

3.26 ZOSTER (Herpes zoster)

Virology

Varicella-zoster virus (VZV) is a DNA virus that is a member of the herpesvirus family. Primary infection with VZV is known as varicella or 'chickenpox'.¹ Herpes zoster (HZ) or 'shingles' is caused by reactivation of latent VZV which typically resides in the dorsal root or trigeminal ganglia following primary infection with VZV.¹

Clinical features

Reactivation of VZV causing HZ is thought to be due to a decline in cellular immunity to the virus, and presents clinically as a unilateral vesicular rash in a dermatomal distribution in the majority of cases. It is often painful and lasts 10 to 15 days in most cases.^{1,2} A prodromal phase occurs 48 to 72 hours prior to the appearance of the lesions in 80% of cases.³ Associated symptoms may include headache, photophobia, malaise, and an itching, tingling, or severe pain in the affected dermatome.^{2,4} In the majority of patients, HZ is an acute and self-limiting disease. However, complications can occur, especially with increasing age.

Post-herpetic neuralgia (PHN), the most frequent debilitating complication of HZ, is a neuropathic pain syndrome that persists or develops after the dermatomal rash has healed. By definition, PHN is established when pain persists for longer than 3 months after the onset of the rash.^{5,6} Other complications may occur depending on the site of reactivation. These include ophthalmic disease (such as keratitis and chorioretinitis), neurological complications (such as meningoencephalitis and myelitis), secondary bacterial skin infection, scarring and pneumonia.⁷ Rarely, disseminated HZ may develop with visceral, central nervous system, and pulmonary involvement. Disseminated disease is more common in people with impaired immunity.⁴ Dermatomal pain without the appearance of rash is also documented (zoster sine herpète).

Antiviral therapy, if initiated within 3 days of the onset of HZ, has been shown to reduce the severity and duration of HZ and may reduce the risk of developing PHN.⁸⁻¹² However, despite medical therapy, PHN may persist for years and may be refractory to treatment.¹³

Epidemiology

HZ occurs most commonly with increasing age (>50 years), impaired immunity, and a history of varicella in the first year of life. The lifetime risk of reactivation of VZV causing HZ is estimated to be approximately 20 to 30% and it affects half of those who live to 85 years.^{1,14-16} Second attacks of HZ occur in <5% of immunocompetent individuals, but are more frequent in individuals with impaired immunity.^{2,17} Internationally, average incidence rates of HZ in the total population vary from 130 to 405 cases per 100 000 person-years depending on the study population.^{18,19} Australian data on the incidence of HZ in the community are limited. However, using general practice and other data, approximately 490 cases per 100 000 population (range 330–830 per 100 000) are estimated to occur annually and approximately 1000 cases per 100 000 population in persons aged 50 years and older.²⁰⁻²³ In the large efficacy study of zoster vaccine, the incidence of HZ in unimmunised participants ≥60 years of age was 1112 cases per 100 000 person-years.²⁴ The incidence of HZ increases with impaired immunity; for example, rates of HZ are up to 15 times higher in those with impaired immunity due to HIV infection, and, in the first year following haematopoietic stem cell transplantation (HSCT), up to 30% of patients may develop HZ.^{2,25}

Overall, an estimated 13 to 26% of patients with HZ develop complications. Complications occur more frequently with increasing age, and with impaired immunity.^{26,27} PHN occurs infrequently in young people, but, in patients over the age of 50 years, it complicates HZ in 25 to 50% of cases.¹

Modelling the outcomes of the introduction of a universal childhood vaccination schedule for varicella has predicted a rise in the incidence of HZ, based on the assumption that exposure to wild-type VZV circulating in the community boosts immunity.²⁸ However, to date, multiple studies and surveillance data do not demonstrate any consistent changes in overall HZ incidence in the United States which has a universal varicella vaccination program that commenced in 1995.^{19,29} The incidence of HZ in children <10 years of age has declined, indicating that HZ rates are lower in varicella vaccine recipients.^{1,29}

In Australia, surveillance for varicella and HZ is currently being implemented in order to track the burden of VZV-related diseases.³⁰ South Australia has conducted passive surveillance of varicella and HZ since January 2002.

Vaccine

Zostavax is a live attenuated vaccine formulated from the same VZV vaccine strain (Oka/Merck) as the licensed varicella (chickenpox) vaccine, Varivax, but is of higher potency (on average, at least 14 times greater). The higher viral titre in Zostavax is required to elicit a boost in immune response in adults who usually remain seropositive to VZV following primary infection, but have declining cellular immunity with increasing age.³¹ The licensed varicella vaccines are *not* indicated for use in preventing HZ in older people and Zostavax is *not* indicated for use in younger people who have not been previously immunised or infected with VZV. Zostavax is not indicated for use for therapeutic benefit during an acute HZ episode, nor for the treatment of PHN.

Several randomised placebo-controlled trials conducted during the clinical development of Zostavax confirmed that vaccine at potencies above 19 400 plaque-forming units (PFU) of VZV stimulated both virus-specific antibodies and a cell-mediated immune response.^{24,31-33} A single large, randomised, double-blind, placebo-controlled efficacy study of the frozen formulation of Zostavax (known as the 'Shingles Prevention Study' [SPS]) was conducted among 38 546 adults aged ≥ 60 years and demonstrated that Zostavax significantly reduced the likelihood of developing both HZ and PHN.²⁴ Overall, compared with placebo, vaccination reduced the incidence of HZ by 51.3% (95% CI: 44.2%–57.6%), the incidence of PHN by 66.5% (95% CI: 47.5%–79.2%), and the burden of illness associated with HZ by 61.1% (95% CI: 51.1%–69.1%) over a median of >3 years follow-up.²⁴ The vaccine was more efficacious in reducing HZ in people aged 60–69 years (64% [95% CI: 56%–71%]) compared with people aged 70–79 years (41% [95% CI: 28%–52%]). However, efficacy against PHN was similar in both age groups.²⁴ Vaccine efficacy against HZ in the ≥ 80 years age group was lower (18% [95% CI: -29%–48%]) and not statistically different to placebo. However, there were fewer participants of this age in the SPS.³⁴ In those people who developed HZ despite vaccination, the severity of pain associated with the episode was also reduced. Many of the participants in the SPS received antiviral and pain medication, suggesting that the effect of the vaccine was in addition to any benefit obtained from medical therapy.

The Shingles Prevention Study, together with other smaller studies, demonstrated that Zostavax is safe and generally well tolerated among adults ≥ 50 years of age.^{24,33} In the SPS, the most common adverse events were injection site reactions, with Zostavax more likely to result in erythema, pain, and swelling at the injection site compared with placebo (48% vs 17%, respectively). Varicella-like rashes at the injection site were also more common; however, varicella-like rash not localised to the injection site did not occur more often. Varicella- or zoster-like rashes that were PCR positive for VZV were mostly due to wild-type VZV.^{24,33} The incidence of fever was no greater in vaccine recipients; however, the rate of vaccine-related systemic symptoms was greater in vaccinees (Zostavax 6.3% vs placebo 4.9%), with the most frequently reported systemic symptoms being headache and fatigue.^{24,35}

In Australia, a refrigerated form of Zostavax is registered on the basis of comparable immunogenicity and safety to the frozen vaccine formulation that was used in the single large efficacy study.³⁵ Similarly, Zostavax is licensed for use in people 50–59 years of age based on a study that demonstrated similar immunogenicity in this age group compared with those ≥ 60 years of age.³⁵ There have been no efficacy studies of Zostavax in people <60 years of age. A study of the simultaneous administration of Zostavax with inactivated influenza vaccine (given separately and at different injection sites) demonstrated comparable immunogenicity and safety to giving the vaccines at different times.³⁶ A study of the simultaneous administration of Zostavax with 23-valent pneumococcal polysaccharide vaccine (Pneumovax 23) suggested that the immunogenicity of Zostavax might be reduced when administered simultaneously with Pneumovax 23, compared with administration 4 weeks apart.³⁷ The immunogenicity of Pneumovax 23 was not affected.

- **Zostavax** – CSL Biotherapies/Merck & Co Inc (lyophilised preparation of live attenuated Oka/Merck strain of varicella-zoster virus). Each 0.65 mL monodose of the reconstituted, lyophilised vaccine contains not less than 19 400 plaque-forming units of Oka/Merck strain of VZV when stored at room temperature for up to 30 minutes; 41.05 mg sucrose; 20.53 mg gelatin; 8.55 mg urea; 5.25 mg sodium chloride; 0.82 mg monosodium L-glutamate; 0.75 mg sodium phosphate dibasic; 0.13 mg potassium phosphate monobasic; 0.13 mg potassium chloride; residual

components of MRC-5 cells; trace amounts of neomycin and fetal bovine serum from MRC-5 culture media. The product contains no preservatives.

Transport, storage and handling

Zostavax, and all VZV vaccines, are less stable than other commonly used live viral vaccines, and adherence to storage and reconstitution requirements is very important. Store at +2°C to +8°C. Protect from light. Do not freeze. After reconstitution, use within 30 minutes at ambient temperature (+20°C to +25°C) to maintain potency.

Transport according to *National Vaccine Storage Guidelines: Strive for 5*.³⁸

Dosage and administration

The dose of Zostavax is 0.65 mL, administered by SC injection.

Zostavax vaccine can be given at the same time as influenza vaccine,³⁶ using separate syringes and injection sites. Simultaneous administration of Zostavax with pneumococcal polysaccharide vaccine should be avoided where possible; the two vaccines should preferably be given at least 4 weeks apart. However, inadvertent administration of Zostavax and pneumococcal polysaccharide vaccine at the same time or at an interval of less than 4 weeks apart does not require revaccination. (see 'Vaccine' above). Zostavax can be administered at the same visit or at any time following receipt of other inactivated vaccines, eg. tetanus-containing vaccines, if required. If administration of both Zostavax and another live parenteral vaccine (eg. MMR or yellow fever) is indicated, the vaccines should be given either on the same day, or at least 4 weeks apart. (See also Chapter 3.24, *Varicella*.)

Recommendations

(i) Adults ≥60 years of age (*Safety-Grade B*)(*Efficacy-Grade B*)(*Immunogenicity-Grade B*)³³

A single dose of zoster vaccine is recommended for adults ≥60 years of age who have not previously received a dose of zoster vaccine. Serologic testing prior to receipt of zoster vaccine is not indicated and it is not necessary to elicit a history of previous varicella (chickenpox) infection (see (vi) below).

People with chronic medical conditions, such as arthritis, chronic renal failure, diabetes and other conditions, can receive zoster vaccine, unless a contraindication or precaution exists due to their condition or medical treatment (see 'Contraindications' and 'Precautions' below). People with significantly impaired immunity should *not* receive zoster vaccine (see also Section 2.3.3, *Vaccination of individuals with impaired immunity due to disease or treatment*). The zoster vaccine has been shown to be less efficacious in people aged ≥80 years and may be less likely to provide a clinical benefit in this age group (see 'Vaccine' above).

(ii) Adults 50–59 years of age (*Safety-Grade B*)(*Efficacy-no data*)(*Immunogenicity-Grade B*)³³

Routine population-based use of zoster vaccine in people aged 50–59 years is not recommended. Although the incidence of HZ in people 50–59 years of age is higher than in younger age groups,^{23,30} and Zostavax is licensed for use in Australia from 50 years of age, the likelihood of developing PHN and other complications of HZ is lower in this age group than in those ≥60 years of age.^{18,39} In addition, efficacy of zoster vaccine has only been demonstrated in clinical trials in adults ≥60 years of age. Small studies of the safety and immunogenicity of Zostavax in the 50–59 year age group suggest that the vaccine is likely to be safe and immunogenic (see 'Vaccine' above).

(iii) People <50 years of age

Zoster vaccination is not recommended for use in people <50 years of age and is not registered for use in this age group. There have been very limited studies of the safety and immunogenicity of zoster vaccine in this age group.³³

(iv) People with a history of a previous episode of HZ (*no studies*)

People with a history of a previous episode of HZ can be given zoster vaccine. It is possible that a history of previous zoster may be inaccurate or a mistaken diagnosis. The safety and efficacy of zoster vaccine in people with a history of a previous episode of HZ has not been studied in clinical trials, as those with a history of HZ were excluded from the SPS.²⁴ However, the risk of a repeat episode of zoster has been estimated at approximately 5% in immunocompetent people in 3 separate studies.^{17,18,40} The length of time following an episode of HZ after which it would be reasonable to vaccinate has not

been established. However, it is suggested that the vaccine could be given at least 1 year after the episode of HZ.

Zoster vaccine is *not* indicated for therapeutic benefit in individuals experiencing an acute episode of HZ (to prevent PHN) or in individuals with PHN.

(v) People previously vaccinated with varicella vaccine

Zoster vaccination of people who have previously received varicella vaccine is not recommended at this time. There have been very limited studies of the safety and immunogenicity of zoster vaccine in this setting, and the currently available data are insufficient to suggest a benefit from vaccination.³³ In addition, it is not yet known whether, in the future, individuals vaccinated with varicella vaccine will experience rates of HZ sufficient to warrant zoster vaccine. Preliminary information suggests that the incidence of HZ in people who have received varicella vaccine is lower than in those infected with wild-type varicella.²⁹ Routine population-based childhood administration of varicella vaccine has been in place in Australia since 2005, and, in general, it is unlikely that a person vaccinated with varicella vaccine would have become age-eligible for the zoster vaccine.

(vi) Serological testing prior to zoster vaccination

Neither a history of previous varicella infection nor evidence of prior immunity to VZV is required prior to the routine administration of the zoster vaccine. Most older people in Australia are seropositive to VZV (see 'Epidemiology' above). Limited data from small studies of the administration of high-dose VZV-containing vaccine (comparable to Zostavax) to VZV seronegative adults, compared with previously infected adults, suggest that the vaccine was well tolerated and immunogenic in seronegative people, although the incidence of self-limited injection site reactions may be slightly higher.^{41,42} If an adult eligible for zoster vaccine has laboratory evidence of a lack of immunity to VZV, and does not have a history of age-appropriate varicella vaccination, they should be vaccinated with 2 doses of licensed varicella vaccine (see Chapter 3.24, *Varicella*).

(vii) Serological testing after zoster vaccination

Laboratory testing to check for an immune response to zoster vaccination is not recommended. Most people aged ≥ 60 years who receive zoster vaccine will be IgG positive on serologic testing prior to vaccination (see (vi) above). Zoster vaccine boosts both humoral (IgG) and cellular immune responses; however, confirmation of such immune responses is neither necessary nor predictive of protection against the development of zoster.

Contraindications

(i) Allergy to vaccine components

Zoster vaccination is contraindicated where there has been:

- anaphylaxis following a previous dose of any VZV-containing vaccine, or
- anaphylaxis following any vaccine component.

(ii) People with impaired immunity

Zoster vaccine is contraindicated in people with significant immune impairment due to either a primary or acquired medical condition, or due to medical treatment. This includes people receiving high-dose systemic immunosuppressive treatment, such as general radiation or oral corticosteroids; people suffering from malignant conditions of the reticuloendothelial system (such as lymphoma, leukaemia, Hodgkin's disease); and any person with similar immune impairment due to a disease or treatment (see Section 2.3.3, *Vaccination of individuals with impaired immunity due to disease or treatment*).

People who have been receiving high-dose systemic steroids (or equivalent) and have ceased therapy may be vaccinated (see Section 2.3.3, *Vaccination of individuals with impaired immunity due to disease or treatment*).

(iii) Pregnancy

VZV-containing vaccines are contraindicated in pregnancy, although women of child-bearing age are unlikely to be eligible for zoster vaccination (see Chapter 3.24, *Varicella*). Pregnancy should be avoided for at least 28 days after vaccination. A non-immune pregnant household contact is *not* a contraindication to zoster vaccination. (See also Table 2.3.1 *Vaccinations in pregnancy*.)

Precautions

(i) People with impaired immunity due to HIV/AIDS

Vaccination with zoster vaccine is not recommended for people with AIDS or symptomatic HIV infection (see Table 2.3.4 *Immunological categories based on age-specific CD4 counts and percentage of total lymphocytes*). Studies of the use of zoster vaccine in HIV-infected people have not been completed. However, people with asymptomatic HIV infection may be considered for vaccination on a case by case basis after seeking appropriate specialist advice. Serologic confirmation of previous VZV infection must be obtained prior to vaccination. Although asymptomatic HIV-infected individuals are likely to experience a higher relative risk of developing HZ in the future,²⁵ it is possible that both the efficacy and the safety of zoster vaccination may be reduced in such recipients, as compared with uninfected people.

(ii) Vaccination of people anticipating future significant immune impairment

Immunocompetent people who anticipate alteration of their immunity because of their existing illness can be given zoster vaccine under certain conditions, on a case by case basis after seeking appropriate specialist advice.³⁴ People with conditions such as chronic lymphocytic leukaemia, conditions requiring organ transplantation,⁴³ solid tumours that will require future chemotherapy or radiation therapy, and inflammatory diseases (eg. rheumatoid arthritis, systemic lupus erythematosus, inflammatory bowel disease, psoriasis) may have minimal alteration to their immune system, but can anticipate significant impairment of immunity in the future due to their disease and/or treatment. Since these individuals are at higher risk of developing zoster than if they remained immunocompetent, vaccination at least 1 month prior to the onset of immune impairment may be appropriate (after seeking specialist advice).³⁴ Serologic confirmation of previous VZV infection must be obtained prior to vaccination.

(iii) Vaccination with other live attenuated vaccines

If zoster vaccine is to be given around the same time as another live viral parenteral vaccine (eg. MMR, yellow fever), the vaccines should be given either at the same visit or at least 4 weeks apart (see Table 1.3.2 *Responses to relevant conditions or circumstances identified by the pre-vaccination screening checklist*).

(iv) Vaccination before or after immunoglobulin or blood products

Zoster vaccine can be given at any time before or after administration of immunoglobulin, or any antibody-containing blood product. This is because zoster vaccine is indicated in people who have had a previous VZV infection who, therefore, have serum antibody levels comparable to those found in blood products. For further information, see Section 2.3.5, *Vaccination of patients following receipt of other blood products including blood transfusions* and 'Variations from product information' below.

(v) Vaccination of household contacts of people with impaired immunity

Vaccination of people ≥ 50 years of age, who are household contacts of a person with impaired immunity, is recommended. Based on evidence that the rate of VZV-like rashes after vaccination was extremely low, it is unlikely that transmission of vaccine-associated virus to a susceptible contact would occur.^{24,35} If vaccinees develop a varicella- or zoster-like rash, they should cover the rash and avoid contact with people with impaired immunity for the duration of the rash. If household contacts (<50 years of age) of a person with impaired immunity have not been previously infected with VZV or immunised with varicella vaccine, they should receive varicella vaccine (see Chapter 3.24, *Varicella*).

(vi) People receiving long-term aspirin or salicylate therapy

People receiving long-term salicylate therapy should be vaccinated if indicated. There have been no reports of an association between Reye syndrome and varicella vaccination, and it is unlikely that vaccination of a previously VZV-infected older person carries any risk of Reye syndrome.

(vii) People receiving antiviral medication

It is possible that the use of antivirals, such as aciclovir, famciclovir or valaciclovir, may interfere with the replication of the Zostavax live attenuated virus. People on such antiviral medication should cease treatment no less than 24 hours prior to vaccination and for at least 14 days after vaccination.^{34,44}

Adverse events

- In clinical trials, zoster vaccine was associated with injection site reactions (including erythema, pain, swelling and/or itch at the injection site) in approximately half of those given the vaccine (see also ‘Vaccine’ above).
- Varicella-like rashes at the injection site occurred rarely, in 0.1% of recipients; however, they were more common than in placebo recipients. Varicella-like rashes that were not localised to the injection site were also rare, and did not occur more often in vaccine compared with placebo recipients (0.1% in both groups). In the clinical trials in which rashes were analysed by PCR for VZV, the majority were due to wild-type virus; only 2 subjects were found to have rashes due to the Oka/Merck VZV vaccine strain (see also ‘Vaccine’ above).
- Fever >38.3°C was not seen more commonly in vaccinees, and occurred in <0.1% (rare) of subjects overall.
- Systemic symptoms were reported in vaccinees more commonly than in placebo recipients (Zostavax 6.3% vs placebo 4.9%), with the most frequently reported systemic symptoms being headache and fatigue.^{24,35}

Variations from product information

The Zostavax product information states that the vaccine can be administered concurrently with inactivated influenza vaccine but not with 23vPPV. If inadvertent concomitant administration of Zostavax and pneumococcal polysaccharide vaccine occurs, there is no need to revaccinate. The NHMRC states that Zostavax may be administered concurrently with other vaccines as indicated.

The Zostavax product information states that the safety and efficacy of Zostavax have not been established in adults who are known to be infected with HIV, with or without evidence of immune impairment. The NHMRC states that Zostavax may be administered to HIV-infected people without immune impairment on a case by case basis after seeking appropriate specialist advice, and following confirmation of pre-existing immunity to VZV.

References

1. Gershon AA, Takahashi M, Seward J. Varicella vaccine. In: Plotkin SA, Orenstein WA, eds. *Vaccines*. 4th ed. Philadelphia, PA: Saunders, 2004.
2. Whitley RJ. Varicella-zoster virus. In: Mandell GL, Bennett JE, Dolin R, eds. *Mandell, Douglas, and Bennett's Principles and practice of infectious diseases*. 6th ed. Philadelphia: Elsevier Churchill Livingstone, 2005.
3. Dworkin RH, Johnson RW, Breuer J, et al. Recommendations for the management of herpes zoster. *Clinical Infectious Diseases* 2007;44(Suppl 1):S1-26.
4. Gnann JW, Jr., Whitley RJ. Clinical practice. Herpes zoster. *New England Journal of Medicine* 2002;347:340-6.
5. Dworkin RH, Portenoy RK. Proposed classification of herpes zoster pain. *Lancet* 1994;343:1648.
6. Kost RG, Straus SE. Postherpetic neuralgia — pathogenesis, treatment, and prevention. *New England Journal of Medicine* 1996;335:32-42.
7. Gross G, Doerr HW. Herpes zoster guidelines of the German Dermatological Society [letter]. *Journal of Clinical Virology* 2003;27:308-9.

8. Tyring SK, Beutner KR, Tucker BA, Anderson WC, Crooks RJ. Antiviral therapy for herpes zoster: randomized, controlled clinical trial of valacyclovir and famciclovir therapy in immunocompetent patients 50 years and older. *Archives of Family Medicine* 2000;9:863-9.
9. Johnson RW, Dworkin RH. Treatment of herpes zoster and postherpetic neuralgia. *BMJ* 2003;326:748-50.
10. Jackson JL, Gibbons R, Meyer G, Inouye L. The effect of treating herpes zoster with oral acyclovir in preventing postherpetic neuralgia: a meta-analysis. *Archives of Internal Medicine* 1997;157:909-12.
11. Meister W, Neiss A, Gross G, et al. Demography, symptomatology, and course of disease in ambulatory zoster patients. A physician-based survey in Germany. *Intervirology* 1998;41:272-7.
12. Simmons A. Management of shingles and post-herpetic neuralgia. *Current Therapeutics* 2000;41:61-6.
13. Dworkin RH, Schmader KE. Treatment and prevention of postherpetic neuralgia. *Clinical Infectious Diseases* 2003;36:877-82.
14. Schmader K. Herpes zoster in older adults. *Clinical Infectious Diseases* 2001;32:1481-6.
15. Brisson M, Edmunds WJ, Law B, et al. Epidemiology of varicella zoster virus infection in Canada and the United Kingdom. *Epidemiology & Infection* 2001;127:305-14.
16. Thomas SL, Hall AJ. What does epidemiology tell us about risk factors for herpes zoster? *The Lancet Infectious Diseases* 2004;4:26-33.
17. Ragozzino MW, Melton LJ, III, Kurland LT, Chu CP, Perry HO. Population-based study of herpes zoster and its sequelae. *Medicine* 1982;61:310-6.
18. Hope-Simpson RE. The nature of herpes zoster: a long-term study and a new hypothesis. *Proceedings of the Royal Society of Medicine* 1965;58:9-20.
19. Jumaan AO, Yu O, Jackson LA, et al. Incidence of herpes zoster, before and after varicella-vaccination-associated decreases in the incidence of varicella, 1992–2002. *Journal of Infectious Diseases* 2005;191:2002-7.
20. Araujo LQ, MacIntyre CR, Vujacich C. Epidemiology and burden of herpes zoster and post-herpetic neuralgia in Australia, Asia and South America. *Herpes*. 2007;14(Suppl 2):40-4.
21. MacIntyre CR, Chu CP, Burgess MA. Use of hospitalization and pharmaceutical prescribing data to compare the prevaccination burden of varicella and herpes zoster in Australia. *Epidemiology & Infection* 2003;131:675-82.
22. Gidding HF, Brisson M, MacIntyre CR, Burgess MA. Modelling the impact of vaccination on the epidemiology of varicella zoster virus in Australia. *Australian & New Zealand Journal of Public Health* 2005;29:544-51.
23. Stein AN, Britt H, Harrison C, et al. Herpes zoster burden of illness and health care resource utilisation in the Australian population aged 50 years and older. *Vaccine* 2008: in press.

24. Oxman MN, Levin MJ, Johnson GR, et al. A vaccine to prevent herpes zoster and postherpetic neuralgia in older adults. *New England Journal of Medicine* 2005;352:2271-84.
25. Vafai A, Berger M. Zoster in patients infected with HIV: a review. *American Journal of the Medical Sciences* 2001;321:372-80.
26. Edmunds WJ, Brisson M, Rose JD. The epidemiology of herpes zoster and potential cost-effectiveness of vaccination in England and Wales. *Vaccine* 2001;19:3076-90.
27. Scott FT, Johnson RW, Leedham-Green M, et al. The burden of herpes zoster: a prospective population based study. *Vaccine* 2006;24:1308-14.
28. Brisson M, Gay NJ, Edmunds WJ, Andrews NJ. Exposure to varicella boosts immunity to herpes-zoster: implications for mass vaccination against chickenpox. *Vaccine* 2002;20:2500-7.
29. Marin M, Guris D, Chaves SS, Schmid S, Seward JF. Prevention of varicella: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR - Morbidity & Mortality Weekly Report* 2007;56(RR-4):1-40.
30. Brotherton J, Wang H, Schaffer A, et al. Vaccine preventable diseases and vaccination coverage in Australia, 2003 to 2005. *Communicable Diseases Intelligence* 2007;31(Suppl):viii-S152.
31. Oxman MN. Vaccination to prevent herpes zoster and postherpetic neuralgia. *Human Vaccines* 2007;3:64-8.
32. Levin MJ. Use of varicella vaccines to prevent herpes zoster in older individuals. *Archives of Virology - Supplementum* 2001;(17):151-60.
33. Australian Technical Advisory Group on Immunisation (ATAGI). Systematic review of the safety, immunogenicity and efficacy of zoster vaccines. 2008. Available at: <http://www.immunise.health.gov.au>.
34. Centers for Disease Control and Prevention (CDC). Prevention of herpes zoster: Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR - Morbidity & Mortality Weekly Report* 2008;57(RR-5):1-30.
35. Merck Sharpe & Dohme (Australia) Pty Limited. Zostavax[®] zoster virus vaccine live (Oka/Merck), MSD. Refrigerator stable (ZST/R-I-092006). Product information - TGA approved 12 September 2007. 2007.
36. Kerzner B, Murray AV, Cheng E, et al. Safety and immunogenicity profile of the concomitant administration of ZOSTAVAX and inactivated influenza vaccine in adults aged 50 and older. *Journal of the American Geriatrics Society* 2007;55:1499-507.
37. MacIntyre CR, Egerton T, McCaughey M, et al. Concomitant administration of zoster and pneumococcal vaccines in adults ≥ 60 years old [Poster # G-399d]. 48th Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC) and the Infectious Disease Society of America (IDSA) 46th Annual Meeting; Oct 2008; Washington, DC, USA.
38. National vaccine storage guidelines. Strive for 5. Canberra: Australian Government Department of Health and Ageing, 2005. Available at:

<http://www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/provider-store>
(accessed Nov 2006).

39. Yawn BP, Saddier P, Wollan PC, et al. A population-based study of the incidence and complication rates of herpes zoster before zoster vaccine introduction. *Mayo Clinic Proceedings* 2007;82:1341-9.
40. Czernichow S, Dupuy A, Flahault A, Chosidow O. Zona: enquête d'incidence chez les médecins généralistes du réseau "Sentinelles" (Herpes zoster: incidence study among sentinel general practitioners. Full text in English on www.e2med.com/ad). *Annales de Dermatologie et de Venerologie* 2001;128:497-501.
41. Diaz C, Dentico P, Gonzalez R, et al. Safety, tolerability, and immunogenicity of a two-dose regimen of high-titer varicella vaccine in subjects > or = 13 years of age. *Vaccine* 2006;24:6875-85.
42. Macaladad N, Marcano T, Guzman M, et al. Safety and immunogenicity of a zoster vaccine in varicella-zoster virus seronegative and low-seropositive healthy adults. *Vaccine* 2007;25:2139-44.
43. Gourishankar S, McDermid JC, Jhangri GS, Preiksaitis JK. Herpes zoster infection following solid organ transplantation: incidence, risk factors and outcomes in the current immunosuppressive era. *American Journal of Transplantation* 2004;4:108-15.
44. Centers for Disease Control and Prevention (CDC). General recommendations on immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP). [erratum appears in MMWR Morb Mortal Wkly Rep. 2006 Dec 8;55(48):1303]. *MMWR - Morbidity & Mortality Weekly Report* 2006;55(RR-15):1-48.