

# Realities of vaccination

## Diseases preventable by vaccines

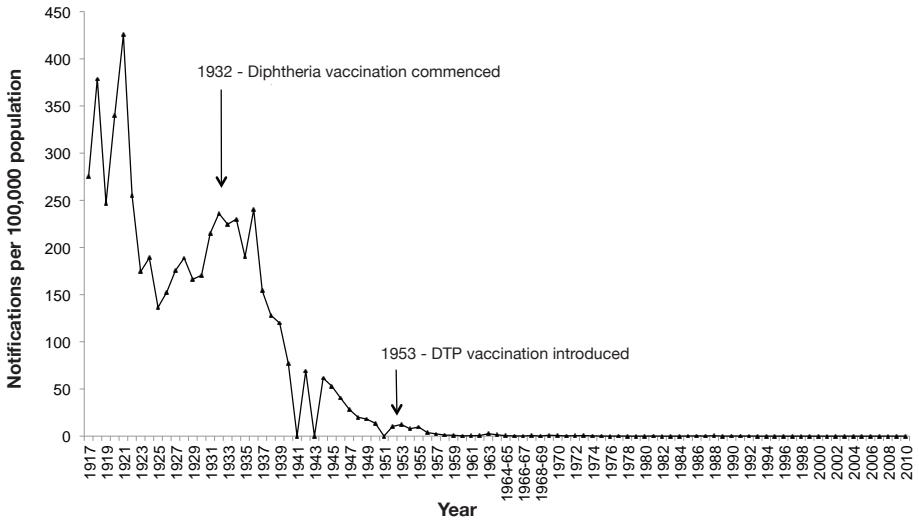
The following section presents data showing the decline in vaccine-preventable diseases in Australia over time (Figures 1 to 10). The majority of the data presented here can be found in the fifth national surveillance report on the epidemiology of vaccine-preventable diseases in Australia, *Vaccine preventable diseases in Australia, 2005 to 2007*, prepared by the National Centre for Immunisation Research and Surveillance (NCIRS). Slides containing figures and tables from the report are available for educational purposes from [www.ncirs.edu.au/immunisation/education/tools/vpd-report-2010.php](http://www.ncirs.edu.au/immunisation/education/tools/vpd-report-2010.php). More recent data on notifications of vaccine-preventable diseases in Australia has been obtained from the 2010 National Notifiable Diseases Surveillance System Annual Report.

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### Diphtheria

Diphtheria is a serious communicable disease caused by strains of the bacterium *Corynebacterium diphtheriae* which produce a toxin that acts on the mucous membranes of the respiratory tract or, less commonly, on damaged skin. Pharyngeal diphtheria is characterised by an inflammatory exudate that forms a greyish or green membrane in the upper respiratory tract which can cause acute severe respiratory obstruction. Life-threatening complications from diphtheria toxin include myocarditis and neuritis (usually affecting motor nerves). Five to 10 per cent of cases are fatal, with the highest death rates occurring in the very young and the elderly.

Although diphtheria has become rare in Australia as a result of vaccination, the potential to encounter the disease remains, especially for travellers. For example, outbreaks of diphtheria have occurred in areas of the former USSR in the last 10 years due to a decline in vaccination rates.

**Figure 1: Diphtheria notification rate and vaccine use, Australia, 1917–2010**

**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

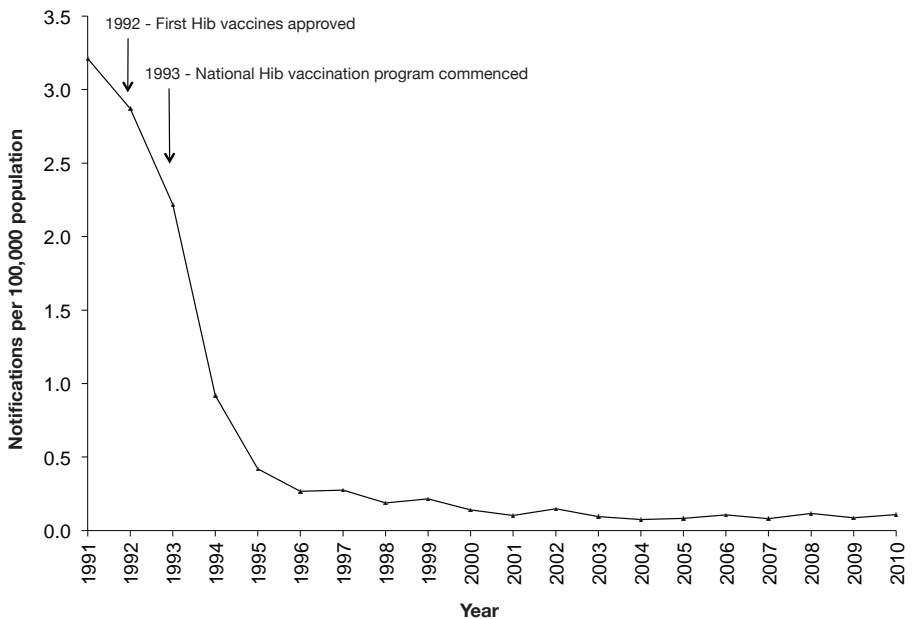
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## *Haemophilus influenzae* type b (Hib)

*Haemophilus influenzae* type b is a bacterium which causes septicaemia, meningitis, epiglottitis and pneumonia. Even with early treatment, five per cent of Hib meningitis cases are fatal, and many survivors have long-term disabilities. Before the introduction of Hib vaccine, there were approximately 500 cases of invasive Hib disease each year in Australia, with 10 to 15 deaths.

Since Hib vaccine has become widely used in Australia, from 1993, the Hib notification rate has declined by more than 95 per cent. There has been a reduction in the number of cases in young children for whom vaccination is targeted, as well as a reduction in the number of cases in older children through herd immunity. Now, there are only around 20 cases of invasive Hib disease every year, and most are in unvaccinated children.

**Figure 2: *Haemophilus influenzae* type b (Hib) notification rate and vaccine use, Australia, 1991–2010**



**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

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## Hepatitis A

Hepatitis A is a virus which causes acute hepatitis. It is transmitted by the faecal–oral route and is easily transmitted from person to person. People with hepatitis A are highly infectious about one week before the symptoms become apparent and remain infectious for a further two weeks, generally following the appearance of jaundice. Infected people can unwittingly spread the disease to others living in the same household before the disease is diagnosed. In developed countries like Australia, the number of hepatitis A cases has declined with improvements in personal hygiene and sanitation. The majority of hepatitis A in Australia is now seen in travellers returning from overseas, particularly from areas in the Middle East, South-east Asia and Eastern Europe. Outbreaks due to contaminated food or water have also been reported. In 2005, routine hepatitis A vaccination was introduced for all Aboriginal and Torres Strait Islander children in the Northern Territory, Queensland, South Australia and Western Australia, where there are the highest population rates of hepatitis A disease.

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## Hepatitis B

Hepatitis B is a virus which causes acute hepatitis. A small proportion of people with acute hepatitis develop chronic infection which can lead to serious complications including liver cirrhosis and liver cancer in later life. Hepatitis B is transmitted by contact with blood and body fluids from an infectious person, for example, by sexual intercourse, injecting drug use or blood transfusion (which is now very rare because of routine blood screening procedures). Hepatitis B can also be transmitted from an infected mother to her baby around the time of birth. This is particularly serious, as the majority of babies infected at birth will become chronically infected with hepatitis B. Chronic infection and its consequences, including cirrhosis and liver cancer, make up most of the disease burden due to hepatitis B in Australia. Newly acquired cases of hepatitis B infection in Australia mostly occur in young

adults, through injecting drug use, skin penetration procedures or sexual contact. A universal infant hepatitis B vaccination program began nationally in 2000. Since then very few cases of new hepatitis B infection have been reported in young children, but the full impact of this program will not be apparent until these children reach older ages and are at higher risk of exposure to the hepatitis B virus. In December 2012, the WHO advised that Australia has achieved the WHO Western Pacific Region's goal of reducing chronic hepatitis B infection rates to less than one per cent among children at least five years of age.

#### Further reading

National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS). Hepatitis B vaccines for Australians: information for immunisation providers (fact sheet). 2012. [www.ncirs.edu.au/immunisation/fact-sheets/index.php](http://www.ncirs.edu.au/immunisation/fact-sheets/index.php) (accessed Jan 2013).

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## Human papillomavirus (HPV)

HPV causes a common and usually asymptomatic viral infection of the genital mucosa which can be transmitted by sexual contact. HPV infection is highly contagious and most people will be infected within a few years of becoming sexually active. Most people clear HPV infection within 12 to 24 months; however, in a small proportion of people, these infections can lead to the development of diseases like cancer. Cancers that are attributable to HPV include cervical and vaginal cancers in women, penile cancer in men, and anal and head and neck cancers which can affect both men and women. HPV types 16 and 18 cause the majority of HPV-associated cancers, while HPV types 6 and 11 cause 90 per cent of genital warts.

There are two available HPV vaccines which both work by preventing the initial HPV infection. One vaccine protects against the most common HPV types associated with cancer and genital warts (HPV 16, 18, 6 and 11) and the other protects against only the HPV types that are associated with the majority of cancers (HPV 16 and 18). Vaccination will not treat or alter

existing HPV infection or disease and, for this reason, is primarily delivered to adolescent boys and girls prior to commencement of sexual activity.

Since the HPV vaccination program was introduced for females in 2007, reductions in HPV infection, genital warts and high-grade pre-cancerous cervical lesions are already being reported in epidemiological studies.

Because HPV vaccine does not provide protection against all HPV types, women who have received an HPV vaccine still require two-yearly cervical Pap screening. Pap screening remains the most important preventive strategy against cervical cancer for women who are sexually active, irrespective of whether they are vaccinated.

#### Further reading

National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS). Human papillomavirus (HPV) vaccines for Australians: information for immunisation providers (fact sheet). 2013. [www.ncirs.edu.au/immunisation/fact-sheets/index.php](http://www.ncirs.edu.au/immunisation/fact-sheets/index.php) (accessed Mar 2013).

Brotherton JM, Fridman M, May CL, et al. Early effect of the HPV vaccination programme on cervical abnormalities in Victoria, Australia: an ecological study. *The Lancet* 2011;377:2085-92.

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## Influenza

Influenza ('the flu') is an infectious disease caused by the influenza virus. The symptoms of influenza include sudden fever, headache, muscle aches and pains, fatigue, cough, sore throat, and stuffy or runny nose. The virus can cause a mild or severe illness depending on the type of influenza virus and general health of the affected person.

People of all ages can become severely ill with influenza and complications following influenza can be fatal, particularly in the elderly and people with an underlying medical condition. In Australia, there are dozens of deaths and thousands of hospitalisations reported every year with influenza recorded as the cause. It is likely that this is an underestimate of the total burden of influenza in the population. The greatest number of hospitalisations due to influenza occurs in children younger than four years of age.

Annual influenza vaccination is provided free for those at greater risk of severe influenza. This includes all people over 65 years of age, Aboriginal and Torres Strait Islander people over 50 years of age, people with underlying medical conditions, and pregnant women.

During a season with good vaccine match, influenza vaccine has been shown to provide approximately 60 per cent to 85 per cent protection against laboratory-confirmed influenza in healthy children less than six years of age and 60 per cent protection against laboratory-confirmed influenza in adults.

#### Further reading

National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS). Influenza vaccines for Australians: information for immunisation providers (fact sheet). 2013. [www.ncirs.edu.au/immunisation/fact-sheets/index.php](http://www.ncirs.edu.au/immunisation/fact-sheets/index.php) (accessed Apr 2013).

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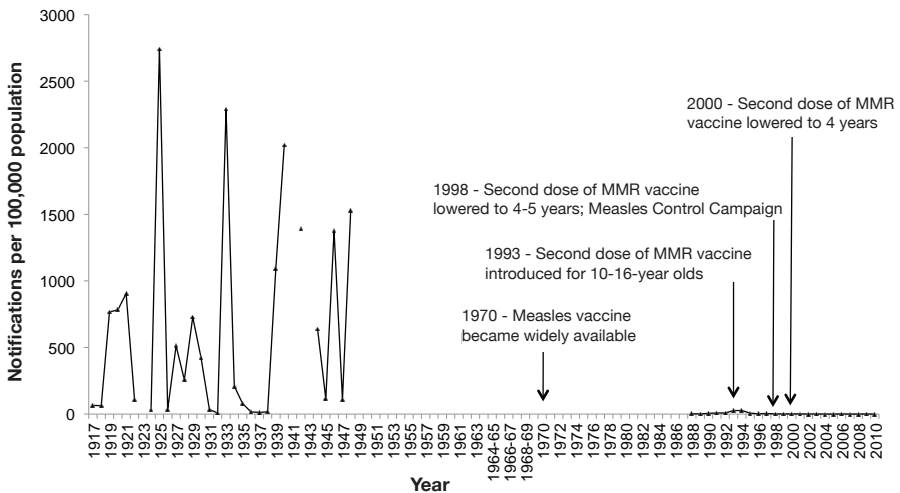
## Measles

Measles is one of the most severe and highly infectious diseases of childhood. In many countries, almost all unvaccinated children will contract measles at some point in their childhood. There has been a marked reduction in measles incidence in countries where vaccine has been widely used. However, it remains a serious and common disease in many parts of the world, including popular holiday destinations for Australians such as South-east Asia and the Pacific Islands.

One in 70 people who get measles will require hospital admission. Measles is complicated by otitis media in five to nine per cent of cases, pneumonia in one to seven per cent of cases, encephalitis in one in 1,000 cases, convulsions in 0.5 per cent of cases, and subacute sclerosing panencephalitis (SSPE) in one in 100,000 cases. SSPE is a delayed response to measles infection, occurring years afterwards, with severe encephalopathy and a uniformly fatal outcome. SSPE does not occur as a result of receiving measles-containing vaccines.

Transmission of measles due to locally acquired cases has not occurred within Australia for some time now and recent cases have involved contact with a person(s) who has acquired measles from overseas. In 2006, there was an increase in measles which was linked to a national tour by a spiritual group. Over 60 cases of measles occurred among people attending these meetings in several Australian cities; most of the people who got measles were unimmunised. Similarly, outbreaks of measles occurred in New South Wales in 2011 and 2012, almost all in unimmunised people, and arose from imported cases of measles, highlighting the importance of maintaining high vaccine coverage to prevent re-introduction of the disease.

**Figure 3: Measles notification rate and vaccine use, Australia, 1917–2010**



**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

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Australian Technical Advisory Group on Immunisation. *The Australian Immunisation Handbook*. 10th ed. Canberra: Australian Government Department of Health and Ageing; 2013.

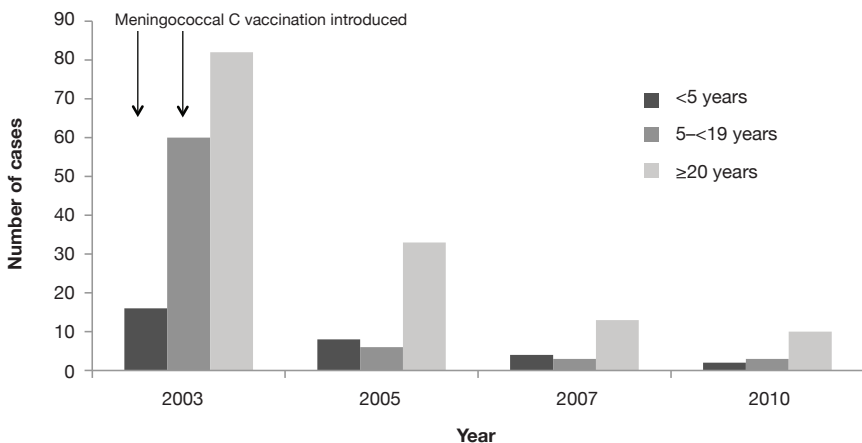


## Meningococcal disease

*Neisseria meningitidis* (meningococcus) is a bacterium that can cause meningitis and septicaemia and which only infects humans. About 10 per cent of cases are fatal, despite early and appropriate treatment. About 10 per cent of the population at any given time will carry meningococci in their upper respiratory tract. Factors associated with an increased risk of carriage include smoking and living in crowded conditions.

Prior to the introduction of meningococcal serogroup C vaccine, most of the clusters of meningococcal disease that occurred were due to this serogroup. The introduction of effective vaccines against serogroup C in 2003 has resulted in a dramatic decrease in the number of serogroup C cases among age groups for whom vaccination was provided (up to 19 years), as well as fewer cases in older age groups through herd immunity. Most cases of meningococcal disease in Australia now are due to serogroup B organisms, a vaccine for which is still to be approved for use in Australia; research into development of a serogroup B vaccine is ongoing.

**Figure 4: Cases of meningococcal C disease before and after introduction of routine vaccination in 2003, Australia, by age group**



**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

Updated with data from: the National Notifiable Diseases Surveillance System, available at [www9.health.gov.au/cda/source/cda-index.cfm](http://www9.health.gov.au/cda/source/cda-index.cfm) (accessed Jan 2013).

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Lahra MM, Enriquez RP. Annual report of the Australian Meningococcal Surveillance Programme, 2011. *Communicable Diseases Intelligence* 2012;36:E251-62.

National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS). Meningococcal vaccines for Australians: information for immunisation providers (fact sheet). 2009. [www.ncirs.edu.au/immunisation/fact-sheets/index.php](http://www.ncirs.edu.au/immunisation/fact-sheets/index.php) (accessed Jan 2013).

## Mumps

Mumps is a viral disease that causes a febrile illness, often with swelling of the parotid glands, and sometimes with complications such as orchitis, pancreatitis, hepatitis, and inflammation of other organs or glands. Nerve deafness is a serious but rare complication.

There was a considerable increase in the number of mumps cases in Australia during 2007 due to a mumps outbreak in two Indigenous communities in the Northern Territory and an increase in the number of cases in Western Australia and, to a lesser extent, New South Wales. Over 90 per cent of cases were in adolescents or young adults, with 50 per cent in those 20 to 34 years of age.

Two doses of mumps-containing vaccine, usually given as MMR vaccine, are highly effective at preventing mumps infection. Following the introduction of universal vaccination against mumps in the early 1980s, the annual number of cases of mumps reported in Australia declined. However, since 2004 in Australia, there has been an increase in mumps cases in adolescents and young adults who have received no doses or only one dose of MMR vaccine because they were too young to be vaccinated as part of the Australian Measles Control Campaign in the late 1990s and the subsequent Young Adults MMR program in 2001. It is for this reason that people born

after 1966 who are not immune or who have not previously received two doses of mumps-containing vaccine should receive MMR vaccine at an opportune occasion.

From 2013, a quadrivalent vaccine against measles, mumps, rubella and varicella (MMRV) is also available in Australia.

#### Further reading

National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS). Vaccines for Australian adults: information for immunisation providers (fact sheet). 2012. [www.ncirs.edu.au/immunisation/fact-sheets/index.php](http://www.ncirs.edu.au/immunisation/fact-sheets/index.php) (accessed Jan 2013).

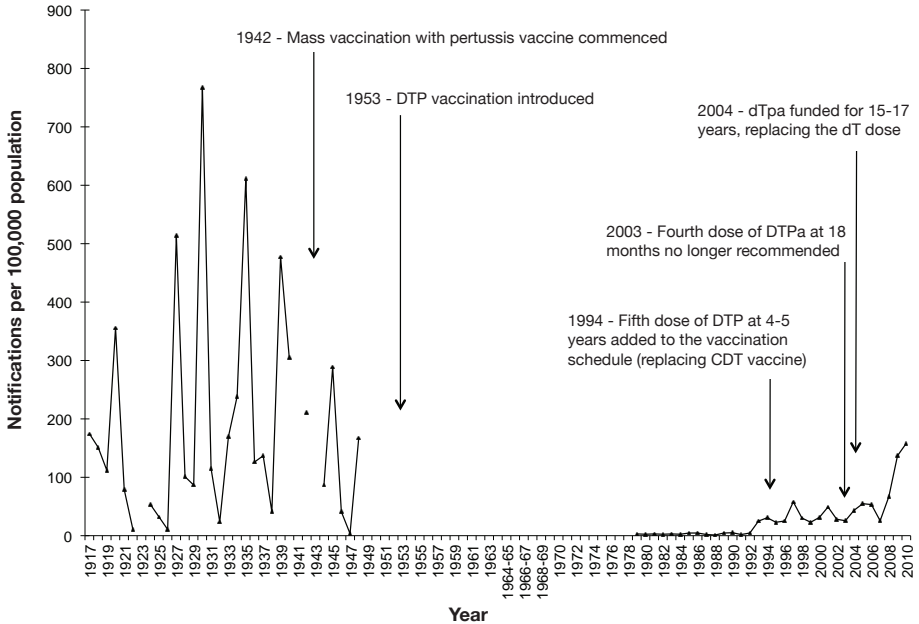
## Pertussis ('whooping cough')

Pertussis is a very infectious disease. In a household where someone has pertussis, up to 90 per cent of unimmunised contacts of that person will acquire the disease. Over the last decade in Australia, the mortality rate of pertussis was less than 0.1 per 1 million individuals, while in babies under one year of age, the pertussis mortality rate was substantially higher (4.7 per million infants). Young infants also have the highest rates of hospitalisation and complications from the disease.

Pertussis can cause significant disease symptoms, particularly in infants. The cough may persist for six months or more and lead to sleep disturbance and significant weight loss. Severe complications, which occur almost exclusively in unvaccinated people, include seizures and pneumonia. Increasing vaccination coverage has been associated with big reductions in disease in children in the age group for whom vaccination is targeted. However, large numbers of cases continue to occur in older people. Pertussis epidemics every two to three years were a regular occurrence in the pre-vaccine era. Even though there has been a resurgence in the number of pertussis cases since the 1990s, the number is still much lower than was seen in the pre-vaccine era, despite more cases being diagnosed due to much more sensitive tests for pertussis being used and available in recent years. Deaths from pertussis, although sadly still occurring in unvaccinated young infants,

are far less common than in the pre-vaccine era (see Figure 11), despite big increases in the Australian population since that time.

**Figure 5: Pertussis notification rate and vaccine use, Australia, 1917–2010**



**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

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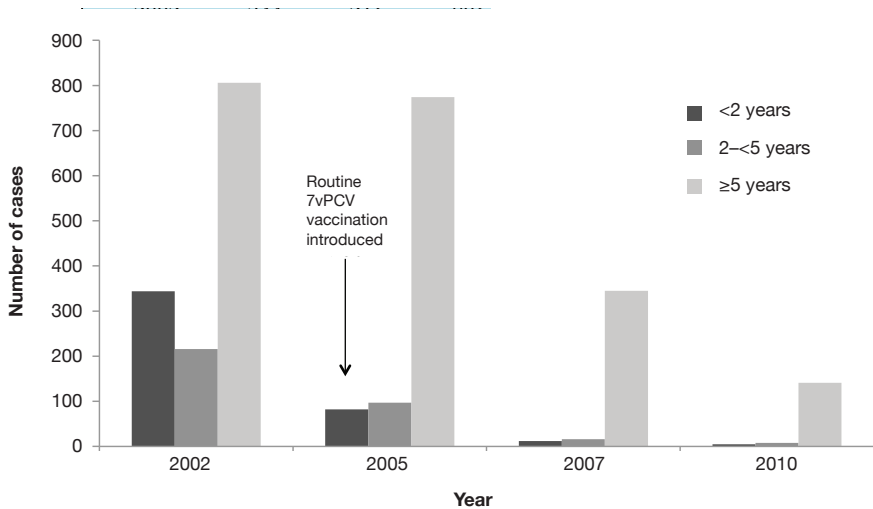
## Pneumococcal disease

The bacteria *Streptococcus pneumoniae*, also known as pneumococcus, causes a range of infections including pneumonia, bacteraemia, sepsis, meningitis and otitis media. The most severe infections, bacteraemia and meningitis, are jointly referred to as invasive pneumococcal disease (IPD) and are primarily the diseases that vaccination aims to prevent. There are over 90 serotypes of *S. pneumoniae* which can cause disease. However, only some are responsible for the majority of IPD cases and therefore included in vaccine formulations. Children under two years of age and the elderly are most susceptible to IPD.

From January 2005, a pneumococcal vaccine protecting against seven of the pneumococcal serotypes, 7-valent pneumococcal conjugate vaccine (7vPCV), was routinely offered to all infants via the National Immunisation Program, together with catch-up vaccination for all children under two years of age. High vaccination uptake of over 90 per cent has been maintained since the inception of universal infant pneumococcal vaccination. In the first year (2005) the number of cases due to the pneumococcus types in the vaccine declined dramatically, especially in children in the primary target age group (under two years). By 2007, case numbers had significantly fallen even in those over five years of age who were not vaccinated.

The 7vPCV is no longer available in Australia and was replaced in mid-2011 by a pneumococcal vaccine protecting against 13 pneumococcal serotypes (13vPCV), made by the same manufacturer.

**Figure 6: Cases of pneumococcal disease due to vaccine serotypes before and after introduction of routine 7vPCV vaccination in 2005, Australia, by age group**



**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

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Australian Government Department of Health and Ageing. Immunise Australia Program. Pneumococcal disease. 2012. [www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/immunise-pneumococcal](http://www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/immunise-pneumococcal) (accessed Jan 2013).

Williams SR, Mernagh PJ, Lee MH, Tan JT. Changing epidemiology of invasive pneumococcal disease in Australian children after introduction of a 7-valent pneumococcal conjugate vaccine. *Medical Journal of Australia* 2011;194:116-20.

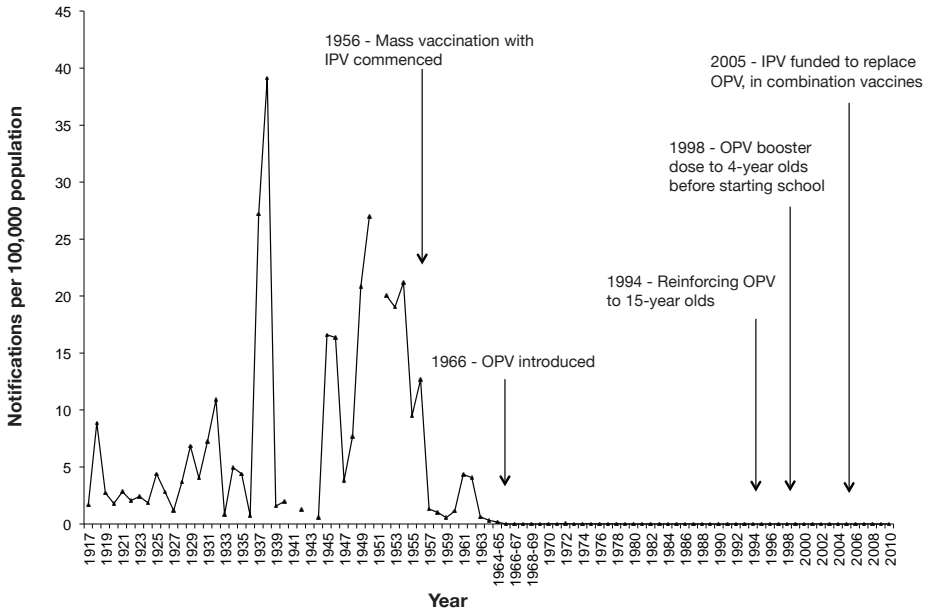
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## Poliomyelitis ('polio')

Polio is caused by a virus which commonly results in mild or asymptomatic illness. In approximately one per cent of cases, acute flaccid paralysis may occur due to a specific effect on the motor nerves in the spinal cord. There may be as many as 75 cases of asymptomatic infection for each paralytic case in adults and up to 1,000 cases of asymptomatic infection for each paralytic case in children, depending on the virus type, age of the population and environmental conditions. For the last 30 years, there has been no transmission of wild-type poliovirus locally in Australia; however, there is a continued risk of importation of polio from overseas. This was exemplified in 2007 when a person returning back to Australia from Pakistan flew while ill with poliomyelitis. The patient recovered from mild paralytic poliomyelitis. However, as a precautionary measure, people on the same flight were notified and offered vaccination. This is an important reminder of the need to maintain high vaccination coverage with polio vaccine.

The WHO planned to achieve global eradication of polio by the year 2005, but recent outbreaks in Africa and several South-east Asian countries have delayed achievement of this goal. As of 2012, only three countries (Afghanistan, Nigeria and Pakistan) still have endemic polio, meaning polio is still consistently present in these countries. In 2012, the Global Polio Eradication Initiative, spearheaded by the WHO, launched their Eradication and Endgame Strategic Plan 2013–2018 which outlines a long-term strategy to deliver a polio-free world by 2018.

Figure 7: Polio notification rate and vaccine use, Australia, 1917–2010



Source: Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

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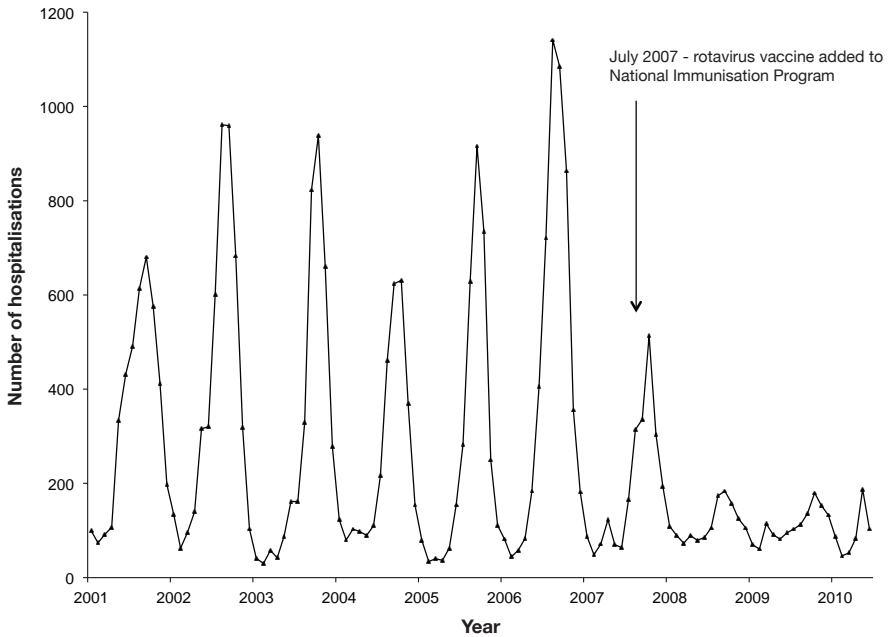
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## Rotavirus

Rotavirus is a common cause of gastroenteritis. The virus is transmitted by the faecal–oral route. Large numbers of viral particles are shed in the faeces and, because the virus is stable in the environment, contamination of hands and objects (fomites) commonly helps spread the virus. Rotavirus infection occurs despite very high standards of hygiene.

Rotavirus is the most common cause of severe diarrhoea in young children worldwide. In addition to diarrhoea, rotavirus infection can also result in vomiting, fever and acute dehydration. Prior to the introduction of rotavirus vaccination, it is estimated that there were approximately 10,000 hospitalisations due to rotavirus in children under five years of age each year in Australia. This translates to approximately one in 27 children being hospitalised with rotavirus gastroenteritis by the age of five years. On average, there are two deaths due to rotavirus each year in Australia.

Rotavirus vaccine first became available in Australia in 2006 and is given orally in the first few months of life. Vaccination prevents rotavirus gastroenteritis of any severity. However, it has a particular impact on severe rotavirus gastroenteritis (that would require a visit to a doctor or emergency department) and rotavirus hospitalisations. Following the introduction of funded routine rotavirus vaccination in 2007 there has been a marked decline in hospitalisations due to rotavirus in Australia. The impact of rotavirus vaccine is further discussed in the section ‘Safety concerns: Specific vaccines’.

**Figure 8: Rotavirus hospitalisations and vaccine use, Australia, 2001–2010**

**Source:** Dey A, Wang H, Menzies R, Macartney K. Changes in hospitalisations for acute gastroenteritis in Australia after the national rotavirus vaccination program. *Medical Journal of Australia* 2012;197:453-7.

#### Further reading

National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS). Rotavirus vaccines for Australian children: information for immunisation providers (fact sheet). 2009. [www.ncirs.edu.au/immunisation/fact-sheets/index.php](http://www.ncirs.edu.au/immunisation/fact-sheets/index.php) (accessed Jan 2013).

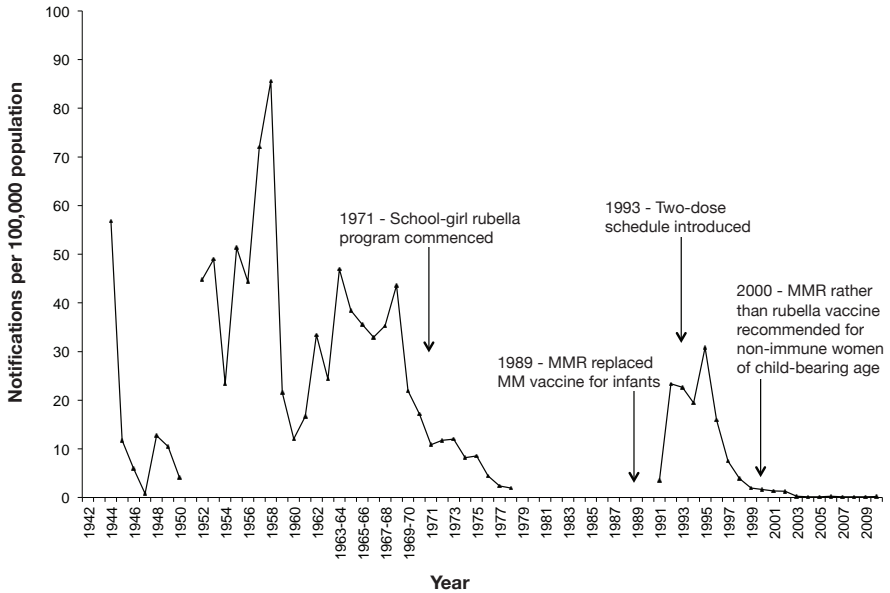
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## Rubella

Rubella is a viral illness that is generally mild, with fever, rash and lymphadenopathy. Some adults who develop rubella can also develop severe arthritis. The greatest risk from rubella is due to infection occurring early in pregnancy. Congenital rubella syndrome occurs in up to 90 per cent of infants born to women who are infected during the first 10 weeks of pregnancy and may result in malformations and death.

Increased vaccination rates have led to a steady fall in the number of rubella cases, and the incidence of congenital rubella syndrome, as most people have received two doses of rubella-containing vaccine, given as MMR vaccine. However, it is still important that women considering becoming pregnant should be checked for rubella immunity and vaccinated if necessary. Checking for immunity to rubella during pregnancy is also recommended. Vaccination of both males and females is important to provide ongoing herd immunity against rubella.

Figure 9: Rubella notification rate and vaccine use, Australia, 1942–2010



**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

Updated with data from: NNDSS Annual Report Writing Group. Australia's notifiable disease status, 2010: annual report of the National Notifiable Diseases Surveillance System. *Communicable Diseases Intelligence* 2012;36:1-69. [www.health.gov.au/internet/main/publishing.nsf/content/cda-cdi3601-pdf-cnt.htm/\\$FILE/cdi3601a.pdf](http://www.health.gov.au/internet/main/publishing.nsf/content/cda-cdi3601-pdf-cnt.htm/$FILE/cdi3601a.pdf)

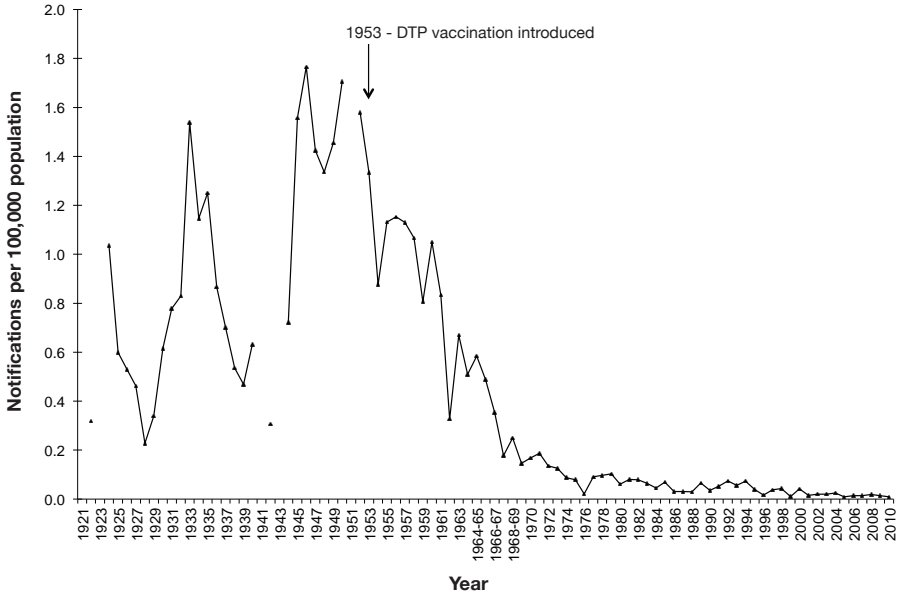
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## Tetanus

Tetanus is an acute, often fatal, disease caused by the toxin of the bacterium *Clostridium tetani*. This neurotoxin acts on the central nervous system causing muscle rigidity with painful spasms. The disease usually occurs after an incubation period of 3 to 21 days but this may range from one day to several months. Death may result from respiratory failure, hypertension, hypotension or cardiac arrhythmia. Tetanus only affects the person who is infected and cannot be passed from person to person. The bacterium is found in soil everywhere and tetanus can follow apparently trivial, even unnoticed, wounds. The only means of protection against tetanus is through vaccination. In Australia, tetanus vaccination is provided as part of the diphtheria-tetanus-pertussis vaccine (DTPa). Even people who have had tetanus disease previously can remain susceptible, so vaccination is also still important for them.

In Australia, tetanus is now rare, occurring primarily in older adults who have never been vaccinated or who were vaccinated many years previously. During 2005–2006 (the latest period for which data on reported deaths is available), there was one death from tetanus, in a person aged over 60 years.

Figure 10: Tetanus notification rate and vaccine use, Australia, 1921–2010



**Source:** Chiu C, Dey A, Wang H, et al. Vaccine preventable diseases in Australia, 2005 to 2007. *Communicable Diseases Intelligence* 2010;34(Suppl):S1-167. [www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm](http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdi34suppl.htm)

Updated with data from: NNDSS Annual Report Writing Group. Australia's notifiable disease status, 2010: annual report of the National Notifiable Diseases Surveillance System. *Communicable Diseases Intelligence* 2012;36:1-69. [www.health.gov.au/internet/main/publishing.nsf/content/cda-cdi3601a.pdf](http://www.health.gov.au/internet/main/publishing.nsf/content/cda-cdi3601a.pdf)

## Varicella ('chickenpox')

Varicella, or chickenpox, is a highly infectious disease caused by the varicella-zoster virus (VZV), one of eight herpes viruses that cause illness in humans. Like other herpes viruses, such as the virus that causes cold sores (HSV), VZV has the unusual ability to establish a latent infection in nerve ganglions, which can later reactivate. Reactivation of VZV causes shingles (herpes zoster).

Varicella is generally a benign, self-limiting illness in children. Before varicella vaccine became available almost all children got chickenpox, so that even a small *proportion* of children experiencing complications meant that a large *number* of children required hospitalisation due to complications from varicella. These complications include secondary bacterial infection (most commonly cellulitis and bacteraemia), meningitis, encephalitis and pneumonia.

Vaccination of children against chickenpox not only prevents serious or complicated disease in childhood but also ensures that immunity is provided prior to reaching adolescence and adulthood when complications from the disease occur more commonly and can result in more severe outcomes. In the first 2.5 years following inclusion of varicella vaccine on the NIP in late 2005, there was a 69 per cent decline in varicella hospitalisations in children 18 months to 4 years of age.

From July 2013, varicella vaccine is available as both the monovalent vaccine and as part of the combined MMRV vaccine.

### Further reading

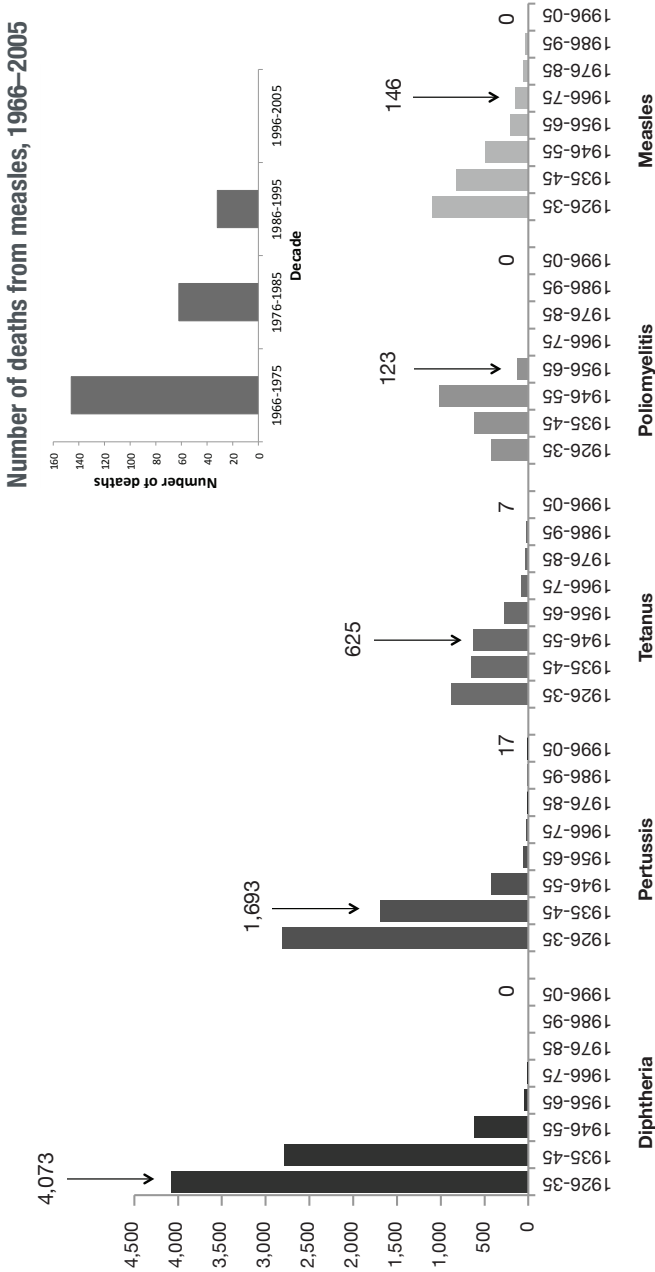
National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases (NCIRS). Varicella-zoster (chickenpox) vaccines for Australian children: information for immunisation providers (fact sheet). 2009. [www.ncirs.edu.au/immunisation/fact-sheets/index.php](http://www.ncirs.edu.au/immunisation/fact-sheets/index.php) (accessed Jan 2013).

## Deaths from vaccine-preventable diseases

Figure 11 shows the most recent data available on the number of deaths recorded on death certificates as being caused by diphtheria, pertussis, tetanus, polio and measles in Australia in the decades between 1926 and 2005. This is the only source of data on these diseases which has been available at the national level over such a long period. The decade in which vaccines against each of these diseases were introduced is depicted by the arrow in each figure; however, it is important to note that this may have been the beginning or end of the decade. Improvements over time in the general health of the population and in medical care are also important factors. In the case of polio, improvements in hygiene and sanitation meant that adults were not being exposed to polio as children, and in turn, there was limited immunity in the population which led to increases in polio cases and deaths in the years before vaccine introduction. After the vaccine was introduced at the beginning of the decade 1956–1965, the number of cases fell dramatically during that decade compared with the one before. By contrast, deaths due to measles were falling due to antibiotics and improved hospital care prior to vaccine introduction in 1970; however, following widespread vaccination, deaths fell to zero by the decade starting in 1996 (see Figure 11 inset). Most dramatic of all is the disappearance of deaths due to diphtheria which was one of the major causes of child mortality before vaccines were available.



Figure 11: Number of deaths from diseases now vaccinated against in Australia, by decade, 1926–2005



Sources: Feery B. One hundred years of vaccination. *New South Wales Public Health Bulletin* 1997;8:61-3; Feery B. Impact of immunisation on disease patterns in Australia. *Medical Journal of Australia* 1981;2:172-6. Deaths recorded for 1966–1975 and 1996–2005 updated with data from the AIHW National Mortality Database.

## Vaccine composition

Vaccines are designed to provide protection against a disease without the risks or complications of the disease itself. The composition of the vaccine may vary from a weakened strain of an otherwise infective agent, such as an attenuated virus, to a non-infectious component of the infective agent (see 'Bacteria and viruses' below). In addition to containing a modified form of the bacteria, virus or toxin that induces immunity against a specific disease, some vaccines contain other substances that are either added during the manufacturing process (see 'Additives' below) or are residual components that remain as a result of the way in which the vaccine is manufactured (see 'Remnants from manufacturing' below).

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### Bacteria and viruses

The great majority of current vaccines protect against either viruses or bacteria and are made in one of the following ways.

#### Attenuating the virus

The live viruses used in vaccines are weakened (or attenuated) so that they reproduce themselves in only a very limited way inside the body. Examples of live attenuated viral vaccines are the measles, mumps, rubella, varicella and rotavirus vaccines. Fully potent viruses (known as natural or 'wild-type' viruses) cause disease by reproducing themselves many thousands or millions of times in the body's cells. However, vaccine viruses usually reproduce fewer than 20 times. Vaccine viruses replicate just well enough to cause the immune system to produce protective antibodies and to make very long-lived 'memory B cells' that remember the infection and produce more antibodies if the natural infectious virus is encountered in the future.

The advantage of live, attenuated vaccines is that only one or two doses of vaccine usually provide life-long immunity. The limitation of this approach is that these vaccines cannot be given to people with severely impaired immunity, as a greatly weakened immune system may not be able to limit the reproduction of the vaccine virus.

## Inactivating the virus

Some viruses in vaccines are completely inactivated (or killed) with a chemical, often formaldehyde. The virus, or part of the virus, that is killed cannot possibly reproduce itself or cause disease but is still recognised by the body's immune system. The inactivated polio and hepatitis A vaccines are made this way.

The strength of this approach is that the vaccine does not cause even a mild form of the disease that it prevents, and these vaccines can be given to people with impaired immunity. The limitation of this approach is that sometimes several doses must be given to achieve immunity, and people with impaired immunity may not respond to even multiple doses.

## Using part of the virus or bacterium

The part of the virus or bacterium required to 'induce immunity' is identified and separated from the part which causes disease symptoms. The hepatitis B, Hib, and HPV vaccines are examples of vaccines produced in this way. In the case of hepatitis B, the vaccine is composed of a protein from the surface of the virus. In the case of the Hib vaccine, only the outer coat (or polysaccharide) is used, joined to another protein so that the immune system responds to it.

These vaccines can be given to people with impaired immunity, although this is not always recommended if the person's immune system is too weak to develop a good response.

## Using a toxin produced by the bacteria

Some vaccines are manufactured by taking specific bacterial toxins (those which cause the most serious manifestations of the particular disease) and inactivating them with a chemical. The toxin is called a 'toxoid' once it is inactivated in the vaccine. Diphtheria and tetanus vaccines are made from toxoids. In the case of tetanus, a small amount of toxin can cause disease but even having tetanus disease does not induce protective antibody. The only way to be protected against tetanus is to be vaccinated using several doses of tetanus toxoid.

## Additives

Additives are used in vaccines for several reasons, such as to stabilise vaccines in adverse conditions (e.g. temperature extremes of heat and freeze drying), to improve the immune response to the vaccine, to prevent the vaccine components adhering to the side of the vial, and to prevent fungal or bacterial contamination of the vaccine. Examples of additives include lactose and sucrose (both sugars), glycine and monosodium glutamate (both are amino acids or salts of amino acids), human or bovine serum albumin (both are proteins), and gelatin. These additives ensure that vaccines remain safe and effective.

### Stabilisers

Some vaccines contain stabilisers to maintain the vaccine's safety and effectiveness under different conditions and temperatures. Gelatin and lactose-sorbitol are examples of stabilisers.

### Adjuvants

Adjuvants are chemicals added to vaccines to enhance the body's immune response to a vaccine. Various forms of aluminium salts are commonly used as adjuvants in vaccines. A recent review of all available studies of aluminium-containing diphtheria, tetanus and pertussis vaccines (either alone or in combination) found that there was no evidence that aluminium salts in vaccines cause any serious or long-term adverse events. This is discussed in more detail in the section 'Vaccine manufacture and testing'.

### Diluents

A diluent is a liquid used to dilute a vaccine to the proper concentration. In vaccines, this is usually sterile saline or water.

### Preservatives

Preservatives are included in some vaccines to prevent fungal or bacterial contamination. Preservatives are mostly used in vaccines that are manufactured in multi-dose vials, to prevent contamination after

the vial is opened; however, multi-dose vials are not routinely used in Australia. Examples of preservatives are thiomersal (also spelt thimerosal), phenoxyethanol and phenol. Thiomersal is a mercury-containing compound and is discussed in more detail in the section 'Safety concerns: General'. Phenoxyethanol is an aromatic ether alcohol and is also used as a preservative in cosmetics.

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## Remnants from manufacturing

Chemicals are often used during the vaccine manufacturing process and then removed from the final product. For example, formaldehyde might be used to kill a vaccine virus, or antibiotics might be used to prevent bacterial contamination while growing viruses in the laboratory. When these chemicals are removed, sometimes a trace amount may remain. While some of these chemicals might be harmful in large doses, the trace amounts left in vaccines are too small to have a toxic effect.

### Further reading

Eldred BE, Dean AJ, McGuire TM, Nash AL. Vaccine components and constituents: responding to consumer concerns. *Medical Journal of Australia* 2006;184:170-5.

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