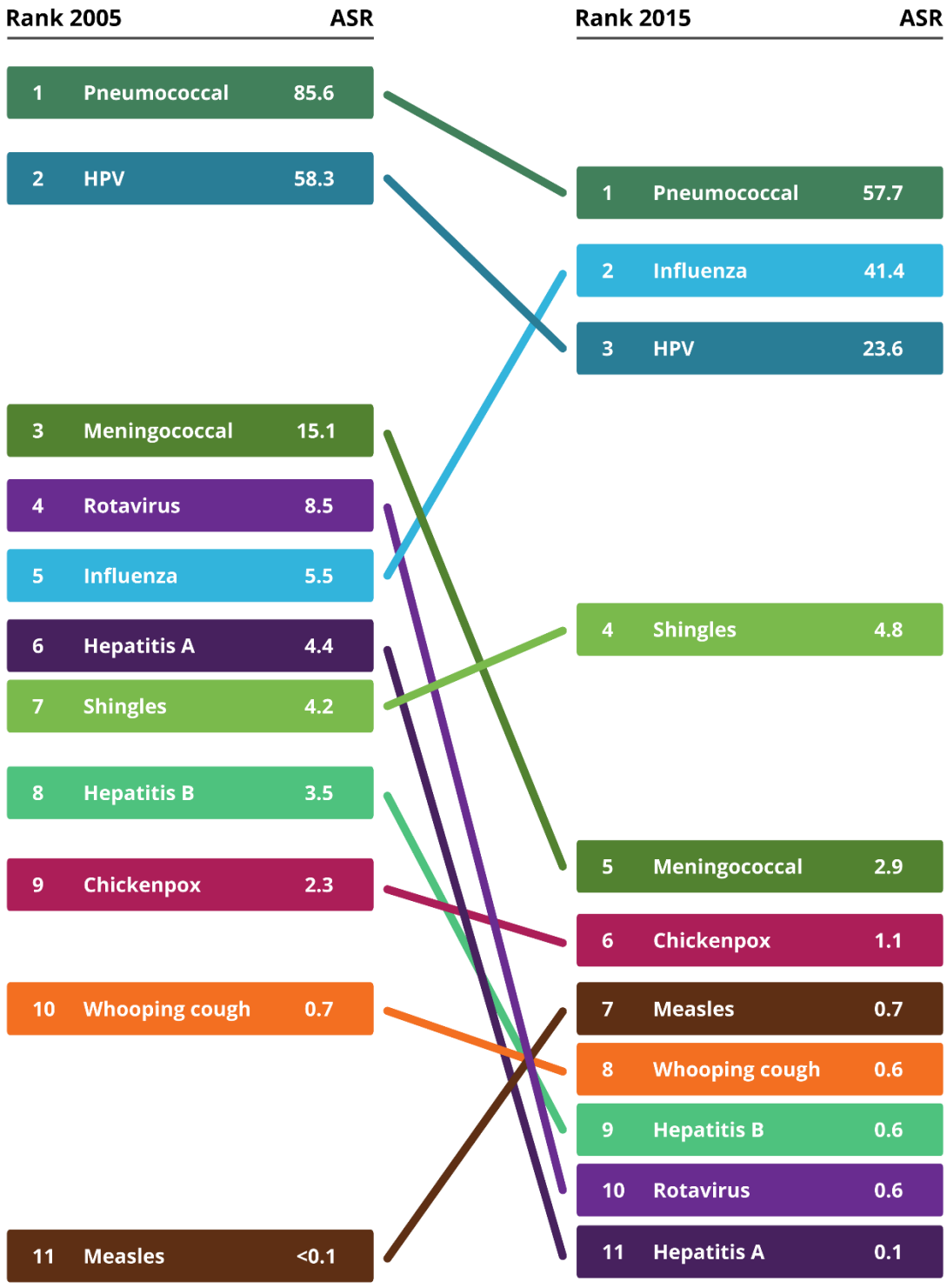
Change in burden since 2005

When comparing results from the 2 reference years (2015 and 2005), it is important to note that differences in the burden may have been affected by both the cyclic epidemics of many diseases (for example, influenza and whooping cough) and changes in disease surveillance and reporting practices.

In the Northern Territory, there was a 29% decrease in the VPD burden rate between 2005 and 2015 (from 188.1 to 134.0 DALY per 100,000 population). Decreases in the burden due to pneumococcal and meningococcal diseases, HPV, rotavirus and hepatitis A exceeded the large increase in the burden due to influenza (Figure A16).

Between 2005 and 2015, there was considerable movement in the rankings of individual VPD in the Northern Territory: for example, meningococcal disease went from third in 2005 to fifth in 2015, rotavirus went from fourth in 2005 to 10th in 2015, hepatitis A went from sixth in 2005 to 11th in 2015, and measles rose from 11th in 2005 to seventh in 2015.

Figure A16: Individual VPD burden (DALY per 100,000 population) and rankings, Northern Territory, 2005 and 2015



ASR = age-standardised rate

Note: Rates age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table A16.

Appendix B: Additional methodological information

Underpinning burden of disease analysis is a series of social value choices and other inputs that determine the methods used to calculate DALY. These choices include the standard life table used, whether future health loss is to be valued differently from current health loss, the disability weights used to account for the severity of health loss associated with a particular state of health, whether and how to adjust for comorbidity, and the choice of diseases included in the study. Each of these choices impacts on the resulting burden estimates. These choices, as well as those related to the derivation of estimates for the Aboriginal and Torres Strait Islander population, are discussed below.

Overarching inputs and methodological choices

The standard life table

Years of life lost (YLL) in burden of disease studies are calculated with reference to a standard life expectancy at each age. The choice of standard life table requires a somewhat arbitrary decision regarding target life expectancies, a decision that will have an impact on the burden of disease estimates produced. In general, a life table with higher life expectancies gives a greater proportional influence to deaths occurring at the older ages in the resulting YLL, and will also result in a greater number of total YLL (and hence greater total DALY).

For this study, an Australian life table for the 2015 reference period was developed using age-specific death rates. The life table shows the life expectancy for a person in a given age group assuming current age-specific death rates are experienced throughout their lifetime.

Discounting and age-weighting

Discounting assumes that health years lived in the present are valued more than those lived in the future. Age-weighting is a method used to assign larger importance to certain age groups compared with others.

Consistent with the ABDS and other recent burden of disease studies, no discounting or age-weighting was applied to estimates of burden for this report.

Disability weights

For each disease or injury included in a burden of disease study, the amount of time lived in less than full health needs to be defined and measured and a value must be assigned to the associated loss of health. The valuation process involves first identifying the specific consequences of each particular disease or injury to be included in the study, known as ‘sequelae’ (for example, septicaemia due to invasive pneumococcal disease), and then developing ‘health states’ that describe the functional consequences or symptoms that people with these sequelae experience. A set of weights is then produced ‘based on individuals’ perceptions of the impact on people’s lives from a particular disability’ (IHME 2013). Commonly known as disability weights, they reflect the severity of health loss associated with a disease or injury on a scale from 0 (perfect health) to 1 (equivalent to death).

The disability weights used in the BVPD study were drawn from the GBD 2013. The GBD disability weights were originally derived for the GBD 2010 from a large, multinational, cross-cultural study (Salomon 2010; Salomon et al. 2012) and further refined for the GBD 2013 (GBD 2013 Collaborators 2015). The GBD disability weights were derived using a survey instrument that allowed respondents in the general public to make pair-wise comparisons between 2 health states. Respondents were surveyed in 2 ways: household surveys (face-to-face interviews in Bangladesh, Indonesia, Peru and Tanzania; and telephone interviews in the United States of America) and an open-access, web-based survey. At least 500 of the more than 16,000 web-based survey participants were based in Australia (Salomon et al. 2012). The result is a set of weights that is claimed to reflect consistent results across different cultural environments (Salomon 2010; Salomon et al. 2012). The same disability weights were applied to both the Australian and Indigenous Australian estimates in the BVPD study.

The GBD 2013 disability weights were also used in the ABDS 2011 and 2015.

Adjusting for comorbidity

'Comorbidity' is having more than 1 disease or injury at the same time. This is common at older ages and in the Indigenous Australian population, particularly where individuals may have several chronic diseases. For burden of disease purposes, simply adding YLD estimates across different diseases may result in overestimation of the total non-fatal burden, as the health loss associated with having; for example, both diabetes and arthritis is less than the sum of the health loss associated with each of these conditions individually. This problem is known as 'comorbidity bias'. In the ABDS and the GBD study, adjustments are made to account for comorbidities across the complete range of around 200 diseases and injuries.

Due to the low rates of most VPD in Australia, the chance of a person having more than 1 of these diseases at the same time is low. Although bacterial pneumonia is a common complication of influenza in vulnerable individuals, it is difficult to determine the proportion of people affected by both influenza and IPD. Studies from Sweden, Denmark and the United States estimate around 5%–8% of IPD cases among adults are attributable to influenza-like illness (Grabowska et al. 2006; Walter et al. 2010; Weinberger et al. 2014). Applied to Australian notifications data, this would mean around 60–100 IPD cases each year, either following or comorbid with influenza.

As only a limited number of diseases were included in the BVPD study—and the probability in Australia of a person's having multiple concurrent VPD is low—no comorbidity adjustment was applied in the BVPD study.

Methods for deriving state and territory estimates

For state and territory estimates, a proxy approach was used to disaggregate national DALY to the sub-national level. This involved applying the sub-national distribution pattern for a particular disease from either notification or hospitalisation data to disaggregate the national-level DALY estimates to the state and territory level. Notification data were used to derive sub-national estimates for 6 diseases, and hospitalisations data were used for 4 diseases. For HPV, data on the rate of high-grade abnormalities detected per 1,000 women screened were applied to the female population to estimate the number of abnormalities that occurred, and this was used to allocate DALY by state and territory. This takes into account the variation in screening rates among the jurisdictions.

For the remaining 6 diseases, the number of DALY were too small to be disaggregated by individual states and territories.

The data sources used to break down national DALY into state and territory estimates are in Table B1. State and territory results are generally presented as age-standardised rates, a method that removes the influence of differences in population size and age structure.

Table B1: Data source used for sub-national distribution of national burden (DALY) estimates

Disease	State/territory data source
Chickenpox	Hospitalisations
Diphtheria	Annual number of cases too small to be disaggregated
Haemophilus influenzae type b (Hib)	Number of DALY too small to be disaggregated
Hepatitis A	Notifications
Hepatitis B	Notifications
Human papillomavirus (HPV)	Rate of high-grade abnormalities
Influenza	Hospitalisations
Measles	Notifications
Meningococcal disease	Notifications
Mumps	Number of DALY too small to be disaggregated
Pneumococcal disease	Notifications
Polio	Zero DALY
Rotavirus	Hospitalisations
Rubella	Number of DALY too small to be disaggregated
Shingles	Hospitalisations
Tetanus	Number of DALY too small to be disaggregated
Whooping cough	Notifications

Methods for deriving Indigenous estimates

As well as the impact of the methodology choices highlighted here, several factors were considered when calculating burden of disease estimates for Indigenous Australians. As a general principle, the methods used to produce Indigenous burden of disease estimates were consistent with those used to produce national estimates. However, this was not always possible due to differences in data availability, data quality and population size and characteristics.

To account for differences in population age structure and size, age-standardisation has been used in this report when comparing burden of disease estimates for the Indigenous and non-Indigenous populations.

Under-identification of Indigenous Australians in administrative data

For some administrative data sources, Indigenous Australians are under-identified to varying degrees across states and territories, remoteness areas and over time. Where the extent of this under-identification is known and adjustment factors are available—such as in the case of mortality and hospitalisations data—estimates can be adjusted to account for such

under-identification. For other data sources, estimates of the extent of under-identification may be made by applying evidence from certain jurisdictions or other data sources. Details on how adjustments for under-identification were made are detailed for each individual data source in the sections below.

Indirect methods for estimating disease incidence in Indigenous Australians

For many of the diseases in this study, estimates of incidence in Indigenous Australians were obtained directly from the National Notifiable Diseases Surveillance System (NNDSS). However, for some diseases, there was no data source that could provide a reliable incidence estimate for the Indigenous population. In such cases, indirect methods were required to derive estimates. Such methods included applying Indigenous:non-Indigenous rate ratios from proxy data sources (for example, hospitalisations) to the total population prevalence. Where indirect methods were used, these are detailed in Appendix C under the specific disease.

Main data sources

National Notifiable Diseases Surveillance System

The NNDSS coordinates surveillance of more than 60 communicable diseases or disease groups across Australia. Notifications are made to state or territory health authorities and supplied daily to the Department of Health for compilation. Notifications data for 3 calendar years were averaged for use as model inputs: data for 2004–2006 for the 2005 reference year, and for 2014–2016 for the 2015 reference year. The NNDSS data used in this study were extracted on 16 January 2018.

For some notifiable diseases, notification data provide a relatively accurate measure of the incidence or prevalence of disease in the population. For other diseases, however (such as influenza), notifications do not accurately reflect true disease incidence. This is because NNDSS data represent only cases for which health care was sought, a test conducted and a diagnosis made, followed by a notification to health authorities (referred to as the 'notified fraction'). The notified fraction varies by disease, jurisdiction and over time due to the influence of several factors, including disease severity, care-seeking behaviour, available diagnostics and changing case definitions, as well as differences in testing and reporting practices between primary care practices, hospitals and pathology laboratories.

As a result, notifications for some conditions were adjusted to estimate the true number of cases in the community. These adjustment factors were based on a variety of evidence, including syndromic surveillance systems, outbreak investigation and expert advice. Where such adjustments were made, these are outlined in the disease-specific methods below.

Case definitions for the notifiable diseases analysed in this report, including reference to any historic changes, are available on the Department of Health website at www.health.gov.au/internet/main/publishing.nsf/Content/cdna-casedefinitions.htm.

Indigenous identification

The completeness of Indigenous identification in notifiable disease registries varies across the states and territories, by disease and over time. This means that the number of notifications recorded as Indigenous is likely to be an underestimate of Aboriginal and Torres Strait Islander notifications.

For the BVPD study, data on Indigenous notifications were included if information on Indigenous status was reported for at least 50% of diagnoses in a jurisdiction for the time period being considered (see Table B2). For some diseases, Indigenous:non-Indigenous notification ratios from jurisdictions with adequate completeness of identification were applied to the notifications for other similar jurisdictions to estimate total Indigenous notifications. This is noted under the relevant diseases below.

Table B2: Jurisdictions with at least 50% completeness for Indigenous identification in notifications data, 2004–2006 and 2014–2016

Disease	2014–2016	2004–2006
Hepatitis A	All jurisdictions	New South Wales, Victoria, Queensland, Western Australia, South Australia, Tasmania and the Northern Territory
Hepatitis B	All jurisdictions	New South Wales, Victoria, Queensland, Western Australia, South Australia and the Northern Territory
Hib	All jurisdictions	All jurisdictions
Measles	All jurisdictions	All jurisdictions
Meningococcal disease	All jurisdictions	All jurisdictions
Mumps	All jurisdictions	Victoria, Western Australia, South Australia, Tasmania, the Northern Territory and the Australian Capital Territory
Pneumococcal disease	All jurisdictions	All jurisdictions
Whooping cough	Victoria, Queensland, Western Australia, South Australia, the Northern Territory and the Australian Capital Territory	Western Australia, South Australia and the Northern Territory

Notes

1. Estimates of burden for diphtheria, rubella and tetanus were not calculated by Indigenous status.
2. Notifications data were not used in modelling Indigenous estimates for chickenpox, HPV, influenza, polio, rotavirus or shingles.

National Hospital Morbidity Database

The National Hospital Morbidity Database (NHMD) was used to estimate the number of cases of severe illness across a number of VPD included in the BVPD study. Identification of VPD hospitalisations for this study was based on the principal diagnosis only (using International Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification, or ICD-10-AM, codes) and averaged over 3 calendar years, centred on the relevant reference year. (See Table B3 for a list of the ICD-10-AM codes used for each disease.)

The NHMD is a compilation of episode-level records from admitted patient morbidity data collection systems in Australian hospitals.

The data are based on the National Minimum Data Set for admitted patient care (see http://meteor.aihw.gov.au/content/index.phtml/itemId/612171) and include demographic, administrative and length-of-stay data, as well as data on the diagnoses of the patients, the procedures they underwent in hospital and external causes of injury and poisoning. Data are a count of hospital separations and not patients. Patients who separated from hospital more than once in the year will be counted more than once in the data set. For the BVPD study, records indicating the patient had been transferred from another hospital were excluded, to minimise double-counting.

The scope of the NHMD is episodes of care for admitted patients in essentially all hospitals in Australia, including public and private acute and psychiatric hospitals, free-standing day hospital facilities, and alcohol and drug treatment centres. Hospitals operated by the Australian Defence Force, corrections authorities and in Australia's off-shore territories are not in scope (although some are included). The NHMD does not include episodes of non-admitted patient care provided in outpatient clinics or emergency departments.

Table B3: Disease list by ICD-10 codes used for hospitalisation and mortality analysis

Disease	ICD-10/ICD-10-AM codes
Chickenpox (varicella)	B01
Diphtheria	A36
Haemophilus influenzae type b (Hib)	G000
Hepatitis A	B15
Hepatitis B	B160, B161, B162, B169, B170
Human papillomavirus (HPV)	C53
Influenza	J09, J10, J11
Measles	B05
Meningococcal disease	A39
Mumps	B26
Pneumococcal disease	G001, A403, J13
Polio	A80, B91
Q fever	A78
Respiratory syncytial virus (RSV)	J121, J205, J210
Rotavirus	A080
Rubella	B06
Congenital rubella syndrome	P350
Shingles	B02
Tetanus	A33, A34, A35
Whooping cough	A37

The number and pattern of hospitalisations can be affected by differing admission practices—among the jurisdictions and from year to year—and differing levels and patterns of service delivery.

Records for newborn episodes that did not include qualified days (that is, the baby was never formally admitted to the hospital), and records for hospital boarders and posthumous organ procurement have been excluded as these activities are not considered to be admitted patient care.

Indigenous identification

Approximately 2% of hospital records each year have an Indigenous status of 'not stated'. This proportion, however, varies across the jurisdictions. (Note that for hospitals in Western Australia, records with an unknown status are reported as non-Indigenous.) The incompleteness of Indigenous identification means the number of hospital separations recorded as Indigenous is an underestimate of hospitalisations involving Aboriginal and Torres Strait Islander Australians.

The AIHW completed an assessment of the level of Indigenous under-identification in selected public hospitals in all states and territories in 2007–08. Results from this assessment indicated that New South Wales, Victoria, Queensland, Western Australia, South Australia and the Northern Territory had adequate Indigenous identification (20% or less overall under-identification of Indigenous patients) in their hospital separations data (AIHW 2010). The study estimated that 89% of Indigenous patients were correctly identified in Australian public hospital admission records in 2007–08.

In 2011–12, the AIHW completed a second study to reassess the level of under-identification in public hospitals data, and found that all jurisdictions had sufficient quality Indigenous identification for reporting from 2010–11 (AIHW 2013). The study estimated that 88% of Indigenous patients were correctly identified in Australian public hospital admission records in 2011–12.

In the BVPD study, Indigenous hospitalisation data were adjusted for Indigenous under-identification using adjustment factors derived from the AIHW audits of the quality of Indigenous identification in hospital records (AIHW 2010, 2013) (see tables B4 and B5).

Table B4: Adjustment factors for 2015 Indigenous hospitalisation estimates

State/territory	Remoteness category	Adjustment factor
New South Wales	Major cities	1.37
	Inner regional	1.09
	Outer regional	1.08
	Remote and Very remote	1.02
Victoria	Major cities	1.41
	Inner regional	1.06
	Outer regional	1.09
Queensland	Major cities	1.17
	Inner regional	1.12
	Outer regional	1.04
	Remote and Very remote	0.97
Western Australia	Major cities	0.99
	Inner regional	1.02
	Outer regional	1.00
	Remote	1.07
	Very remote	1.00
South Australia	Major cities	1.16
	Inner regional and Outer regional	1.03
	Remote and Very Remote	1.00
Tasmania	Inner regional	1.37
Australian Capital Territory	Major cities	1.69
Northern Territory	Outer regional	1.03
	Remote	0.99
	Very remote	1.00
Total		**1.09**

Source: AIHW 2013.

Table B5: Adjustment factors used for 2005 Indigenous hospitalisation estimates

Disaggregation	Adjustment factor
Major cities	1.25
Inner regional	1.11
Outer regional	1.06
Remote and Very remote	1.03
Total	1.12

Source: AIHW 2010.

Bettering the Evaluation and Care of Health

The Bettering the Evaluation and Care of Health (BEACH) survey was conducted annually from April 1998 to March 2016. The survey collected information about encounters with general practitioners (GPs), including GP and patient characteristics, patient reasons for the visit, problems managed and treatments provided. Information was collected from a random sample of approximately 1,000 GPs from across Australia each year, with each participating GP providing details of 100 consecutive patient encounters. Rates of events derived from the BEACH survey data can be extrapolated to estimate the number of occurrences at the national level using Medicare claims data for GP service items (Britt et al. 2016).

For this study, data were based on VPD recorded as 'problems managed' by GPs, scaled up to a national estimate.

Indigenous identification

Although the BEACH questionnaire contained an Indigenous identifier, it is unknown whether all GPs asked their patients this question. A sub-study of approximately 9,000 patients found that if a question on Indigenous status was asked within the context of a series of questions about origin and cultural background, 1.3% identified as Indigenous. This was twice the rate routinely recorded in BEACH, indicating that BEACH may underestimate the number of encounters with Indigenous Australians. BEACH data on encounters for Indigenous Australians have therefore not been used to directly estimate the incidence of VPD in Indigenous Australians in this study. Instead, indirect methods have been applied and are detailed in Appendix C for the relevant diseases.

National Mortality Database

The National Mortality Database (NMD) includes information on the factors that led to death, as well as other information about the deceased person, such as their age at death, place of death, country of birth and, where applicable, the circumstances of their death. These data are collected in Australia by the Registrars of Births, Deaths and Marriages in each state and territory. The data are then compiled nationally by the Australian Bureau of Statistics (ABS), which codes the data according to the ICD. See Table B3 for a list of the ICD-10 codes used for each disease.

For the BVPD study, data were extracted on deaths with VPD as the underlying cause of death. Unless otherwise specified, due to the generally small number of deaths for most diseases included in the BVPD study, case-fatality rates were based on an average of 10 years of mortality data, using the calendar years 1997–2006 for the 2005 reference year and 2007–2016 for the 2015 reference year.

Indigenous identification

Almost all deaths in Australia are registered. However, the Indigenous status of the deceased is not always recorded/reported and/or recorded correctly. The incompleteness of Indigenous identification means the number of deaths registered as Indigenous is an underestimate of deaths occurring in the Aboriginal and Torres Strait Islander population (ABS 2013).

The ABS's Census Data Enhancement Indigenous Mortality Study (2011–12) linked Census records with death registration records and produced mortality adjustment factors that can be used to adjust for Indigenous under-identification in Australian mortality data (ABS 2013). The BVPD study used the national age-specific mortality adjustment factors from the ABS report to adjust Indigenous deaths for under-identification in mortality data (see Table B6).

Table B6: Adjustment factors used for 2005/2015 Indigenous mortality estimates

Disaggregation	Adjustment factor
0–14 years	1.21
15–59 years	1.12
60 years and over	1.29

Source: ABS 2013.

Other data sources

A literature search using MeSH terms for diseases included in the BVPD study was conducted in PubMed (www.ncbi.nlm.nih.gov/pubmed). The search was further limited to studies conducted in humans and articles written in English.

Search results were reviewed by 2 members of the team, and relevant articles were identified, based on the title and abstract. Articles were then reviewed to identify and extract any relevant information on disease severity, complications, case-fatality rates, occurrence of long-term sequelae, and under-reporting. This information was used to inform calculation of the various model inputs, with data from Australian studies being given preference over data from other countries.

Reference populations

All Australian population-based rates for 2005 and 2015 were calculated using the Australian Estimated Resident population as at 30 June of the relevant year, as published in *Australian Demographic Statistics* (ABS 2017).

All Indigenous population-based rates for 2005 and 2015 were calculated using population estimates and projections based on the 2011 Census (ABS 2014).

The Australian 2001 standard population was used for all age-standardisation, as per the AIHW and ABS standards.

Appendix C: Disease models

This appendix details the specific methods used for each disease included in the BVPD study, and describes the main data sources used. For each disease, the relevant health states, sequelae, durations, disability weights, transition probabilities and case-fatality rates are presented. Unless otherwise specified, the same model, parameters and data sources were used to derive both the 2005 and 2015 estimates. The diseases are presented in alphabetical order, except for chickenpox and shingles, which are covered under 'varicella'.

Diphtheria

Description

Diphtheria is a highly contagious and potentially life-threatening disease caused by toxins produced by *Corynebacterium diphtheriae* or *Corynebacterium ulcerans* bacteria. Diphtheria usually affects a person's nose, throat and windpipe, but it can also infect their skin. Although the skin infection generally does not itself cause severe illness, it can spread to others and potentially cause the more severe respiratory form of the illness.

Acute infections

Diphtheria is a nationally notifiable disease in Australia, and these notifications are considered to be a good estimate of disease occurrence. Unadjusted notifications data sourced from the NNDSS were therefore used to estimate incidence rates.

During the period 2014–2016, cases of cutaneous diphtheria were not nationally notifiable. All notified diphtheria cases for the 2015 reference period were therefore assumed to be respiratory and assigned to the 'Infectious disease: acute episode, severe' health state, with a disability weight of 0.133, for a duration of 14 days.

For other recent time periods, cases of cutaneous diphtheria were assigned to the health state 'Infectious disease: acute episode, mild' for a duration of 14 days (Table C1).

Long-term sequelae

Despite literature that suggests that nerve paralysis and inflammation of the heart (myocarditis) may occur as a result of infection, these complications were not included in the model due to the small number of cases and to the lack of evidence to support estimating the probability of these complications occurring in Australia.

Case-fatality

The number of cases and deaths from diphtheria were too small to calculate reliable case-fatality rates using observed mortality data from the NMD. A case-fatality rate range of 5%–10% for respiratory cases was applied to all age groups, based on published estimates (Heymann 2015). Case-fatality for cutaneous cases was assumed to be zero.

Indigenous Australians

Only 2 cases of diphtheria among Indigenous Australians were notified over the period 2000–2016, and no deaths were registered. Due to the small number of diphtheria cases

occurring among Indigenous Australians, no estimate of the Indigenous burden of diphtheria was made for this study.

Table C1: Model inputs for diphtheria, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate (%)
Diphtheria, respiratory	Infectious disease: acute episode, severe	0.133	14 days	5–10 in all age groups
Diphtheria, cutaneous	Infectious disease: acute episode, mild	0.006	14 days	Zero

Haemophilus influenzae type b

Description

Hib disease is caused by bacteria commonly found in the nose and throat of some people, most of whom remain healthy. However, some people can develop acute illness, including invasive disease (that is, infection of parts of the body usually free of bacteria, such as the blood, cerebrospinal fluid or bone marrow). The most severe infections include the membranes around the brain and spinal cord (meningitis), part of the throat (epiglottitis) or the blood (septicaemia), but infection can also occur in other parts of the body, such as the lungs or skin. Hib is most dangerous in infants and young children.

Acute infections

Invasive forms of Hib are nationally notifiable in Australia. Due to the severity of this illness, notifications are considered to be a good estimate of the true number of cases of invasive disease in Australia. Unadjusted notifications data sourced from the NNDSS were therefore used to estimate incidence rates.

The acute phase of Hib disease (septicaemia and meningitis) were assigned to the 'Infectious disease: acute episode, severe' health state, with a disability weight of 0.133, for a duration of 28 days.

Long-term sequelae

Published literature was used to estimate the risk of developing a long-term disability following Hib meningitis. Long-term outcomes following meningitis may include hearing and vision loss, motor impairment, cognitive impairment, behavioural problems and seizures. Probabilities for each outcome were informed by meta-analyses by Edmond and others (2010) and Lucas and others (2016), modified using evidence from an Australian study by Grimwood and others (2000).

The risk of each long-term outcome was estimated by multiplying the proportion of Hib cases with meningitis by the proportion of cases developing each outcome. The proportion of Hib cases with a clinical category of meningitis was estimated using published reports of the *Haemophilus influenzae* type b Case Surveillance Scheme (Wang et al. 2008). The duration of disability was considered to be 'remaining lifetime' for each case (Table C2).

Case-fatality

The case-fatality rate used in each model was based on 10 years of observed mortality data from the NMD, using death with an underlying cause of death of *Haemophilus* meningitis (ICD-10 code G00.0). For 2015, an overall case-fatality rate of 0.5% was applied to all age

groups, as the number of cases and deaths from Hib meningitis were too small to calculate age-specific rates. For 2005, the overall case-fatality rate was 2.7%, which was distributed among the youngest and oldest age groups. This compares with the published historical case-fatality rate of 5.8% when using deaths reported to NNDSS between July 2000 and December 2005 (Wang et al. 2008).

Indigenous Australians

For both the periods 2004–2006 and 2014–2016, all jurisdictions had good levels of Indigenous completeness for Hib notifications. Incidence rates based on NNDSS data were used as inputs to the model. The same transition probabilities for the long-term sequelae were used as for the total population, as there was insufficient evidence to calculate Indigenous-specific probabilities.

Fewer than 3 deaths of Indigenous Australians from Hib were recorded in the NMD over the 20 years from 1997 to 2016. This was not considered adequate to inform an Indigenous-specific case-fatality rate estimate, so national case-fatality rates were used.

Table C2: Model inputs for Hib, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Acute invasive Hib (septicaemia or meningitis)	Infectious disease: acute episode, severe	0.133	28 days	0.5 across all age groups
Behavioural problems	Attention deficit hyperactivity disorder	0.045	Remaining lifetime	5.0
Clinical impairments	Generic uncomplicated disease: worry and daily medication	0.049	Remaining lifetime	0.4
Cognitive difficulties	Intellectual disability, borderline to moderate (range)	0.044–0.188	Remaining lifetime	0.3–0.8
Hearing loss	Hearing loss, moderate to severe (range)	0.027–0.158	Remaining lifetime	0.6
Motor deficit	Motor impairment, moderate to severe (range)	0.061–0.402	Remaining lifetime	0.8
Seizure disorder	Generic uncomplicated disease: worry and daily medication	0.049	Remaining lifetime	0.4–0.8
Visual disturbance	Distance vision, moderate to severe impairment (range)	0.031–0.184	Remaining lifetime	2.0

Hepatitis A

Description

Infection with the hepatitis A virus can cause an illness that affects the liver. Hepatitis A is transmitted through contaminated food or water, or through direct contact (including oral/anal sexual contact) with an infectious person.

Although symptoms are often mild or absent in young children, the infection can still be spread. In older children and adults, symptoms include extreme tiredness, fever, decreased appetite, nausea, vomiting, clay-coloured bowel movements and yellowing of the eyes and skin (jaundice). Symptoms may last for several weeks but recovery can take a long time. Both duration and severity are age related, with young children tending to have milder symptoms for a shorter period than older children and adults.

Acute infections

Hepatitis A is nationally notifiable disease in Australia—however, notifications are considered to underestimate disease occurrence. An adjustment factor of 3.93 (assuming around 4 cases not notified for every notified case) was used, based on an Australian study (Hall et al. 2008).

Hepatitis A cases among children aged under 5 were assigned to the 'Infectious disease: acute episode, moderate' health state, with a disability weight of 0.051, for a duration of 10–14 days.

Hepatitis A cases among people aged 5 and over were assigned uniformly across the health states 'Infectious disease: acute episode, moderate' and 'Infectious disease: acute episode, severe', with a disability weight of 0.051–0.133, for a duration of 14–28 days (Table C3).

Long-term sequelae

Although in some cases symptoms may recur for several months, there are generally no long-term complications of hepatitis A infection.

Case-fatality

A case-fatality rate of 0.1% was applied overall, based on the lower range of published estimates (Heymann 2015). This probability was redistributed by age group, based on 10 years of observed mortality data from the NMD, using death with an underlying cause of death of Hepatitis A (ICD-10 code B15), which suggested that most deaths in Australia occur among older people.

Indigenous Australians

All jurisdictions had good levels of Indigenous completeness for hepatitis A notifications over the period 2014–2016.

For the period 2004–2006, all jurisdictions except the Australian Capital Territory had acceptable Indigenous completeness rates; however, this jurisdiction accounted for less than 1% of all hepatitis A notifications in this period. Incidence rates based on NNDSS data were used as inputs to the model, with an adjustment factor of 3.93 as described above.

Fewer than 3 deaths of Indigenous Australians from hepatitis A were recorded in the NMD over the 10 years from 2007 to 2016. This was not considered adequate to inform an Indigenous-specific case fatality rate estimate, so national case-fatality rates were used.

Table C3: Model inputs for hepatitis A, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate (%)
Acute hepatitis A, children aged under 5	Infectious disease: acute episode, moderate	0.051	10–14 days	0.1
Acute hepatitis A, people aged 5 and over	Infectious disease: acute episode, moderate to severe	0.051–0.133	14–28 days	0.1 over all age groups, skewed toward older people

Hepatitis B

Description

Hepatitis B is a potentially life-threatening liver infection caused by the hepatitis B virus. It is transmitted by contact with blood or body fluids from an infected person. Hepatitis B can also be transmitted from an infected mother to her baby at birth. This is particularly serious, as 90% of babies infected at birth will become chronically infected with hepatitis B, whereas most people infected as older children or adults will spontaneously clear the infection.

Many people, especially young children, do not have any symptoms during the acute infection phase. Others have symptoms that last from several weeks to up to 6 months, including yellowing of the skin and eyes (jaundice), dark urine, extreme tiredness, nausea, vomiting and stomach pain.

While most older children and adults get rid of the virus, up to 10% develop chronic hepatitis B, often having no symptoms until many years after the acute infection. This puts them at high risk of death from liver cirrhosis (permanent scarring, causing loss of liver function) or liver cancer. The risk of progressing to chronic hepatitis B decreases with age.

Acute infections

Although hepatitis B is a nationally notifiable disease in Australia, notifications are not considered to be a good estimate of acute disease occurrence due to the high proportion of asymptomatic cases. In the absence of reliable estimates of the number of acute infections, it was assumed that notifications of ‘newly diagnosed’ hepatitis B represented symptomatic acute cases.

The likelihood of developing symptoms is age dependent, and estimates of the proportion of symptomatic infections by age, reported by Shepard and others (2006), and advice from the Doherty Institute were used to estimate total infections as follows:

- infants (under 1 year): 5% symptomatic
- 1–4 years: 10% symptomatic
- 5–14 years: 33% symptomatic
- 15 years and over: 50% symptomatic.

Symptomatic acute cases of hepatitis B were assigned a health state range of 'Infectious disease: acute episode, moderate' to 'Infectious disease: acute episode, severe', with a disability weight of 0.051–0.133, for a duration ranging from 4–26 weeks. Asymptomatic cases were assumed to impart no health loss in the acute phase, but could move through the model to develop long-term sequelae (Table C4).

Long-term sequelae

Estimates of the proportion of cases (both symptomatic and asymptomatic) that progress to chronic hepatitis B infection were included in the model, based on age at initial infection as follows:

- infants (under 1 year): 90%
- 1–4 years: 10%–30%
- 5–14 years: 20%
- 15–44 years: 6%
- 45 years and over: 4%.

Sequelae of chronic hepatitis include liver cancer and liver cirrhosis. Transition probabilities of 0.01%–5% for liver cancer and 0.03%–4% for compensated cirrhosis were applied to chronic cases. Compensated cirrhosis may also progress to liver cancer (transition rate 0.35%–5%) or decompensated cirrhosis (transition rate 1%–3%).

Case-fatality

Acute infection can be complicated by fulminant liver failure, which can be fatal. A transition rate of 0.5%–1.0% to liver failure was applied, followed by a 20%–33% case fatality rate.

A case-fatality rate of 20% was applied, following decompensated cirrhosis.

In Australia, the probability of being alive 5 years after a diagnosis of liver cancer when compared with the general population (a measure called 5-year relative survival) is 17.3% (AIHW 2017). A case-fatality rate of 0.05%–14% was applied, based on the age distribution of liver cancer deaths.

Indigenous Australians

Over the 3-year period 2014–2016, all jurisdictions had good levels of Indigenous completeness for newly acquired hepatitis B notifications. Incidence rates were estimated by assuming notified cases represented symptomatic infections as described earlier.

For the period 2004–2006, all jurisdictions except Tasmania and the Australian Capital Territory had good levels of Indigenous completeness. The ratio of Indigenous to all notifications for the other 6 jurisdictions was applied to the total Australian notifications to estimate the expected number of Indigenous notifications nationally for newly acquired hepatitis B during this period.

The same disability weights, durations, transition probabilities and case-fatality rates as earlier were used for the Indigenous estimates.

Table C4: Model inputs for hepatitis B, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Acute hepatitis B infection	Infectious disease: acute episode, moderate to severe (symptomatic infections only)	0.051–0.133	4–26 weeks	Transition to chronic: Infants (under 1 year): 90 1–4 years: 10–30 5–14 years: 20 15–44 years: 6 45 years and over: 4
Chronic hepatitis B infection	Generic uncomplicated disease: anxiety about diagnosis	0.12	Remaining lifetime or until transition to sequelae	Liver cancer: 0.01–5.00 Compensated cirrhosis: 0.03–4.00
Compensated cirrhosis of the liver	Generic uncomplicated disease: worry and daily medication	0.049	Remaining lifetime or until transition to sequelae	Liver cancer: 0.35–5.00 Decompensated cirrhosis: 1–3
Decompensated cirrhosis of the liver	Decompensated cirrhosis and chronic liver disease	0.178	Remaining lifetime	Case-fatality: 20
Liver cancer	Cancer, diagnosis and primary therapy	0.288	1 year	Case-fatality: 22.9–91.4 depending on age

Human papillomavirus

Description

HPV is a common sexually transmissible virus that affects both men and women. Many HPV infections are asymptomatic and cleared by the immune system. The virus causes a range of conditions, from warts on the genitals and surrounding skin, to serious conditions such as cancers of the cervix, vagina, vulva, penis and anus.

Indigenous women are more likely to be diagnosed with and die from cervical cancer than non-Indigenous women (AIHW 2018a).

Symptomatic infections

Two separate models were developed for HPV: the first estimated the burden of symptomatic HPV infection (genital warts), and the second, the burden of high-risk HPV infection with the potential to progress to cancer.

The incidence of genital warts was estimated using BEACH GP survey data. This estimate was adjusted for the proportion of respondents who had sought treatment for genital warts in sexual health clinics, based on studies conducted by Grulich and others (2003, 2014).

Genital warts were assigned to the ‘Infectious disease: acute episode, mild’ health state, with a disability weight of 0.006, for a duration of 28 days.

Acute infections

Prevalence of high-risk HPV types 16 and 18 was estimated using studies conducted by Brotherton and others (2015) for the pre-vaccine period and MacGregor and others (2018) following the introduction of the HPV vaccine. A study by Garland and others (2011) found no difference in the prevalence of HPV types 16 and 18 by Indigenous status.

Incident infections were estimated by dividing prevalence by duration. The average (mean) duration of HPV type 16 infection was 11.9 months (Trottier et al. 2008).

Long-term sequelae

The transitional probability of HPV infections progressing to a high-grade abnormality (HGA; a precancerous lesion) and cervical cancer was based on observed data from the National Cervical Screening Program (AIHW 2018b).

As well as cervical cancer, persistent infection with HPV can result in other types of cancer, such as cancers of the vagina, vulva, penis and anus. However, there was insufficient information available to estimate the probability of these outcomes.

Case-fatality

In Australia, the probability of a woman's being alive 10 years after a diagnosis of cervical cancer when compared with the general population (a measure called 10-year relative survival rate) is 68.7% (AIHW 2019a). A case-fatality rate between 12% and 72% was applied by taking the complement of age-specific cervical cancer survival rates (Table C5).

Indigenous Australians

The same disability weights and durations were used to calculate Indigenous estimates; however, transition probabilities for progression to HGA and cervical cancer, and cervical cancer case-fatality rates, were adjusted to reflect the increased likelihood of being diagnosed with cervical cancer and worse survival outcomes for Indigenous women diagnosed with cervical cancer (AIHW 2018a).

Table C5: Model inputs for HPV, 2015

Disease	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Genital warts	Infectious disease, acute episode, mild	0.006	28 days	. .
HPV acute infection (asymptomatic)	Nil	. .	. .	Transition to HGA: 0.10
High-grade abnormality (HGA)	Generic uncomplicated disease: anxiety about diagnosis	0.012	1 year	Transition to cervical cancer: 0.05
Cervical cancer	Cancer, diagnosis and primary therapy	0.288	1 year	Case-fatality: 12.19–72.20 depending on age

Influenza

Description

Influenza is a contagious respiratory disease that causes seasonal epidemics in Australia. It can be passed from an infected person when they cough or sneeze, or through close contact. Influenza symptoms include fever and chills, cough, tiredness, sore throat and joint and muscle pain. Nausea, vomiting and diarrhoea are possible, especially in children. In severe infections, symptoms get quickly worse and complications can arise.

Acute infections

Although laboratory-diagnosed influenza is notifiable in Australia, notification rates are affected by a range of factors, including the amount of testing undertaken, the types of tests used and the propensity of unwell people to seek medical attention. A range of approaches are used to monitor influenza activity in Australia, as notifications data alone are likely to underestimate the true number of cases. For this study, we used a combination of primary care survey data from BEACH, notifications data from the NNDSS and hospital admitted patient data from the NHMD to estimate the incidence of 'medically-attended influenza'. As BEACH data are based on GP diagnosis of symptoms, rather than laboratory testing, this may result in an over-estimate of the number of less severe cases. No adjustment was made to estimate the number of cases not seeking medical attention.

Hospitalised cases were assigned to the severe health state, with a disability weight of 0.133, for a duration of 14 days.

The remaining cases were assigned to the 'Infectious disease: acute episode, moderate' health state, with a disability weight of 0.051, for a duration of 10–14 days (Table C6).

Long-term sequelae

No long-term sequelae from influenza were included in the model. Long-term outcomes following influenza are rare in developed countries and their contribution to disease burden is considered to be negligible.

Case-fatality

Influenza is fatal in about 0.1% of all cases; however, the case-fatality rate is considerably greater among hospitalised cases. Age-specific case-fatality rates by age group for hospitalised cases were therefore calculated based on 3 years of hospitalisation data with a principal diagnosis of influenza (ICD-10-AM codes J09–J11). Age-specific case-fatality rates for non-hospitalised cases were calculated using 3 years of observed mortality data from the NMD, using an underlying cause of death of influenza (ICD-10 codes J09–J11) and subtracting the number of in-hospital deaths from the total (Table C7).

Indigenous Australians

The number of Indigenous Australians in the BEACH sample is too small to give a reliable estimate of GP encounters for this population. The ratio of Indigenous:total hospitalisations (at each age/sex level) was applied to the estimated total incidence data to estimate the number of medically attended influenza cases among Indigenous Australians. The same severity distribution, durations and disability weights as described earlier were applied.

The number of Indigenous deaths from influenza was too small to calculate reliable case-fatality rates. The hospital and non-hospital case-fatality rates described earlier were therefore applied.

Table C6: Model inputs for influenza, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability
Influenza, medically attended cases (not hospitalised)	Infectious disease: acute episode, moderate	0.051	10–14 days	See Table C7
Influenza, hospitalised cases	Infectious disease: acute episode, severe	0.133	14 days	See Table C7

Table C7: Age-specific case-fatality rates for influenza, hospitalised and non-hospitalised cases, 2015 (%)

Age group (years)	Hospitalised cases	Non-hospitalised cases
Infants (<1)	0.0000	0.0002
1–4	0.0004	0.0001
5–9	0.0009	<0.0001
10–14	0.0000	<0.0001
15–19	0.0024	0.0000
20–24	0.0000	<0.0001
25–29	0.0019	<0.0001
30–34	0.0016	<0.0001
35–39	0.0017	0.0001
40–44	0.0025	<0.0001
45–49	0.0026	0.0002
50–54	0.0096	0.0001
55–59	0.0089	0.0003
60–64	0.0129	0.0005
65–69	0.0154	0.0013
70–74	0.0074	0.0013
75–79	0.0197	0.0062
80–84	0.0299	0.0092
85 and over	0.0421	0.0534

Measles

Description

Measles is a highly infectious viral illness. Symptoms usually start with fever, runny nose, cough, red eyes and a sore throat. A few days later, a rash appears, first on the face or neck and then spreading over the body; it lasts up to a week.

Serious complications of measles include infections like pneumonia (lung infection) and encephalitis (brain inflammation). Other complications may include otitis media (middle ear infection), croup and seizures. Otitis media occurs in up to 1 in 10 cases, while encephalitis develops in around 1 in 1,000 cases.

Post-infectious encephalomyelitis (inflammation of the brain and spinal cord, which damages the protective covering of the nerves) may occur following measles infection, but is rare.

Subacute sclerosing panencephalitis is a progressive neurological disorder that is a rare complication of measles. Its onset may not present for several years after the measles infection (Hanna et al. 1998; Huppatz et al. 2009).

Acute infections

Measles is a nationally notifiable disease in Australia. Due to the severity of illness and high awareness, notifications are considered to be a good estimate of the true number of cases in Australia.

Complications were assumed to occur in about 40% of cases, based on the proportion of hospitalisations compared with notified cases over several years.

Uncomplicated measles cases were assigned to the ‘Infectious disease: acute episode, moderate’ health state, with a disability weight of 0.051, for a duration of 14 days. Cases with complications were assigned to the ‘Infectious disease: acute episode, severe’ health state, with a disability weight of 0.133, also for 14 days (Table C8).

Long-term sequelae

Permanent disability may occur following measles complicated by otitis media or encephalitis, or as a result of post-infectious encephalomyelitis. Hearing loss is estimated to occur in around 1 in 10,000 cases with otitis media, and brain damage in 1 in 4 cases with encephalitis.

Due to the rarity of long-term outcomes relating to otitis media, post-infectious encephalomyelitis and subactute sclerosing panencephalitis, combined with the low number of measles cases in Australia, these sequelae were not included in the model. Disability due to measles encephalitis was included at a rate of 0.025% of all measles cases.

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using death with an underlying cause of death of measles (ICD-10 code B05). A case-fatality rate of 0.15% was applied to all age groups.

Indigenous Australians

Over the periods 2004–2006 and 2014–2016, all states and territories had adequate completeness of Indigenous identification in notifications for measles. NNDSS data were

therefore used to estimate the incidence of measles among the Indigenous population. The same disability weights, severity distribution and durations described earlier were applied. Robust Indigenous-specific case-fatality rates could not be calculated due to the small number of cases and deaths; the case-fatality rates calculated for the total population were therefore applied.

Table C8: Model inputs for measles, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Acute measles infection, uncomplicated	Infectious disease: acute episode, moderate	0.051	14 days	0.150 in all age groups
Acute measles infection with complications	Infectious disease: acute episode, severe	0.133	14 days	0.150 in all age groups
Permanent disability due to encephalitis	Motor plus cognitive impairments, mild to severe (range)	0.031–0.542	Remaining lifetime	0.025 in all age groups

Meningococcal disease (invasive)

Description

Meningococcal disease is a rare bacterial disease caused by *Neisseria meningitidis*. This bacterium is found in the nose and throat of some people, most of whom remain healthy. However, some can develop acute illness, including invasive disease (that is, infection of parts of the body usually free of bacteria, such as the blood, cerebrospinal fluid or bone marrow). The most common invasive forms of meningococcal disease are meningitis (inflammation of the lining of the brain and spinal cord) and septicaemia (blood poisoning).

Meningococcal disease is contagious, but spread usually only happens with close contact for a long time.

Acute infections

IMD is a nationally notifiable disease in Australia. Due to the severity of illness, notifications are considered to be a good estimate of the true number of cases of invasive disease in Australia. Unadjusted NNDSS data were therefore used to estimate incidence.

The acute phases of IMD (that is, septicaemia and meningitis) were assigned to the ‘Infectious disease: acute episode, severe’ health state, with a disability weight of 0.133, for a duration of 28 days.

Long-term sequelae

Published literature was used to estimate the risk of developing a long-term disability following meningitis. Long-term outcomes following meningococcal meningitis may include hearing and vision loss, motor impairment, cognitive impairment, behavioural problems and seizures. Probabilities for each outcome were informed by meta-analyses (Edmond et al. 2010; Lucas et al. 2016), and modified using evidence from an Australian study (Grimwood et al. 2000).

The risk of each long-term outcome was estimated by multiplying the proportion of cases with meningitis by the proportion of cases developing each outcome (Table C9). The risk was redistributed by age group, based on the incidence of meningococcal meningitis. The duration of disability was considered to be the remaining lifetime for each case. The risk of multiple impairments was not estimated separately, instead being split across the individual outcomes.

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using deaths with an underlying cause of death of meningococcal infection (ICD-10 code A39). A case fatality rate of 4.9% was applied to children aged under 5, 3.5% among those aged 5–64 and 9.9% for those aged 65 and over.

Indigenous Australians

Over the periods 2004–2006 and 2014–2016, all states and territories had adequate completeness of Indigenous identification in notifications for IMD. NNDSS data were therefore used to estimate the incidence of IMD among the Indigenous population. The same disability weights, severity distribution and durations described earlier were applied.

Table C9: Model inputs for meningococcal disease, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Acute invasive meningococcal disease (septicaemia or meningitis)	Infectious disease: acute episode, severe	0.133	28 days	4.9: under 5 years 3.5: ages 5–64 9.9: ages 65+
Behavioural problems	Attention deficit hyperactivity disorder	0.045	Remaining lifetime	4.8
Clinical impairments	Generic uncomplicated disease: worry and daily medication	0.049	Remaining lifetime	0.4
Cognitive difficulties	Intellectual disability, borderline to moderate (range)	0.043–0.088	Remaining lifetime	0.3–0.8
Hearing loss	Hearing loss, moderate to severe (range)	0.027–0.158	Remaining lifetime	0.6
Motor deficit	Motor impairment, moderate to severe (range)	0.061–0.402	Remaining lifetime	0.8
Seizure disorder	Generic uncomplicated disease: worry and daily medication	0.049	Remaining lifetime	0.4–0.8
Visual disturbance	Distance vision, moderate to severe impairment (range)	0.031–0.184	Remaining lifetime	2.0

Mumps

Description

Mumps is a contagious infection of the salivary glands, caused by the mumps virus. The virus spreads when an infected person coughs or sneezes, or through close contact. One-third of people infected with mumps experience no symptoms, but may still infect other people. The main symptoms of mumps are headache, aching muscles, fever and swelling under the jaw.

Although mumps is usually a mild disease, occasionally it can cause other complications, including inflammation of the testicles (orchitis), ovaries, pancreas, liver, heart and brain; and hearing loss. Meningitis following mumps is viral and generally benign with no long-term neurological complications, unlike the bacterial meningitis that may complicate diseases such as Hib. Death and long-term complications are rare.

Acute infections

Mumps is a nationally notifiable disease in Australia. Although it is likely that there are undiagnosed cases, no evidence to suggest an appropriate adjustment factor to account for these could be obtained. A combination of unadjusted NNDSS data (for people aged 0–79) and hospital records (for people aged 80 and over) was used to estimate incidence, as there were no notifications of mumps among the older age groups.

Non-hospitalised mumps cases were assigned to the ‘Infectious disease: acute episode, moderate’ health state, with a disability weight of 0.051, for a duration of 7 days.

Hospitalised mumps cases were assigned to the ‘Infectious disease: acute episode, severe’ health state, with a disability weight of 0.133, for a duration of 10 days (Table C10).

Long-term sequelae

Long-term outcomes following mumps include hearing loss (believed to occur in around 1 in 20,000 cases), subfertility and infertility (rare). Due to the rarity of these outcomes, combined with the low incidence of mumps in Australia, no long-term sequelae were included in the model.

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using death with an underlying cause of death of mumps (ICD-10 code B26). All deaths occurred in people aged 80 and over. A case-fatality rate of 0.1% was applied in 2015 and 0.2% in 2005, redistributed by age to fall among the oldest 2 age groups.

Indigenous Australians

Over the period 2014–2016, all states and territories had adequate completeness of Indigenous identification in notifications for mumps. NNDSS data were therefore used to estimate the incidence of mumps among the Indigenous population for 2015.

For the period 2004–2006, not all jurisdictions had adequate completeness of Indigenous status in mumps notifications. The Indigenous proportion of mumps notifications for those jurisdictions with adequate completeness was therefore applied to all jurisdictions to estimate the total number of Indigenous cases.

The same disability weights, severity distribution and durations described earlier were applied for both time periods.

Table C10: Model inputs for mumps, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality (%)
Acute mumps infection, non-hospitalised	Infectious disease: acute episode, moderate	0.051	7 days	0.107 overall, redistributed to occur in ages 80+
Acute mumps infection, hospitalised	Infectious disease: acute episode, severe	0.133	10 days	0.107 overall, redistributed to occur in ages 80+

Pneumococcal disease (invasive)

Description

Pneumococcal disease is caused by *Streptococcus pneumoniae* bacteria (also known as pneumococcus). These bacteria are commonly found in the nose and throat of some people, most of whom remain healthy.

Pneumococcus bacteria can cause infections of the inner ear, sinus, lungs (pneumonia) and elsewhere. The most severe infections occur in places usually free of bacteria (for example, the bloodstream or membranes around the brain) and are known as invasive pneumococcal disease (IPD).

Acute infections

IPD is a notifiable disease in Australia. Due to the severity of illness, notifications are considered to be a good estimate of the true number of cases of invasive disease in Australia. Unadjusted NNDSS data were therefore used to estimate incidence.

Long-term sequelae

As described previously for Hib and meningococcal disease, published literature was used to estimate the risk of developing a long-term disability following meningitis (including hearing and vision loss, motor impairment, cognitive impairment, behavioural problems and seizures), with probabilities of various outcomes sourced from Australian studies (Davis & McIntyre 1995; Grimwood et al. 2000; King & Richmond 2004) and informed by various meta-analyses (Edmond et al. 2010; Jit 2010; Lucas et al. 2016). The risk of multiple impairments was not estimated separately, instead being split across the individual outcomes.

The risk of each long-term outcome was estimated by multiplying the proportion of cases with meningitis by the proportion of cases developing each outcome (Table C11). The risk was redistributed by age group, based on the incidence of pneumococcal meningitis. The duration of disability was considered to be ‘remaining lifetime’ for each case.

Case-fatality

Two data sources are available to assess mortality due to IPD in Australia: the NMD and the NNDSS enhanced pneumococcal surveillance data. Enhanced follow-up of IPD cases is undertaken for all cases in Queensland (except for 2 public health units, who follow up those aged under 5 years only), Western Australia, South Australia, Tasmania Australian Capital Territory and the Northern Territory. In New South Wales and Victoria, enhanced surveillance is undertaken for patients aged under 5, and 50 and over. Information on deaths occurring within 2 weeks of diagnosis is collected and submitted to the NNDSS.

Comparison of data from the 2 sources suggested that using the NMD data would substantially underestimate the number of IPD-associated deaths occurring in Australia. Case-fatality rates were therefore estimated, using 10 years of enhanced surveillance data from the NNDSS (Table C12).

Indigenous Australians

Over the periods 2004–2006 and 2014–2016, all states and territories had adequate completeness of Indigenous identification in notifications for IPD. NNDSS data were therefore used to estimate the incidence of IPD among the Indigenous population. As there are fewer than 10 IPD deaths among Indigenous Australians each year, it was not possible to calculate robust age-specific case-fatality rates. Therefore, age-specific case-fatality rates calculated for the total population were applied in the Indigenous models.

The same disability weights, severity distribution and durations described earlier were applied for both time periods. Transition probabilities for long-term sequelae were recalculated based on the proportion of meningitis cases occurring in Indigenous Australians.

Table C11: Model inputs for pneumococcal disease, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Acute invasive pneumococcal disease	Infectious disease: acute episode, severe	0.133	14–28 days	As per Table C12
Behavioural problems	Attention deficit hyperactivity disorder	0.045	Remaining lifetime	0.4
Clinical impairments	Generic uncomplicated disease: worry and daily medication	0.094–0.231	Remaining lifetime	0.4
Cognitive difficulties	Intellectual disability, borderline to moderate (range)	0.011–0.100	Remaining lifetime	1.4
Hearing loss	Hearing loss, mild to severe (range)	0.008–0.204	Remaining lifetime	1.6
Motor deficit	Motor impairment, moderate to severe (range)	0.061–0.402	Remaining lifetime	1.2
Seizure disorder	Generic uncomplicated disease: worry and daily medication	0.049	Remaining lifetime	1.2
Visual disturbance	Distance vision, moderate to severe impairment (range)	0.017–0.187	Remaining lifetime	0.4

Table C12: Age-specific case-fatality rates for pneumococcal disease, 2015 (%)

Age group (years)	Case-fatality rate
Infants (<1)	4.8
1–4	2.0
5–9	2.0
10–14	2.0
15–19	2.0
20–24	2.0
25–29	2.0
30–34	2.0
35–39	2.0
40–44	6.6
45–49	6.6
50–54	6.6
55–59	6.6
60–64	6.6
65–69	9.4
70–74	11.5
75–79	13.7
80–84	15.5
85 and over	20.4

Polio

Description

Polio (poliomyelitis) is a highly contagious viral infection caused by the poliovirus. Polio is spread mainly through contact with infected faeces, leading to gastrointestinal (stomach and gut) infection. Good sanitation and hand hygiene are important in limiting the spread of polio.

Infection involves the gastrointestinal tract and most people do not experience symptoms. Of infected people, around 10% have mild fever, headache, tiredness, nausea and vomiting. In another 3% of infected people, the virus moves to the nervous system; two-thirds of these develop severe muscle pain and one-third develop severe muscle weakness (paralytic polio). Up to 3 in 10 patients with paralytic polio die.

The last case of polio acquired in Australia was in 1972. Since then, 1 case has been detected in a person who acquired their infection overseas. This was in 2007.

As there were no incident cases of polio in Australia in either of the 2 time periods under study (2004–2006 and 2014–2016), the burden of polio under the incidence-based method is zero. Therefore, no model was developed for this disease.

Rotavirus

Description

Rotavirus is a common cause of severe gastroenteritis among infants and young children, but may affect people of any age. It is believed that nearly all children have been exposed to the virus by the time they turn 3.

The main symptom of rotavirus is watery diarrhoea, lasting up to 7 days. Fever, stomach pain and vomiting may also occur. Infants can become severely dehydrated, resulting in hospitalisation and occasionally death. Older adults can also experience severe symptoms.

Acute infections

Rotavirus has only recently become nationally notifiable. However, in many cases, people do not seek medical attention and, for those who do, a formal laboratory test to confirm the diagnosis is often not undertaken. Notifications data are therefore not considered a good estimate of disease occurrence.

Estimates of the 2010 incidence of rotavirus were sourced from a study on the incidence of gastrointestinal infectious diseases (including rotavirus) in Australia (Kirk et al. 2014). The 2015 incidence of rotavirus was then estimated by applying the proportional change in overall notification rates between 2010 and 2015 (using NNDSS data from 6 jurisdictions that reported over that period) to the 2010 estimate of rotavirus sourced from Kirk and others (2014). The total number of 2015 cases estimated using this process was then distributed by age and sex, based on the proportions in the NNDSS data.

The overall 2005 incidence of rotavirus was sourced from a study by Hall and others (2005), which estimated the incidence of rotavirus in a typical pre-vaccine year in Australia. This is the same method as used for the 2003 rotavirus estimates in the ABDS 2011 and 2015.

For both the 2005 and 2015 estimates, admitted patient data from the NHMD on hospitalisations with a principal diagnosis of rotavirus were used to represent severe illness, and all hospitalised cases were assumed to be notified. The difference between the number of notified cases and hospitalised cases were assumed to represent moderate illness. The remainder of the estimated total were assumed to be mild. This is the same method used to determine the severity split for rotavirus as in the ABDS 2015. As the notifications data do not include any information about the severity of illness, this method may overestimate the number of ‘moderate’ cases.

Hospitalised cases were assigned the health state ‘diarrhoea, severe’, with a disability weight of 0.247, for a duration of 7 days. Notified (but non-hospitalised) cases were assigned the health state ‘diarrhoea, moderate’, with a disability weight of 0.188, for a duration of 7 days. All other cases were assigned the health state of ‘diarrhoea, mild’ with a disability weight of 0.074, for a duration of 5 days (Table C13).

Long-term sequelae

No long-term outcomes of rotavirus infection were included in the model.

Case-fatality

Death due to rotavirus is rare in Australia and results from severe dehydration. In the 10 years from 2007 to 2016, only 5 deaths with an underlying cause of death of rotavirus

were recorded, all among people aged 80 and over. Case-fatality rates of 0.01% and 0.026% were applied to those aged 80–84 and 85 and over, respectively.

In the 10 years from 1997 to 2006, 11 deaths from rotavirus were recorded, occurring among both children aged under 5 and among people aged 70 and over. A case-fatality rate of 0.01% was applied to those aged 0–4 and 85 and over, and 0.0001% to those aged 70–84.

Indigenous Australians

The study by Kirk and others (2014) did not estimate rotavirus incidence among the Indigenous population. The ratio of Indigenous:total hospitalisations (at each age/sex level) was therefore applied to the national level data to estimate the total number of cases and the expected number of notifications among Indigenous Australians. Severity was then assigned as described earlier.

The same disability weights and durations described earlier were applied for both time periods. Due to the very small number of deaths from rotavirus, the same case-fatality rates calculated for the total population were applied.

Table C13: Model inputs for rotavirus, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality (%)
Rotavirus infection, acute (other cases)	Diarrhoea, mild	0.074	5 days	Zero in ages 0–79 0.0015 in ages 80+
Rotavirus infection, notified cases (non-hospitalised)	Diarrhoea, moderate	0.188	7 days	Zero in ages 0–79 0.0015 in ages 80+
Rotavirus infection, hospitalised cases	Diarrhoea, severe	0.247	7 days	Zero in ages 0–79 0.0015 in ages 80+

Rubella and Congenital Rubella Syndrome

Description

Rubella (also known as German measles) is a viral disease. For most people, a rubella infection causes mild illness with fever, a rash and swollen lymph glands.

If a woman is infected with rubella in the first trimester of her pregnancy, there is a risk of miscarriage or of the unborn baby developing congenital rubella syndrome (CRS). Problems associated with CRS include lifelong hearing and vision loss, heart defects and intellectual disabilities, as well as an increased risk of diabetes and thyroid disorders later in life.

Acute infections

Rubella and CRS are both notifiable diseases in Australia. Notifications are considered to have good coverage, so information from the NNDSS was used to estimate the average annual number of cases.

Acute rubella infections were assumed to be mild and assigned the ‘Infectious disease, acute episode, mild’ health state, with a disability weight of 0.006, for a duration of 7 days.

Acute infections occurring before birth were not considered to impose a measurable burden on the unborn baby, so no disability weight was applied to these.

Long-term sequelae

Despite a number of permanent disabilities resulting from CRS, there is now, on average, less than 1 incident case of CRS in Australia each year, and data on the occurrence of various complications are limited. The transition probabilities derived for the BCoDE study were therefore used to estimate the burden of CRS in this study (Table C14).

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using death with an underlying cause of death of rubella (ICD-10 code B06). A case-fatality rate of 0.56% following acute (non-fetal) infection was applied across all age groups. A fatality rate of 10% following fetal infections was applied, based on the rate used in the BCoDE study.

Indigenous Australians

Only 2 cases of rubella and no cases of CRS among Indigenous Australians were notified during the periods 2004–2006 and 2014–2016, with good completeness of Indigenous identification in most jurisdictions. Due to the small number of cases, no estimate of rubella burden among Indigenous Australians was made in this study.

Table C14: Model inputs for rubella and CRS, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability
Rubella (non-fetal)				
Acute rubella infection (non-fetal)	Infectious disease: acute episode, mild	0.006	7 days	0.56% in all age groups
Congenital rubella syndrome (CRS)				
Acute rubella infection (fetal)	Nil	0	N/A	10% of CRS cases
Hearing impairment	Hearing loss, mild to severe (range)	0.008–0.103	Remaining lifetime	60% of CRS cases
Congenital heart defects	Heart failure, mild to severe (range)	0.052–0.173	Remaining lifetime	45% of CRS cases
Microcephaly	Intellectual disability, borderline to severe (range)	0.011–0.421	Remaining lifetime	27% of CRS cases
Cataracts	Vision loss, mild to severe (range)	0.004–0.171	Remaining lifetime	16%–25% of CRS cases
Cognitive difficulties	Intellectual disability, borderline to severe (range)	0.011–0.421	Remaining lifetime	13%–25% of CRS cases
Retinopathy	Vision loss, mild to severe (range)	0.004–0.171	Remaining lifetime	5% of CRS cases
Diabetes	Generic uncomplicated disease: worry and daily medication	0.07	Remaining lifetime	20%–40% of CRS cases aged 35 and over
Thyroid problems	Generic uncomplicated disease: worry and daily medication	0.07	Remaining lifetime	2% of CRS cases aged 15–19

Tetanus

Description

Tetanus is an acute, sometimes fatal disease caused by toxins produced by the bacterium *Clostridium tetani*. The bacterium is widespread in the environment, including in soil and manure and in items contaminated by these. It usually enters the bloodstream through broken skin.

Early symptoms of tetanus infection include stiffness of the jaw muscles ('lockjaw'); difficulty in swallowing; and stiffness or pain in the neck, shoulders and back. This progresses to general muscle stiffness, severe and painful spasms and breathing failures.

Acute infections

Tetanus is a notifiable disease in Australia. The Australian Immunisation Handbook (ATAGI 2018) notes that the difference between the number of hospitalisations and notifications suggests tetanus may be under-notified. Therefore, an adjustment factor of 2 was applied to the NNDSS notifications.

Tetanus was assigned to the 'Infectious disease: acute episode, severe' health state, with a disability weight of 0.133, for a duration of 14 days.

Long-term sequelae

Long-term disability from neonatal tetanus was not included in the model as there are now very few cases in Australia.

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using death with an underlying cause of death of tetanus (ICD-10 codes A33–A35). All deaths occurred among people aged 75 and over. A case-fatality rate of 0.15% was applied, redistributed to occur among people aged 75 and over (Table C15).

Indigenous Australians

No cases of tetanus in Indigenous Australians were notified and no deaths were registered, during the periods 2004–2006 or 2014–2016, but 2 hospitalisations were recorded. However, due to the small number of tetanus cases occurring in Australia (4 per year, on average), no estimate of the burden among Indigenous Australians was made for this study.

Table C15: Model inputs for tetanus, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality (%)
Tetanus, acute infection	Infectious disease: acute episode, severe	0.133	14 days	Zero for ages <75 0.15 in those aged 75 and over, redistributed to have 14% of deaths in ages 75–79, 29% in ages 80–84 and 57% in ages 85+

Varicella zoster (chickenpox and shingles)

Description

Chickenpox (varicella) is a very contagious disease caused by the varicella-zoster virus. It can be passed from an infected person when they cough or sneeze, or through direct contact with blisters on the skin. Symptoms include a blister-like skin rash, itchiness, tiredness and fever. Chickenpox in children is usually mild. However, infections in newborn babies, immunocompromised people and adults can be severe and occasionally fatal.

Shingles (herpes zoster) is an illness that occurs among people who have previously had chickenpox, when the virus is reactivated in the nerve tissue. People with shingles experience a painful blistering rash. Post-herpetic neuralgia, the most common complication, causes a persistent burning pain which may last for several months.

One in 3 people will develop shingles in their lifetime. The risk of shingles increases with age and is most common among those aged 60 and over.

Acute infections

Varicella has been notifiable in all Australian states and territories apart from New South Wales since 2006. However, in many cases, people do not seek medical attention and, for those who do, a formal laboratory test to confirm the diagnosis is often not undertaken. It is also difficult for a laboratory to differentiate between shingles and chickenpox without further information on symptoms and presentation. Notifications data are therefore not considered a good estimate of disease occurrence for either of these 2 conditions. A combination of primary care survey data from BEACH, notifications data from NNDSS and admitted patient data from the NHMD was used to estimate incidence for this study.

Chickenpox was assigned to the ‘Infectious disease: acute episode, mild’ health state, with a disability weight of 0.006, for a duration of 7 days.

Shingles was assigned to the ‘Herpes zoster’ health state, with a disability weight of 0.058, for a duration of 14 days.

Post-herpetic neuralgia was assigned to the ‘Herpes zoster’ health state, with a disability weight of 0.058, for a duration of 3 to 6 months (Table C16).

Long-term sequelae

No additional long-term outcomes of varicella infection were included in the model.

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using death with an underlying cause of death of varicella (chickenpox) (ICD-10 code B01) or herpes zoster (ICD-10 code B02).

For chickenpox, 59 deaths were identified over the period 2007–2016, with the majority (80%) occurring among people aged 70 and over. A case-fatality rate of 0.01% was applied, redistributed by age to match the distribution observed in the NMD (Table C17). The same case-fatality rate was applied to both time periods.

For shingles, 268 deaths were identified over the period 2007–2016, with almost all (265) occurring among people aged 60 and over. Although there is some evidence from the United States that shingles deaths may be over-reported in both hospital and mortality records

(Mahamud et al. 2012), similar validation has not been undertaken in Australia. A case-fatality rate of 0.036% was applied to those aged 60 and over only.

In the period 1997–2006, there were fewer shingles deaths recorded, but across a broader age range (excluding infants under 12 months). Case-fatality rates of 0.002% among people aged 1–59, 0.005% among people aged 60–74, 0.030% among people aged 75–84 and 0.300% among people aged 85 and over were applied.

Indigenous Australians

The number of Indigenous Australians in the BEACH sample is too small to give a reliable estimate of GP encounters for this population. The ratio of Indigenous:total hospitalisations (at each age/sex level) for each disease was applied to the BEACH data to estimate the number of cases among Indigenous Australians. The same disability weights, durations and transition probabilities described earlier were applied.

Over the 20 years from 1997 to 2016, there were only 5 registered deaths from shingles among Indigenous people, and so Indigenous-specific case-fatality rates could not be calculated. The general case-fatality rates described above were therefore applied.

There have been no recorded deaths from chickenpox in the Indigenous population since 1997. A case-fatality rate of zero was therefore applied for both time periods.

Table C16: Model inputs for chickenpox and shingles, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Chickenpox	Infectious disease: acute episode, mild	0.006	7 days	CFR: 0.01 overall, redistributed by age as per Table C17
Shingles	Herpes zoster	0.058	14 days	CFR: Zero for ages 0–59 0.036 in ages 60+
Post-herpetic neuralgia	Herpes zoster	0.058	3–6 months	Transition probability: Zero for ages 0–24 0.05 in ages 25–59 0.19 in ages 60+

Table C17: Age-specific redistribution of case-fatality rates for chickenpox, 2005 and 2015 (%)

Age group (years)	2005	2015
Infants (<1)	0.027	0.000
1–4	0.110	0.017
5–9	0.027	0.017
10–14	0.014	0.000
15–19	0.014	0.000
20–24	0.027	0.000
25–29	0.027	0.017
30–34	0.055	0.000
35–39	0.027	0.051
40–44	0.027	0.034
45–49	0.027	0.000
50–54	0.014	0.000
55–59	0.041	0.017
60–64	0.014	0.051
65–69	0.068	0.000
70–74	0.082	0.068
75–79	0.096	0.068
80–84	0.110	0.373
85 and over	0.192	0.288

Whooping cough

Description

Whooping cough (pertussis) is a serious, contagious respiratory infection caused by the bacterium *Bordetella pertussis*. The disease is spread when an infected person coughs or sneezes, or through close contact.

Whooping cough usually begins with cold-like symptoms. The cough gradually worsens and there may be bouts of uncontrolled coughing, which may be followed by vomiting, choking, or a gasping breath that causes the distinctive ‘whooping’ sound. The cough may be less severe in older children, adolescents and adults.

The most common complication of whooping cough is pneumonia (lung infection).

Acute infections

Whooping cough is a nationally notifiable disease in Australia; however, notifications are not considered to be a good estimate of disease occurrence as many people do not seek medical attention or are not tested for whooping cough. A combination of primary care survey data from BEACH and admitted patient data from the NHMD were therefore used to estimate incidence. Hospitalised cases were considered an adequate estimate of the severe spectrum of illness among infants and young children.

Hospitalised cases of whooping cough among infants were assigned to the 'Infectious disease: acute episode, severe' health state, with a disability weight of 0.133, for a duration of 14–28 days.

The remaining cases of whooping cough were assigned to the 'Infectious disease: acute episode, moderate' health state, with a disability weight of 0.051, for a duration of 14–28 days (Table C18).

Long-term sequelae

Whooping cough does not generally result in long-term complications, so no long-term sequelae were included in the model.

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using deaths with an underlying cause of death of whooping cough (ICD-10 code A37). A case-fatality rate of 0.16% was applied to infants under 12 months, 0.01% among those aged 1–74 and 0.25% for those aged 75 and over.

Indigenous Australians

The number of Indigenous Australians in the BEACH sample is too small to give a reliable estimate of GP encounters for this population. However, Indigenous status completeness in whooping cough notifications data is adequate for 6 jurisdictions (excluding New South Wales and Tasmania). Indigenous notification rates for Victoria were used to estimate Indigenous whooping cough notifications for these 2 states; then the proportion of Indigenous notifications by age and sex was applied to the BEACH data to estimate total whooping cough cases among Indigenous Australians. Hospitalisation data for Indigenous Australians were used to estimate the number of severe cases.

The same durations and disability weights described earlier were applied. As there have been no recorded deaths of Indigenous Australians older than 12 months from whooping cough in the last 20 years, a case-fatality rate of 0.15% was applied among infants only.

Table C18: Model inputs for whooping cough, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality (%)
Whooping cough, hospitalised infants	Infectious disease: acute episode, severe	0.133	14–28 days	0.5 in females; 1.0 in males Redistributed to infants and those aged 65 and over
Whooping cough, remaining cases	Infectious disease: acute episode, moderate	0.051	14–28 days	0.5 in females; 1.0 in males Redistributed to infants and those aged 65 and over

Appendix D: Supplementary tables

Table D2.1: Non-fatal (YLD), fatal (YLL) and total burden (DALY) due to VPD, by age, 2015

				Per 100,000 population		
Age group (years)	**YLD**	**YLL**	**DALY**	**YLD**	**YLL**	**DALY**
Infants (<1)	236	570	806	76.7	185.0	261.8
1–4	218	663	881	17.5	53.2	70.6
5–9	117	222	339	7.6	14.5	22.1
10–14	130	74	205	9.2	5.3	14.5
15–19	165	395	561	11.2	26.9	38.1
20–24	137	314	452	8.2	18.7	26.9
25–29	483	1,459	1,943	26.9	81.4	108.3
30–34	246	574	820	14.0	32.7	46.8
35–39	178	574	752	11.3	36.4	47.7
40–44	129	413	542	7.8	24.9	32.7
45–49	136	620	756	8.7	39.6	48.3
50–54	195	725	919	12.5	46.4	58.9
55–59	139	636	775	9.6	43.9	53.5
60–64	153	746	899	11.9	58.1	70.0
65–69	130	908	1,039	11.2	78.5	89.7
70–74	137	591	728	16.1	69.5	85.5
75–79	124	815	939	19.7	129.2	148.9
80–84	93	663	756	20.7	147.5	168.2
85 and over	58	1,613	1,671	12.4	344.3	356.6

Table D2.2: Burden (DALY and DALY per 100,000 population) due to VPD, by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	6,761	101.9	4,794	58.6
Victoria	3,561	71.5	3,502	54.2
Queensland	3,552	90.7	3,455	69.8
Western Australia	1,670	83.1	1,534	58.6
South Australia	1,221	81.0	1,536	80.3
Tasmania	515	109.9	348	63.4
Australian Capital Territory	308	90.0	238	59.7
Northern Territory	391	188.1	312	134.0
Australia	**17,979**	**89.5**	**15,718**	**62.2**

Notes

1. Includes chickenpox, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, pneumococcal disease, rotavirus, shingles and whooping cough. The annual number of cases (or the overall burden attributed to diphtheria, Hib, rubella, mumps, polio and tetanus) was too small to be disaggregated by individual states and territories.
2. DALY columns may not add to totals due to rounding.
3. Rates age-standardised to the 2001 Australian population.

Table D2.3: Contribution of individual diseases to overall burden (DALY) due to VPD, 2015 (%)

Disease	DALY	DALY per 100,000	% of total DALY
Influenza	5,674	21.1	36.0
Pneumococcal disease	3,793	15.1	24.0
HPV	3,710	15.8	23.5
Shingles	1,153	4.3	7.3
Meningococcal disease	645	2.7	4.1
Hepatitis B	269	1.2	1.7
Whooping cough	259	1.1	1.6
Chickenpox	107	0.4	0.7
Rotavirus	69	0.3	0.4
Hepatitis A	23	0.1	0.1
Measles	18	0.1	0.1
Diphtheria	15	0.1	0.1
Tetanus	14	<0.1	0.1
Rubella	14	0.1	0.1
Hib	13	0.1	0.1
Mumps	6	<0.1	<0.1
Polio	0	0.0	0.0
Total	**15,781**	**62.5**	**100.0**

Notes

1. Columns may not add to totals due to rounding.
2. Rates age-standardised to the 2001 Australian population.

Table D2.4: Rate of cases, deaths and burden, and burden per case, by disease, Australia, 2015

	Per 100,000 population			
Disease	**Cases**	**Deaths**	**DALY**	**DALY per case**
Influenza	1,313	1.41	21.1	0.02
HPV	1,224	0.23	15.8	0.01
Pneumococcal disease	7	0.53	15.1	2.41
Shingles	585	0.11	4.3	<0.01
Meningococcal disease	1	0.04	2.7	3.22
Hepatitis B	1	0.03	1.2	1.70
Whooping cough	195	0.01	1.1	<0.01
Chickenpox	232	0.02	0.4	<0.01
Rotavirus	200	<0.01	0.3	<0.01
Hepatitis A	3	<0.01	0.1	0.03
Measles	1	<0.01	0.1	0.11
Diphtheria	<1	<0.01	0.1	3.72
Rubella	<1	<0.01	0.1	0.85
Hib	<1	<0.01	0.1	0.75
Tetanus	<1	<0.01	<0.1	1.42
Mumps	2	<0.01	<0.1	<0.1

Note: DALY rates age-standardised to the 2001 Australian population.

Table D2.5: Proportion of fatal (YLL) and non-fatal (YLD) burden, by disease, 2015

Disease	YLL	YLD	DALY	% fatal	% non-fatal
Diphtheria	15	<1	15	99.9	0.1
Tetanus	14	<1	14	99.6	0.4
Chickenpox	101	6	107	94.1	5.9
Hepatitis B	252	17	269	93.7	6.3
Measles	17	1	18	93.4	6.6
Influenza	5,117	556	5,674	90.2	9.8
Mumps	5	1	6	87.6	12.4
Hepatitis A	19	4	23	84.4	15.6
Pneumococcal disease	3,114	679	3,793	82.1	17.9
HPV	2,850	860	3,710	76.8	23.2
Meningococcal disease	473	172	645	73.3	26.7
Rubella	8	6	14	54.9	45.1
Whooping cough	121	138	259	46.8	53.2
Shingles	462	691	1,153	40.1	59.9
Hib	5	8	13	38.5	61.5
Rotavirus	4	64	69	6.1	93.9
Total	**12,578**	**3,204**	**15,781**	**79.7**	**20.3**

Note: YLL, YLD and DALY columns may not add to totals due to rounding.

Table D2.6: Proportion of total burden (DALY) by disease and sex, 2015

	Number of DALY			Per cent (%)	
Disease	**Males**	**Females**	**Persons**	**Male**	**Female**
Rubella	10	4	14	70.9	29.1
Hepatitis B	184	85	269	68.5	31.5
Hepatitis A	13	10	23	56.6	43.4
Hib	7	6	13	55.5	44.5
Pneumococcal disease	2,085	1,708	3,793	55.0	45.0
Measles	10	8	18	54.6	45.4
Meningococcal disease	348	298	645	53.9	46.1
Whooping cough	135	124	259	52.1	47.9
Mumps	3	3	6	52.0	48.0
Diphtheria	7	7	15	50.0	50.0
Tetanus	7	7	14	50.0	50.0
Shingles	549	604	1,153	47.6	52.4
Rotavirus	32	36	69	47.2	52.8
Chickenpox	49	58	107	45.6	54.4
Influenza	2,399	3,275	5,674	42.3	57.7
HPV	4	3,706	3,710	0.1	99.9
Total	**5,843**	**9,938**	**15,781**	**37.0**	**63.0**

Note: Number of DALY columns may not add to totals due to rounding.

Table D2.7: Burden (DALY and DALY per 100,000 population) due to VPD, by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	1,271	412.4	806	261.8
1–4	1,454	116.6	881	70.6
5–9	355	23.1	339	22.1
10–14	190	13.5	205	14.5
15–19	4,805	326.2	561	38.1
20–24	2,763	164.3	452	26.9
25–29	1,494	83.3	1,943	108.3
30–34	764	43.6	820	46.8
35–39	596	37.8	752	47.7
40–44	310	18.7	542	32.7
45–49	612	39.1	756	48.3
50–54	651	41.7	919	58.9
55–59	509	35.2	775	53.5
60–64	417	32.5	899	70.0
65–69	325	28.1	1,039	89.7
70–74	394	46.4	728	85.5
75–79	367	58.2	939	148.9
80–84	307	68.3	756	168.2
85 and over	476	101.6	1,671	356.6

Table D2.8: Influenza burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	94	36.7	34	11.0
1–4	154	15.1	332	26.6
5–14	64	2.4	218	7.4
15–39	176	2.5	713	8.6
40–64	178	2.8	1,277	17.0
65 and over	268	10.3	3,100	87.2
All ages	**934**	**4.6**	**5,674**	**21.1**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.9: Influenza burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	264	3.9	1,609	18.1
Victoria	188	3.7	1,182	17.2
Queensland	211	5.3	1,502	29.2
Western Australia	163	8.3	338	12.8
South Australia	82	5.2	747	34.3
Tasmania	12	2.2	114	18.5
Australian Capital Territory	8	2.7	99	25.0
Northern Territory	8	5.5	82	41.4

Note: Rates age-standardised to the 2001 Australian population.

Table D2.10: IPD burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	526	204.4	396	128.4
1–4	650	63.7	360	28.8
5–14	192	7.1	192	6.5
15–39	419	5.9	336	4.1
40–64	1,293	20.0	1,393	18.5
65 and over	1,076	41.2	1,117	31.4
All ages	**4,156**	**20.4**	**3,793**	**15.1**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.11: IPD burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	1,600	23.4	1,212	14.8
Victoria	740	14.7	896	14.0
Queensland	786	20.1	590	11.8
Western Australia	345	17.3	473	18.2
South Australia	332	21.2	337	19.1
Tasmania	106	20.8	106	18.1
Australian Capital Territory	85	28.5	42	11.0
Northern Territory	161	85.6	137	57.7

Note: Rates age-standardised to the 2001 Australian population.

Table D2.12: HPV burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	0	0.0	0	0.0
1–4	0	0.0	0	0.0
5–14	0	0.0	0	0.0
15–39	9,004	126.5	2,999	36.2
40–64	630	9.7	711	9.5
65 and over	0	0.0	0	0.0
All ages	**9,634**	**48.2**	**3,710**	**15.8**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.13: HPV burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	3,826	58.6	1,159	15.6
Victoria	1,884	38.0	807	13.3
Queensland	1,935	49.4	850	18.4
Western Australia	827	40.5	493	18.6
South Australia	550	37.3	179	11.3
Tasmania	313	68.7	87	19.8
Australian Capital Territory	165	43.7	66	15.3
Northern Territory	134	58.3	68	23.6

Note: Rates age-standardised to the 2001 Australian population.

Table D2.14: Shingles burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	0	0.0	0	0.0
1–4	3	0.2	0	0.0
5–14	12	0.5	3	0.1
15–39	86	1.2	75	0.9
40–64	166	2.6	344	4.6
65 and over	360	13.8	731	20.6
All ages	**627**	**3.0**	**1,152**	**4.3**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.15: Shingles burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	193	2.7	352	4.0
Victoria	163	3.1	308	4.5
Queensland	121	3.1	251	4.8
Western Australia	61	3.1	98	3.8
South Australia	60	3.3	95	4.4
Tasmania	17	3.3	25	3.7
Australian Capital Territory	7	2.2	15	4.0
Northern Territory	5	4.2	9	4.8

Note: Rates age-standardised to the 2001 Australian population.

Table D2.16: IMD burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	317	123.4	145	47.1
1–4	270	26.5	105	8.4
5–14	164	6.1	47	1.6
15–39	410	5.8	240	2.9
40–64	90	1.4	49	0.7
65 and over	33	1.3	59	1.7
All ages	**1,285**	**6.5**	**645**	**2.7**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.17: IMD burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	436	6.6	164	2.2
Victoria	287	5.9	162	2.7
Queensland	259	6.6	133	2.8
Western Australia	134	6.8	68	2.7
South Australia	67	4.8	96	6.0
Tasmania	40	8.7	9	1.8
Australian Capital Territory	27	8.0	7	1.6
Northern Territory	36	15.1	8	2.9

Note: Rates age-standardised to the 2001 Australian population.

Table D2.18: Hepatitis B burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	102	39.6	101	32.8
1–4	29	2.8	37	3.0
5–14	28	1.0	6	0.2
15–39	194	2.7	74	0.9
40–64	54	0.8	47	0.6
65 and over	4	0.2	3	0.1
All ages	**411**	**2.1**	**269**	**1.2**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.19: Hepatitis B burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	95	1.4	106	1.4
Victoria	147	3.0	41	0.7
Queensland	62	1.6	48	1.1
Western Australia	46	2.3	21	0.8
South Australia	41	3.0	47	3.1
Tasmania	9	2.0	2	0.6
Australian Capital Territory	4	1.2	1	0.2
Northern Territory	8	3.5	2	0.6

Note: Rates age-standardised to the 2001 Australian population.

Table D2.20: Whooping cough burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	65	25.4	100	32.4
1–4	6	0.5	12	1.0
5–14	5	0.2	50	1.7
15–39	24	0.3	29	0.4
40–64	19	0.3	32	0.4
65 and over	7	0.3	36	1.0
All ages	**126**	**0.6**	**259**	**1.1**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.21: Whooping cough burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	55	0.8	128	1.7
Victoria	14	0.3	56	0.9
Queensland	20	0.5	27	0.6
Western Australia	21	1.1	25	1.0
South Australia	12	0.8	16	1.0
Tasmania	1	0.1	1	0.1
Australian Capital Territory	2	0.6	5	1.2
Northern Territory	2	0.7	1	0.6

Note: Rates age-standardised to the 2001 Australian population.

Table D2.22: Chickenpox burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	22	8.7	<1	0.1
1–4	91	8.9	9	0.7
5–14	36	1.3	10	0.3
15–39	86	1.2	22	0.3
40–64	43	0.7	20	0.3
65 and over	67	2.6	47	1.3
All ages	**346**	**1.7**	**107**	**0.4**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.23: Chickenpox burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	123	1.8	28	0.4
Victoria	73	1.5	27	0.4
Queensland	72	1.8	27	0.6
Western Australia	37	1.9	9	0.4
South Australia	26	1.7	9	0.5
Tasmania	8	1.8	2	0.5
Australian Capital Territory	4	1.1	3	0.9
Northern Territory	4	2.3	1	1.1

Note: Rates age-standardised to the 2001 Australian population.

Table D2.24: Rotavirus burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	106	41.1	14	4.4
1–4	218	21.4	22	1.7
5–14	24	0.9	9	0.3
15–39	7	0.1	7	0.1
40–64	6	0.1	6	0.1
65 and over	17	0.7	11	0.3
All ages	378	1.9	69	0.3

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.25: Rotavirus burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	140	2.2	22	0.3
Victoria	50	1.0	11	0.2
Queensland	78	2.0	20	0.4
Western Australia	24	1.2	5	0.2
South Australia	49	3.6	7	0.4
Tasmania	9	2.0	1	0.2
Australian Capital Territory	6	1.8	1	0.3
Northern Territory	23	8.5	2	0.6

Note: Rates age-standardised to the 2001 Australian population.

Table D2.26: Hepatitis A burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	<0.1	<0.01	0.0	0.00
1–4	28.8	2.82	0.1	0.01
5–14	1.5	0.05	4.9	0.16
15–39	9.3	0.13	5.3	0.06
40–64	18.4	0.28	6.6	0.09
65 and over	18.9	0.72	6.2	0.17
All ages	**76.9**	**0.38**	**23.0**	**0.09**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.27: Hepatitis A burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	26.7	0.39	9.4	0.12
Victoria	14.5	0.29	6.1	0.10
Queensland	8.7	0.22	4.2	0.08
Western Australia	12.4	0.63	2.3	0.09
South Australia	2.0	0.13	0.6	0.04
Tasmania	1.1	0.21	<0.1	<0.01
Australian Capital Territory	0.4	0.13	0.2	0.04
Northern Territory	11.3	4.42	0.2	0.10

Note: Rates age-standardised to the 2001 Australian population.

Table D2.28: Measles burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	0.4	0.16	2.3	0.75
1–4	1.2	0.12	2.0	0.16
5–14	1.6	0.06	3.0	0.10
15–39	3.1	0.04	10.1	0.12
40–64	0.1	<0.01	1.0	0.01
65 and over	0.0	0.00	0.0	0.00
All ages	**6.5**	**0.03**	**18.3**	**0.08**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.29: Measles burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015

	2005		2015	
State/territory	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
New South Wales	2.8	0.04	3.4	0.05
Victoria	1.0	0.02	5.2	0.09
Queensland	0.2	<0.01	3.8	0.08
Western Australia	1.5	0.08	2.2	0.09
South Australia	0.6	0.04	1.1	0.07
Tasmania	0.4	0.09	0.3	0.06
Australian Capital Territory	<0.1	0.01	0.5	0.12
Northern Territory	0.1	0.03	1.9	0.66

Note: Rates age-standardised to the 2001 Australian population.

Table D2.30: Diphtheria burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	0	0.0	0	0.00
1–4	0	0.0	0	0.00
5–14	0	0.0	0	0.00
15–39	0	0.0	11	0.14
40–64	0	0.0	2	0.02
65 and over	0	0.0	2	0.05
All ages	0	0.0	15	0.06

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.31: Tetanus burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	0.0	0.00	0.0	0.00
1–4	0.0	0.00	0.0	0.00
5–14	0.0	0.00	<0.1	<0.01
15–39	<0.1	<0.01	<0.1	<0.01
40–64	<0.1	<0.01	<0.1	<0.01
65 and over	11.3	0.43	14.2	0.40
All ages	**11.4**	**0.05**	**14.2**	**0.05**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.32: Rubella and CRS burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
		Rubella		
Infants (<1)	0.0	0.00	0.0	0.00
1–4	0.5	0.05	0.0	0.00
5–14	0.1	<0.01	0.1	0.01
15–39	2.5	0.04	3.7	0.04
40–64	0.2	<0.01	0.8	0.01
65 and over	0.0	<0.01	0.1	<0.01
All ages	**3.3**	**0.02**	**4.7**	**0.02**
		CRS		
Infants (<1)	**27.2**	**10.6**	**9.1**	**3.0**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.33: Hib burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	10.4	4.02	5.8	1.88
1–4	3.1	0.30	2.5	0.20
5–14	17.5	0.65	1.7	0.06
15–39	0.9	0.01	1.2	0.01
40–64	0.4	0.01	1.5	0.02
65 and over	2.0	0.08	0.8	0.02
All ages	**34.2**	**0.17**	**13.4**	**0.06**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D2.34: Mumps burden (DALY and DALY per 100,000 population), by age, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	<0.1	<0.01	<0.1	<0.01
1–4	<0.1	<0.01	<0.1	<0.01
5–14	<0.1	<0.01	0.1	<0.01
15–39	0.2	<0.01	0.4	<0.01
40–64	0.1	<0.01	0.1	<0.01
65 and over	4.6	0.17	5.4	0.15
All ages	**4.9**	**0.02**	**6.2**	**0.02**

Notes

1. DALY columns may not add to totals due to rounding.
2. 'All ages' rates age-standardised to the 2001 Australian population.

Table D3.1: Burden (DALY and DALY per 100,000 population) due to VPD, by age, Indigenous Australians, 2005 and 2015

	2005		2015	
Age group (years)	**DALY**	**DALY per 100,000**	**DALY**	**DALY per 100,000**
Infants (<1)	286	1,771.9	165	910.5
1–4	179	285.8	132	195.4
5–9	39	50.6	42	50.6
10–14	37	52.4	35	44.5
15–19	1,115	1,890.5	122	157.1
20–24	503	1,029.0	65	91.4
25–29	249	618.0	342	587.3
30–34	110	256.0	107	222.3
35–39	70	176.6	75	189.2
40–44	33	94.6	84	201.2
45–49	70	243.5	86	225.5
50–54	47	214.1	99	300.7
55–59	30	197.0	66	251.6
60–64	11	106.0	42	218.9
65–69	7	94.6	33	260.4
70–74	11	220.3	22	281.3
75–79	4	127.8	17	377.4
80–84	1	49.2	9	373.3
85 and over	5	580.4	10	663.2
All ages	**2,807**	**400.0**	**1,552**	**237.3**

Notes

1. Includes chickenpox, Hib, hepatitis A, hepatitis B, HPV, influenza, measles, meningococcal disease, mumps, pneumococcal disease, rotavirus, shingles and whooping cough.
2. DALY columns may not add to totals due to rounding.
3. 'All ages' rates age-standardised to the 2001 Australian population.

Table D3.2: Contribution of individual diseases to overall burden (DALY) due to VPD, Indigenous Australians, 2015

Disease	DALY	% of DALY
HPV	610	39.3
Pneumococcal disease	465	30.0
Influenza	229	14.8
Hepatitis B	102	6.5
Meningococcal disease	85	5.5
Shingles	25	1.6
Whooping cough	20	1.3
Rotavirus	7.4	0.5
Mumps	3.5	0.2
Hib	3.0	0.2
Measles	0.4	<0.1
Chickenpox	0.4	<0.1
Hepatitis A	0.3	<0.1
Total	**1,552**	**100.0**

Note: Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.

Table D3.3: Proportion of fatal (YLL) and non-fatal (YLD) burden by disease, Indigenous Australians, 2015

	Number			Per cent (%)	
Disease	**YLL**	**YLD**	**DALY**	**YLL**	**YLD**
Hepatitis B	99	2	102	97.7	2.3
Measles	0	0	0	93.3	6.7
HPV	547	63	610	89.7	10.3
Whooping cough	17	2	20	88.5	11.5
Mumps	3	0	4	88.1	11.9
Pneumococcal disease	396	70	465	85.0	15.0
Hepatitis A	0	0	0	83.5	16.5
Influenza	190	40	229	82.7	17.3
Meningococcal disease	64	21	85	74.9	25.1
Hib	1	2	3	32.3	67.7
Shingles	7	18	25	27.6	72.4
Rotavirus	0	7	7	0.4	99.6
Chickenpox	0	0	0	0.0	100.0
Total	**1,325**	**227**	**1,552**	**85.4**	**14.6**

Note: Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.

Table D3.4: Burden rates (DALY and DALY per 100,000 population) and rate ratios, by age, Indigenous and non-Indigenous Australians, 2015

	Indigenous		Non-Indigenous			
Age group (years)	DALY	DALY per 100,000	DALY	DALY per 100,000	DALY rate difference	DALY rate ratio
Infants (<1)	165	910.5	632	218.9	691.6	4.2
1–4	132	195.4	749	64.0	131.4	3.1
5–14	77	47.6	466	16.8	30.8	2.8
15–39	710	241.3	3,802	47.9	193.4	5.0
40–64	377	238.2	3,511	47.7	190.5	5.0
65 and over	90	313.5	5,026	142.1	171.4	2.2
All ages	**1,552**	**237.3**	**14,186**	**57.3**	**180.0**	**4.1**

Note: 'All ages' rates age-standardised to the 2001 Australian population.

Table D3.5: Burden rate ratios and rate differences between Indigenous and non-Indigenous Australians, by disease, 2015

	DALY per 100,000			
Disease	Indigenous	Non-Indigenous	Rate ratio	Rate difference
HPV	81.0	13.7	5.9	67.3
Pneumococcal disease	78.3	13.5	5.8	64.7
Influenza	49.4	20.6	2.4	28.9
Hepatitis B	9.3	0.8	12.4	8.5
Meningococcal disease	7.2	2.5	2.9	4.7
Shingles	6.9	4.2	1.6	2.7
Mumps	2.6	<0.1	n.p.[(a)]	2.6
Whooping cough	1.5	1.1	1.4	0.4
Rotavirus	0.7	0.3	2.5	0.4
Hib	0.2	<0.1	5.3	0.2
Hepatitis A	0.1	0.1	0.9	—
Measles	0.1	0.1	0.7	—
Chickenpox	<0.1	0.4	0.1	–0.4

(a) Due to the very low rate in the non-Indigenous population, a reliable rate ratio for mumps could not be calculated.

Notes

1. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
2. Rates age-standardised to the 2001 Australian population.
3. Rate difference is calculated as Indigenous age-standardised rate minus non-Indigenous age-standardised rate.
4. Rate ratio is calculated as Indigenous age-standardised rate divided by non-Indigenous age-standardised rate.

Table D3.6: Contribution of individual diseases to the gap in VPD burden between Indigenous and non-Indigenous Australians (based on DALY rate differences), 2005 and 2015 (%)

	Contribution to gap (%)	
Disease	**2005**	**2015**
HPV	69.4	37.4
Pneumococcal disease	15.0	36.0
Influenza	2.2	16.0
Hepatitis B	5.7	4.7
Meningococcal disease	2.9	2.6
Shingles	0.2	1.5
Mumps	0.0	1.4
Whooping cough	0.1	0.2
Rotavirus	3.6	0.2
Hib	0.4	0.1
Hepatitis A	1.1	0.0
Measles	0.0	0.0
Chickenpox	–0.5	–0.2
Total gap (DALY per 100,000 population)	**321.6**	**180.0**

Notes

1. Estimates of burden for diphtheria, rubella and tetanus could not be calculated by Indigenous status.
2. Rate difference (gap) is calculated as Indigenous age-standardised rate minus non-Indigenous age-standardised rate.

Appendix E: Methods and results for diseases not covered by NIP vaccines

This appendix provides methods and estimates of burden for 2 additional diseases not currently covered by the NIP, but for which vaccines are either available at individual cost or are under development: Q fever and respiratory syncytial virus (RSV).

Q fever

Q fever is caused by *Coxiella burnetti* bacteria, commonly found in cattle, sheep and goats. The bacteria may also be carried by Australian native species (including kangaroos, bandicoots and wallabies) and other domesticated and feral animals. Infected animals shed the bacteria through urine, feces, milk and birth products. The bacteria can survive in the soil for many years and contaminated dust can be carried to other areas by the wind.

High-risk occupation groups include livestock and dairy farmers and related workers (such as farmhands and shearers), abattoir and meat workers, veterinary or wildlife workers, and animal breeders. Family members of those in high-risk occupations, and people visiting or living on or near high-risk industries, are also at increased risk.

Q fever infection may have no symptoms in around half of all cases. Symptoms are flu-like and include high fever and chills, tiredness, headaches, and joint and muscle pain. Complications may include hepatitis (inflammation of the liver) and pneumonia (lung infection), occurring in up to 50% of symptomatic cases. There is also some evidence of post Q fever fatigue syndrome, which occurs in 10%–15% of acute cases (Eastwood et al. 2018).

Methods

Acute infections

Q fever is a notifiable disease in Australia; however, expert advice suggested that notifications would underestimate the number of cases of Q fever. An adjustment factor of 2 was applied to the NNDSS data to estimate the number of cases that occur.

Acute Q fever infection was assigned to the ‘Infectious disease: acute episode, moderate’ health state, with a disability weight of 0.051, for a duration of 14–28 days (Table E1).

Long-term sequelae

Q fever fatigue syndrome was assigned to the ‘Infectious disease: post-acute consequences’ health state, with a disability weight of 0.219, for a duration of 6–18 months.

Case-fatality

Death from Q fever is not common, but several deaths with the underlying cause of death of Q fever (ICD-10 code A78) have been recorded over the past 10 years. A case-fatality rate of 0.1% was applied to all age groups.

Table E1: Model inputs for Q fever, 2015

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Acute Q fever infection	Infectious disease: acute episode, severe	0.051	14–28 days	0.1
Q fever fatigue syndrome	Infectious disease: post-acute consequences	0.219	6–18 months	10.0–15.0

Results

There were more than 1,600 notifications of Q fever in Australia over the 3 years from 2014 to 2016, and 440 hospitalisations. Over the 10 years from 2007 to 2016, 7 deaths from Q fever were recorded.

A vaccine for Q fever has been available in Australia since 1989. The National Q Fever Management Program, funded by the Australian Government, was implemented between 2001–2002 and 2004–2006 across several jurisdictions. The program provided subsidised vaccinations to non-immune individuals in high-risk occupations.

Burden in 2015

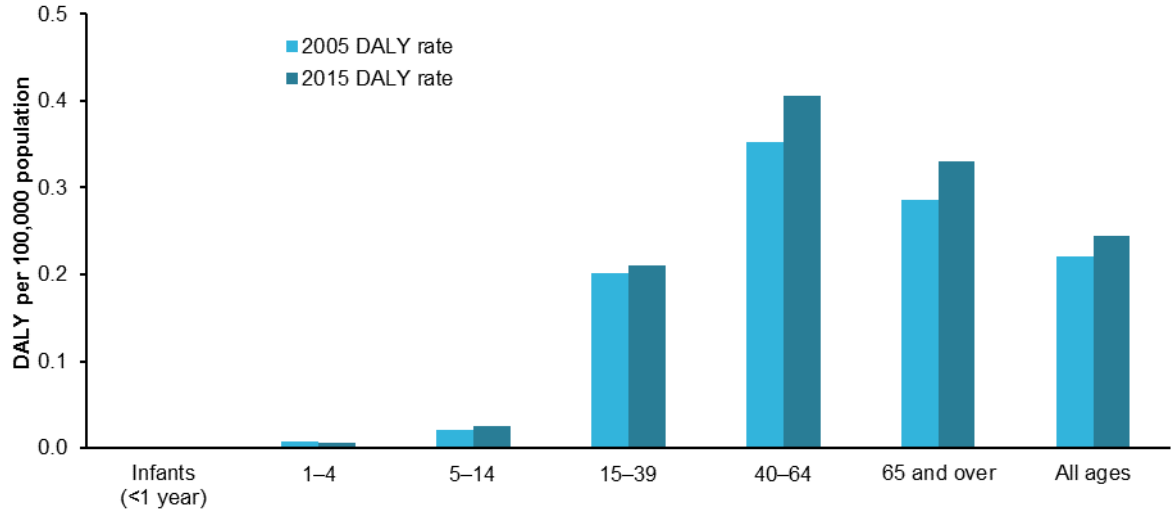
In 2015, Q fever contributed an estimated burden of 60.6 DALY. Half (50%) of this burden was attributed to Q fever fatigue syndrome. The burden was highest among people in the working age groups (15–64 years).

Q fever has an individual burden of 0.25 DALY per case.

Change since 2005

In 2005, the estimated burden of Q fever was 45.3 DALY, slightly lower than in 2015 (0.22 compared with 0.24 per 100,000 population) (Figure E1)—a result of there being fewer cases in 2005 than in 2015.

Figure E1: Q fever burden (DALY per 100,000 population), by age, 2005 and 2015



Note: 'All ages' rate age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table E1.

Respiratory syncytial virus

RSV causes respiratory infections. It is most common among infants and young children, where it can cause bronchiolitis (inflammation of the small breathing tubes in the lungs) or pneumonia (lung infection). Symptoms are generally mild to moderate (runny nose, cough, fever), but can be severe in babies with wheezing, shortness of breath and poor feeding.

Methods

Acute infections

RSV is not a notifiable disease in Australia and there are no reliable sources of data on infection rates in the general population. Information from the NHMD was used to estimate the number of severe cases. This was considered an adequate estimate of the severe spectrum of illness experienced mostly by infants and young children.

Severe RSV infection was assigned to the 'Infectious disease: acute episode, severe' health state, with a disability weight of 0.133, for a duration of 14 days (Table E2).

Long-term sequelae

No long-term sequelae of RSV were included in the model.

Case-fatality

The case-fatality rates used in the model were based on 10 years of observed mortality data from the NMD, using deaths with an underlying cause of death of RSV pneumonia (ICD-10 code J12.1), RSV bronchitis (J20.5) or RSV bronchiolitis (J21.0). Case-fatality rates of 0.01%–0.10% were applied, based on age at infection.

Table E2: Model inputs for RSV

Disease/sequela	Health state	Disability weight	Duration	Case-fatality rate/ sequela transition probability (%)
Acute RSV infection	Infectious disease: acute episode, severe	0.133	14 days	0.01–0.10, depending on age

Results

More than 22,000 hospitalisations had a principal diagnosis of RSV over the 3 years from 2014 to 2016. Around two-thirds of these (65%) were for infants under 12 months of age, with a further 23% in young children aged 1–4. Over the 10 years from 2007 to 2016, 32 deaths from RSV were recorded, with three-quarters (24 deaths) of these being among people aged 60 or over.

A maternal vaccine for RSV is currently undergoing clinical trials in Australia.

Burden in 2015

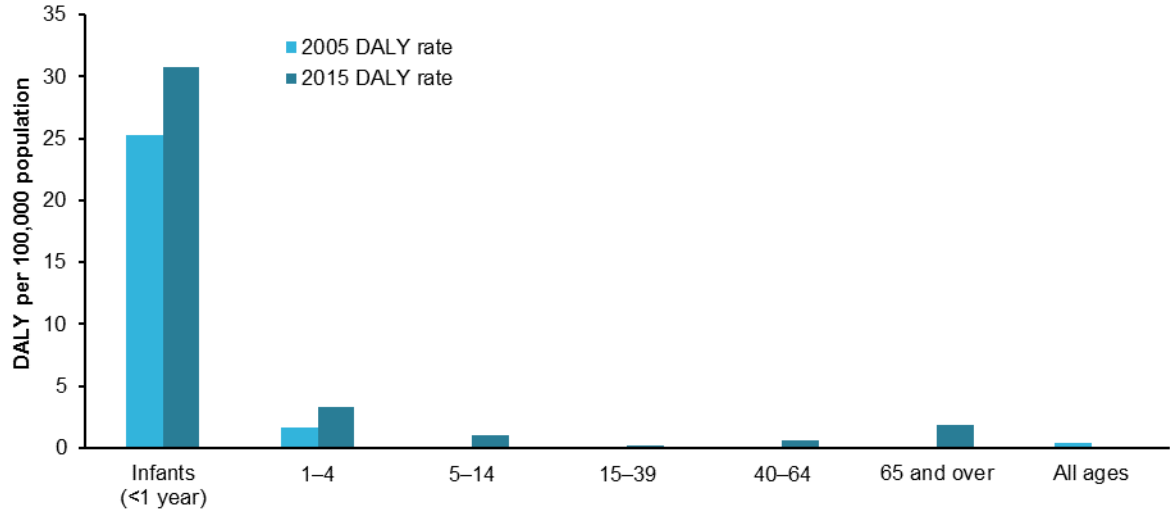
In 2015, RSV contributed an estimated burden of 294.9 DALY. Nearly all (93%) of this burden was attributed to YLL. The burden was highest among infants (30.8 DALY per 100,000 population), with the rate of burden in all other age groups being fewer than 4 DALY per 100,000 (Figure E2).

RSV has a low individual burden of 0.03 DALY per case.

Change since 2005

The overall burden of RSV in 2005 was lower than in 2015 (0.5 compared with 1.2 DALY per 100,000 population), the result of a smaller number of cases in the earlier year.

Figure E2: RSV burden (DALY per 100,000 population), by age, 2005 and 2015



Note: 'All ages' rate age-standardised to the 2001 Australian population.

Source: This figure is based on data in a supplementary table available online—Table E2.

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Abbreviations

ABDS	Australian Burden of Disease Study
ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
BCoDE	Burden of Communicable Diseases in Europe study
BEACH	Bettering the Evaluation and Care of Health
BVPD	Burden of Vaccine Preventable Diseases in Australia
CRS	Congenital rubella syndrome
DALY	disability-adjusted life years
GBD	Global Burden of Disease
Hib	*Haemophilus influenzae* type b
HPV	Human papillomavirus
ICD	International Classification of Diseases
ICD-10	International Classification of Diseases and Related Health Problems, 10th revision
ICD-10-AM	International Classification of Diseases and Related Health Problems, 10th revision, Australian modification
IMD	invasive meningococcal disease
IPD	invasive pneumococcal disease
MMR	Measles-mumps-rubella
MMR-V	Measles-mumps-rubella-varicella
NHMD	National Hospital Morbidity Database
NIP	National Immunisation Program
NMD	National Mortality Database
NNDSS	National Notifiable Diseases Surveillance System
PCR	polymerase chain reaction
RSV	Respiratory syncytial virus
VPD	vaccine preventable diseases
WHO	World Health Organization
YLD	years of life lost due to disability
YLL	years of life lost due to premature death

Symbols

—	nil or rounded to zero
. .	not applicable
<	less than

Glossary

Aboriginal or Torres Strait Islander: A person of Aboriginal and/or Torres Strait Islander descent who identifies as an Aboriginal and/or Torres Strait Islander person. See also **Indigenous**.

age-specific rate: Rate for a specific age group. The numerator and denominator relate to the same age group.

age-standardised rate: Rate for which the influence of age is removed by converting the age structures of the different populations to the same 'standard' structure. This provides a more valid way to compare rates from populations with different age structures.

burden of disease (and injury): The quantified impact of a disease or injury on a population, using the **disability-adjusted life years (DALY)** measure.

disability-adjusted life years (DALY): A measure of healthy life lost, either through premature death or living with disability due to illness or injury. Often used synonymously with health loss.

disability weight: A factor that reflects the severity of health loss from a particular health state on a scale from 0 (perfect health) to 1 (equivalent to death).

fatal burden: The burden from dying prematurely as measured by years of life lost. Often used synonymously with **years of life lost,** and also referred to as 'life lost'.

health state: Consequences of diseases and conditions reflecting key differences in symptoms and functioning, with which health losses can be associated.

incidence: The number of new cases (of an illness or injury) occurring during a given period.

Indigenous: Person of Aboriginal or Torres Strait Islander descent who identifies as an Aboriginal or Torres Strait Islander. See also **Aboriginal or Torres Strait Islander**.

non-fatal burden: The burden from living with ill-health as measured by years lived with disability. Often used synonymously with **years lived with disability**.

prevalence: The number of cases of a disease or injury in a population at a given time.

sequelae: Health consequences of diseases; for example, septicaemia due to meningococcal disease.

vaccine hesitancy: The reluctance or refusal to vaccinate, despite the availability of vaccines.

years lived with disability (YLD): The number of years of what could have been a healthy life that were instead spent in states of less than full health. YLD represent **non-fatal burden**

years of life lost (YLL): The number of years of life lost due to premature death, defined as dying before the ideal life span. YLL represent **fatal burden**.

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List of tables

Table 1.1: Diseases included in the BVPD study 1

Table 1.2: NIP schedule as at 8 August 2018 2

Table 3.1: Burden (DALY per 100,000 population) due to VPD, Indigenous Australians, 2005 and 2015 47

Table 3.2: Gap measures of VPD burden (rates and rate differences per 100,000 population), by disease, 2005 and 2015 50

Table 4.1: Summary of burden results by disease, 2005 and 2015 54

Table 4.2: Comparison of the top 5 VPD in selected burden of disease studies 58

Table B1: Data source used for sub-national distribution of national burden (DALY) estimates 79

Table B2: Jurisdictions with at least 50% completeness for Indigenous identification in notifications data, 2004–2006 and 2014–2016 81

Table B3: Disease list by ICD-10 codes used for hospitalisation and mortality analysis 82

Table B4: Adjustment factors for 2015 Indigenous hospitalisation estimates 83

Table B5: Adjustment factors used for 2005 Indigenous hospitalisation estimates 84

Table B6: Adjustment factors used for 2005/2015 Indigenous mortality estimates 85

Table C1: Model inputs for diphtheria, 2015 87

Table C2: Model inputs for Hib, 2015 88

Table C3: Model inputs for hepatitis A, 2015 90

Table C4: Model inputs for hepatitis B, 2015 92

Table C5: Model inputs for HPV, 2015 93

Table C6: Model inputs for influenza, 2015 95

Table C7: Age-specific case-fatality rates for influenza, hospitalised and non-hospitalised cases, 2015 (%) 95

Table C8: Model inputs for measles, 2015 97

Table C9: Model inputs for meningococcal disease, 2015 98

Table C10: Model inputs for mumps, 2015 100

Table C11: Model inputs for pneumococcal disease, 2015 101

Table C12: Age-specific case-fatality rates for pneumococcal disease, 2015 (%) 102

Table C13: Model inputs for rotavirus, 2015 104

Table C14: Model inputs for rubella and CRS, 2015 105

Table C15: Model inputs for tetanus, 2015 106

Table C16: Model inputs for chickenpox and shingles, 2015 108

Table C17: Age-specific redistribution of case-fatality rates for chickenpox, 2005 and 2015 (%) 109

Table C18: Model inputs for whooping cough, 2015 110

Table D2.1: Non-fatal (YLD), fatal (YLL) and total burden (DALY) due to VPD, by age, 2015 111
Table D2.2: Burden (DALY and DALY per 100,000 population) due to VPD, by state and territory, 2005 and 2015 111
Table D2.3: Contribution of individual diseases to overall burden (DALY) due to VPD, 2015 (%) 112
Table D2.4: Rate of cases, deaths and burden, and burden per case, by disease, Australia, 2015 112
Table D2.5: Proportion of fatal (YLL) and non-fatal (YLD) burden, by disease, 2015 113
Table D2.6: Proportion of total burden (DALY) by disease and sex, 2015 113
Table D2.7: Burden (DALY and DALY per 100,000 population) due to VPD, by age, 2005 and 2015 114
Table D2.8: Influenza burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 114
Table D2.9: Influenza burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 115
Table D2.10: IPD burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 115
Table D2.11: IPD burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 115
Table D2.12: HPV burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 116
Table D2.13: HPV burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 116
Table D2.14: Shingles burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 116
Table D2.15: Shingles burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 117
Table D2.16: IMD burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 117
Table D2.17: IMD burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 117
Table D2.18: Hepatitis B burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 118
Table D2.19: Hepatitis B burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 118
Table D2.20: Whooping cough burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 118
Table D2.21: Whooping cough burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 119
Table D2.22: Chickenpox burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 119
Table D2.23: Chickenpox burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 119

Table D2.24: Rotavirus burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 120
Table D2.25: Rotavirus burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 120
Table D2.26: Hepatitis A burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 120
Table D2.27: Hepatitis A burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 121
Table D2.28: Measles burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 121
Table D2.29: Measles burden (DALY and DALY per 100,000 population), by state and territory, 2005 and 2015 121
Table D2.30: Diphtheria burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 122
Table D2.31: Tetanus burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 122
Table D2.32: Rubella and CRS burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 122
Table D2.33: Hib burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 123
Table D2.34: Mumps burden (DALY and DALY per 100,000 population), by age, 2005 and 2015 123
Table D3.1: Burden (DALY and DALY per 100,000 population) due to VPD, by age, Indigenous Australians, 2005 and 2015 124
Table D3.2: Contribution of individual diseases to overall burden (DALY) due to VPD, Indigenous Australians, 2015 125
Table D3.3: Proportion of fatal (YLL) and non-fatal (YLD) burden by disease, Indigenous Australians, 2015 125
Table D3.4: Burden rates (DALY and DALY per 100,000 population) and rate ratios, by age, Indigenous and non-Indigenous Australians, 2015 126
Table D3.5: Burden rate ratios and rate differences between Indigenous and non-Indigenous Australians, by disease, 2015 126
Table D3.6: Contribution of individual diseases to the gap in VPD burden between Indigenous and non-Indigenous Australians (based on DALY rate differences), 2005 and 2015 (%) 127
Table E1: Model inputs for Q fever, 2015 129
Table E2: Model inputs for RSV 130

List of figures

Figure 1.1: Generic conceptual model for infectious diseases 8

Figure 2.1: Non-fatal (YLD), fatal (YLL) and total burden (DALY) due to VPD, by age, 2015 10

Figure 2.2: Burden (DALY per 100,000 population) due to VPD, by state and territory, 2005 and 2015 11

Figure 2.3: Contribution of individual diseases to overall burden (DALY) due to VPD, 2015 (%)..... 11

Figure 2.4: Number of cases, deaths and population-level burden due to VPD, Australia, 2015 12

Figure 2.5: Proportion of fatal (YLL) and non-fatal (YLD) burden, by disease, 2015 13

Figure 2.6: Proportion of total burden (DALY), by disease and sex, 2015 14

Figure 2.7: Burden (DALY and DALY per 100,000 population) due to VPD, by age, 2005 and 2015 15

Figure 2.8: Influenza burden (DALY per 100,000 population), by age, 2005 and 2015 17

Figure 2.9: Influenza burden (DALY per 100,000 population), by state and territory, 2005 and 2015 17

Figure 2.10: IPD burden (DALY per 100,000 population), by age, 2005 and 2015 19

Figure 2.11: IPD burden (DALY per 100,000 population), by state and territory, 2005 and 2015 19

Figure 2.12: HPV burden (DALY per 100,000 population), by age, 2005 and 2015..... 21

Figure 2.13: HPV burden (DALY per 100,000 population), by state and territory, 2005 and 2015 21

Figure 2.14: Shingles burden (DALY per 100,000 population), by age, 2005 and 2015 22

Figure 2.15: Shingles burden (DALY per 100,000 population), by state and territory, 2005 and 2015 23

Figure 2.16: IMD burden (DALY per 100,000 population), by age, 2005 and 2015 24

Figure 2.17: IMD burden (DALY per 100,000 population), by state and territory, 2005 and 2015 25

Figure 2.18: Hepatitis B burden (DALY per 100,000 population), by age, 2005 and 2015 27

Figure 2.19: Hepatitis B burden (DALY per 100,000 population), by state and territory, 2005 and 2015 27

Figure 2.20: Whooping cough burden (DALY per 100,000 population), by age, 2005 and 2015 29

Figure 2.21: Whooping cough burden (DALY per 100,000 population), by state and territory, 2005 and 2015 29

Figure 2.22: Chickenpox burden (DALY per 100,000 population), by age, 2005 and 2015 31

Figure 2.23: Chickenpox burden (DALY per 100,000 population), by state and territory, 2005 and 2015 32

Figure 2.24: Rotavirus burden (DALY per 100,000 population), by age, 2005 and 2015..... 33

Figure 2.25: Rotavirus burden (DALY per 100,000 population), by state and territory, 2005 and 2015 34

Figure 2.26: Hepatitis A burden (DALY per 100,000 population), by age, 2005 and 2015 35
Figure 2.27: Hepatitis A burden (DALY per 100,000 population), by state and territory, 2005 and 2015 36
Figure 2.28: Measles burden (DALY per 100,000 population), by age, 2005 and 2015 37
Figure 2.29: Measles burden (DALY per 100,000 population), by state and territory, 2005 and 2015 38
Figure 2.30: Diphtheria burden (DALY per 100,000 population), by age, 2015..... 39
Figure 2.31: Tetanus burden (DALY per 100,000 population), by age, 2005 and 2015..... 40
Figure 2.32: Rubella (excl. CRS) burden (DALY per 100,000 population), by age, 2005 and 2015 41
Figure 2.33: Hib burden (DALY per 100,000 population), by age, 2005 and 2015..... 42
Figure 2.34: Mumps burden (DALY per 100,000 population), by age, 2005 and 2015 43
Figure 3.1: Burden (DALY and DALY per 100,000 population) due to VPD, by age, Indigenous Australians, 2015..... 45
Figure 3.2: Contribution of individual diseases to overall burden (DALY) due to VPD, Indigenous Australians, 2015 (%) 46
Figure 3.3: Proportion of fatal (YLL) and non-fatal (YLD) burden by disease, Indigenous Australians, 2015 46
Figure 3.4: Burden rates (DALY per 100,000 population) and rate ratios, by age, Indigenous and non-Indigenous Australians, 2015..... 48
Figure 3.5: Burden rate ratios and rate differences between Indigenous and non-Indigenous Australians, by disease, 2015 49
Figure 3.6: Contribution of individual diseases to the gap in VPD burden between Indigenous and non-Indigenous Australians (based on DALY rate differences), 2005 and 2015 (%) 50
Figure 4.1: Burden (DALY per 100,000 population) due to selected VPD, Australia, 2005 and 2015 53
Figure 4.2: Contribution of total VPD burden (DALY) excluding HPV, top 5 VPD, BVPD study and ABDS, 2015 (%) 56
Figure 4.3: Estimates of fatal (YLL) and non-fatal (YLD) burden due to VPD from the ABDS and BVPD study, 2015..... 57
Figure A1: Contribution of individual diseases to overall VPD burden (DALY), New South Wales, 2015 (%)..... 61
Figure A2: Individual VPD burden (DALY per 100,000 population) and rankings, New South Wales, 2005 and 2015..... 62
Figure A3: Contribution of individual diseases to overall VPD burden (DALY), Victoria, 2015 (%)..... 63
Figure A4: Individual VPD burden (DALY per 100,000 population) and rankings, Victoria, 2005 and 2015 64
Figure A5: Contribution of individual diseases to overall VPD burden (DALY), Queensland, 2015 (%)..... 65
Figure A6: Individual VPD burden (DALY per 100,000 population) and rankings, Queensland, 2005 and 2015..... 66
Figure A7: Contribution of individual diseases to overall VPD burden (DALY), Western Australia, 2015 (%) 67

Figure A8: Individual VPD burden (DALY per 100,000 population) and rankings, Western Australia, 2005 and 2015 68
Figure A9: Contribution of individual diseases to overall VPD burden (DALY), South Australia, 2015 (%) 69
Figure A10: Individual VPD burden (DALY per 100,000 population) and rankings, South Australia, 2005 and 2015 70
Figure A11: Contribution of individual diseases to overall VPD burden (DALY), Tasmania, 2015 (%) 71
Figure A12: Individual VPD burden (DALY per 100,000 population) and rankings, Tasmania, 2005 and 2015 72
Figure A13: Contribution of individual diseases to overall VPD burden (DALY), Australian Capital Territory, 2015 (%) 73
Figure A14: Individual VPD burden (DALY per 100,000 population) and rankings, Australian Capital Territory, 2005 and 2015 74
Figure A15: Contribution of individual diseases to overall VPD burden (DALY), Northern Territory, 2015 (%) 75
Figure A16: Individual VPD burden (DALY per 100,000 population) and rankings, Northern Territory, 2005 and 2015 76
Figure E1: Q fever burden (DALY per 100,000 population), by age, 2005 and 2015 129
Figure E2: RSV burden (DALY per 100,000 population), by age, 2005 and 2015 131

List of boxes

Box 1.1: Key terms used in this report 4
Box 2.1: Interpreting the results in this report 9

Related publications

The following AIHW publications relating to immunisation might be of interest:

- AIHW 2018. Vaccine-preventable diseases fact sheets. Cat.no PHE 236. Canberra: AIHW.
- AIHW 2018. Immunisation rates for children in 2016–17. Cat.no HPF 16. Canberra: AIHW.
- AIHW 2018. HPV immunisation rates in 2015–16. Cat.no HPF 17. Canberra: AIHW.

This report presents detailed methods and results from the Burden of Vaccine Preventable Diseases in Australia study which focused on diseases with vaccines on Australia's National Immunisation Program (NIP) schedule. The study found the rate of vaccine preventable burden decreased by 31% between 2005 and 2015. The decrease was driven by falls for diseases that have had vaccines added to, or vaccine eligibility extended on, the NIP schedule during the past 20 years, such as HPV, pneumococcal disease and rotavirus.

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