
4 Immunisation of special groups

This chapter discusses the special immunisation requirements of individuals at risk of vaccine-preventable diseases due to certain conditions or underlying disease, or through their occupation or other risk factors. The topics covered are:

- pregnancy and lactation (section 4.1)
- infants with special immunisation considerations (section 4.2)
- immunocompromised individuals of all ages (section 4.3)
- immigrants and refugees (section 4.4)
- travel (section 4.5)
- occupational and other risk factors (section 4.6).

Note: Vaccinators are advised to check the Pharmaceutical Schedule and any online updates (www.pharmac.govt.nz) for changes to funding decisions for special groups.

4.1 Pregnancy and lactation

4.1.1 For women planning pregnancy

Women who are planning pregnancy should know whether they are immune to rubella (see section 18.5.3) and varicella (see section 21.5.4).

MMR

Two doses of MMR vaccine are recommended and funded for women who are susceptible to measles, mumps and/or rubella (see sections 11.5, 13.5 and 18.5). Women who are to receive the rubella vaccine (as MMR) are advised to ensure they are not pregnant at the time of immunisation and for at least four weeks afterwards, although there is no current evidence that rubella vaccine is teratogenic (see

section 18.6.1). If the mother is non-immune, two doses of MMR vaccine, separated by four weeks, should be given after delivery.

Varicella

VV is recommended (but not funded) for adults who are susceptible to varicella. Two doses are given, four to eight weeks apart (see section 21.5 and the manufacturers' data sheets for administration and dosing information). Women who are to receive VV are advised to ensure they are not pregnant at the time of immunisation and for at least four weeks afterwards.

4.1.2 During pregnancy

Inactivated vaccines are considered safe in pregnancy, but because of the theoretical possibility of harm to the fetus, live vaccines should not be administered to a pregnant woman. In some circumstances where there is increased risk of exposure to the microbe, the need for immunisation may outweigh any possible risk to the fetus.

See the relevant disease chapters, particularly rubella (section 18.8.3) and varicella (section 21.8.6), for recommendations on managing exposure to diseases during pregnancy.

Influenza vaccine

The influenza vaccine is recommended and funded for pregnant women, and should be offered to women at any stage of pregnancy, as soon as the annual influenza vaccine becomes available (see section 10.5). Both the pregnant woman and her fetus are at increased risk of influenza complications; influenza immunisation is therefore recommended during pregnancy to reduce this risk.

Maternal influenza immunisation also offers protection to the neonate through maternal antibody transfer.¹ Influenza vaccines are not registered for infants aged under 6 months, therefore immunisation during pregnancy confers protection to newborns and infants who are too young to have received vaccination at the time of exposure.^{1,2} Maternal influenza immunisation is significantly associated with reduced risk of influenza virus infection³ and hospitalisation for an

influenza-like illness in infants up to 6 months of age,^{4, 5} and increased influenza antibody titres are seen in infants through to age 2–3 months.¹

Influenza immunisation during pregnancy may also reduce the incidence of stillbirth. In an Australian study, stillbirth was 51 percent less likely among vaccinated mothers compared to unvaccinated mothers.⁶

There is no evidence that influenza vaccine prepared from an inactivated virus causes harm to the fetus or to the neonate.⁷

Pertussis vaccine (Tdap)

Pertussis is a severe infection in infants too young to have been immunised. Vaccination with Tdap should be offered in every pregnancy (currently funded between 28 and 38 weeks' gestation, see section 14.5) to protect the mother and so that antibodies can pass to the fetus; post-partum maternal vaccination will reduce the risk of a mother infecting her baby but does not have the added benefit of providing passive antibodies.

In October 2012 the UK introduced a pertussis vaccination programme for pregnant women in response to a nationwide pertussis outbreak. An observational study of the programme in England estimated vaccine effectiveness at 91 percent (95% CI: 84–95) for preventing pertussis in infants aged under 3 months.⁸ This high vaccine effectiveness is likely to be a result of protection of infants by both passive antibody transfer and reduced exposure to maternal disease.⁸ Three years after the introduction of the programme, vaccine effectiveness in infants was sustained at 90 percent, despite changing to another acellular vaccine with a different antigen composition.⁹ Disease incidence in infants aged under 3 months remained low, despite high activity persisting in those aged 1 year and older.⁹ Vaccine effectiveness against infant deaths was estimated at 95 percent (95% CI: 79–100).⁹

An observational study of the safety of the UK's maternal pertussis vaccination programme found no evidence of an increased risk of any of the extensive predefined list of adverse events related to pregnancy.¹⁰ In particular, there was no evidence of an increased risk of stillbirth.

Close contacts

The confirmation of pregnancy should act as a trigger to update the pertussis vaccination status of all close contacts. This includes making sure siblings have received their routine scheduled vaccines (funded for children aged under 18 years) and offering Tdap to adults, although this is not currently funded.

4.1.3 Breastfeeding and post-partum

All vaccines on the National Immunisation Schedule and those recommended for special groups are safe for breastfeeding women.

MMR

MMR vaccine (two doses) is recommended (and funded) after delivery for women who are susceptible to any of the three diseases. Breastfeeding is not a contraindication to MMR vaccine.

Pertussis vaccine (Tdap)

To protect the newborn infant, Tdap is recommended (but not funded) for close contacts of newborns, including women who were not vaccinated during pregnancy.

Varicella

VV is recommended (but not funded) for all susceptible adults. Pregnant women who are non-immune can receive VV after delivery.

VV for the mother is recommended (and funded) after delivery if the baby is immunocompromised and the mother is susceptible to varicella (see sections 4.3 and 21.5).

4.2 Infants with special immunisation considerations

4.2.1 Preterm and low birthweight infants

Vaccination as per the Schedule (ie, at the usual chronological age, with the usual vaccine dosage and interval) is recommended for preterm infants and infants with low birthweight. If an infant is in hospital when 6 weeks old, the scheduled vaccines, including rotavirus vaccine, should be given. If standard infection control precautions are maintained, the risk of transmission of vaccine strain rotavirus will be minimal.¹¹

Note that there is a potential risk of apnoea in infants born before 28 weeks' gestation. If a preterm infant had apnoeas following immunisation in hospital (6-week and/or 3-month event), readmission for the next infant immunisation and respiratory monitoring for 48 to 72 hours may be warranted,¹² but do not avoid or delay immunisation.

Hepatitis B vaccine

All preterm and low birthweight infants born to HBsAg-positive mothers should be managed the same way as term infants and receive immunoprophylaxis (HBIG and HepB) as soon as possible after birth (see section 8.5.2). They should continue routine immunisation as per the Schedule, starting at age 6 weeks.

Influenza vaccine

Preterm infants who develop chronic lung disease are recommended to receive influenza vaccine once they are aged 6 months or older, and a second dose four weeks later (influenza vaccine is usually available from March each year). Influenza vaccine is recommended (but not funded) for close contacts of preterm infants, including children (see section 10.5).

Pertussis vaccine (for contacts)

It is essential that siblings of preterm infants be up to date with immunisations to reduce the risk of pertussis transmission to vulnerable infants (see section 14.5). Adolescents should have received Tdap in

year 7 as part of the Schedule. Pertussis-containing vaccine is funded for primary and catch-up immunisation of all children aged under 18 years (see Appendix 2 for catch-up schedules).

Tdap is recommended (but not funded) for adult contacts of young infants, with the exception of funded Tdap vaccine for pregnant women from 28 to 38 weeks' gestation.

Pneumococcal vaccines (PCV10, PCV13 and 23PPV)

- PCV10 should be given as per the Schedule at ages 6 weeks, 3, 5 and 15 months.
- For preterm infants who develop chronic lung disease, PCV13 (funded) replaces the scheduled PCV10. Give 23PPV (funded) when the child is aged 2 years or older. There must be a minimum of eight weeks between the last dose of PCV13 and the 23PPV dose. Revaccinate once with 23PPV five years later if still considered at risk.

4.2.2 Infants with congenital heart disease

- Some children with congenital heart disease may have asplenia or polysplenia (functional hyposplenia) (see section 4.3.4).
- Certain conditions such as DiGeorge syndrome may have associated T-cell deficiency (see section 4.3.2).
- Children with complex single ventricle or shunt-dependent lesions (eg, post-Norwood procedure) have an increased risk of deterioration or collapse following immunisation. Discuss with the specialist, as monitoring in hospital may be required for the primary immunisation series.
- Rotavirus vaccine should be given to children with congenital heart disease even if they have received blood products.

4.2.3 Infants with liver and renal disease

Some infants with congenital biliary or renal conditions are likely to need transplantation. An accelerated immunisation schedule for these infants is provided in Table 4.1. The aim of the accelerated schedule is to maximise protection against vaccine-preventable diseases and to deliver live viral vaccines prior to transplantation and immunosuppression.

Infants with biliary atresia may have polysplenia (functional hyposplenia) (see section 4.3.4).

Other chronic kidney diseases also warrant extra immunisations (see section 4.3.3).

Table 4.1: Accelerated immunisation schedule (funded) for infants in whom liver or kidney transplant is likely

Refer to the Pharmaceutical Schedule (www.pharmac.govt.nz) for any changes to funding decisions.

Age	Immunisation/serology	Comments
6 weeks	Usual Schedule, but use PCV13 (Prevenar 13) instead of PCV10 (Synflorix)	Do not start earlier than age 6 weeks.
3 months	Usual Schedule, but use PCV13 instead of PCV10 MenCCV (NeisVac-C)	
5 months	Usual Schedule, but use PCV13 instead of PCV10 MenCCV (NeisVac-C)	
7 months	MMR (Priorix)	MMR should not be given within 1 month of predicted transplant.
	Varicella (Varilrix)	In general, VV should not be given within 1 month of predicted transplant but may be given closer at the discretion of the specialist.
	Hep A (Havrix Junior)	
	Anti-HBs serology	If anti-HBs is negative, give a further 3 doses of monovalent HepB vaccine, 4 weeks apart (HBvaxPRO 10 µg or Engerix-B 20 µg).
12 months	PCV13 (Prevenar 13)	
	MMR (Priorix)	MMR should not be given within 1 month of predicted transplant.
	Varicella (Varilrix)	In general, VV should not be given within 1 month of predicted transplant but may be given closer at the discretion of the specialist.
	MenCCV (NeisVac-C)	

Continued overleaf

Age	Immunisation/serology	Comments
13 months	DTaP-IPV-HepB/Hib (Infanrix-hexa)	
	MMR (Priorix)	MMR should not be given within 1 month of predicted transplant.
	Hep A (Havrix Junior)	If Hep A and HepB are due at the same time, consider using combined Hep A-HepB vaccine (Twinrix; not funded).
24 months	23PPV (Pneumovax 23)	Revaccinate once after 5 years.
	MCV4-D (Menactra)	2 doses of MCV4-D, 8 weeks apart, and at least 4 weeks after last PCV13. ^a Give a booster after 3 years, then 5-yearly.
4 years	Usual schedule: DTaP-IPV (Infanrix-IPV)	
	MMR (Priorix)	MMR can only be given if pre-transplant. MMR not required if received 2 doses after age 12 months; contraindicated if post-transplant.
From age 9 years	HPV9 vaccine (Gardasil 9)	3 doses at 0, 2 and 6 months. ^b Funded pre- or post-transplant. If given early, they do not require the usual Schedule doses in year 7/8 (age 11/12 years).
11 years	Usual schedule: Tdap (Boostrix)	
6 months post-transplant	HepB (HBvaxPRO or Enderix-B), plus anti-HBs serology before and 1 month after the initial HepB series	3 doses of HepB vaccine (HBvaxPRO 5 µg if available, or Enderix-B 20 µg). If HepB was not previously given, and anti-HBs is negative, give 3 doses of HepB vaccine (HBvaxPRO 10 µg or Enderix-B 20 µg). If there is an inadequate immune response to the initial 3-dose HepB series, give a further 3 doses (HBvaxPRO 10 µg or Enderix-B 20 µg).
	23PPV	If at least 24 months old and not given pre-transplant. Revaccinate once after 5 years.

Continued overleaf

Age	Immunisation/serology	Comments
Annually	Influenza (Fluarix Tetra if aged under 3 years; Influvac Tetra if aged 3 years and older)	Recommended for patients (funded) and all family members (not funded). For patients (from age 6 months) and family members aged under 9 years, give 2 doses 4 weeks apart in the first year, and 1 dose in subsequent years.
Household contacts of transplant patients	National Immunisation Schedule vaccines	Immune-competent siblings and other household contacts may receive all the Schedule vaccines, and should be fully vaccinated for age.
	Varicella (Varilrix)	Two doses of VV are funded for susceptible household contacts of transplant patients.

a Give MCV4-D at least 4 weeks after PCV13^{13, 14} (see section 12.4.4).

b Individuals who started with HPV4 may complete their remaining doses with HPV9.

Source: Starship Children's Health.

4.2.4 Asplenic infants

No vaccines are contraindicated for infants with functional or anatomical asplenia. The usual National Immunisation Schedule should be followed (replacing PCV10 with PCV13), with the addition of age-appropriate pneumococcal polysaccharide, meningococcal conjugate and influenza vaccines, as discussed in section 4.3.4.

4.2.5 Infants exposed to hepatitis B, with mothers with chronic HBV infection

Infants exposed to maternal hepatitis B infection require a birth dose of HepB and HBIG (see section 8.5.2).

4.2.6 Immune-deficient infants

Diagnosis of immune deficiency is often not made before children start their immunisation schedules. However, no parenteral live virus vaccines are given on the Schedule in the first year of life.

Rotavirus vaccine

Rotavirus vaccine is an oral, live, attenuated viral vaccine, which should not be given when severe combined immune deficiency (SCID) has been diagnosed. There have been case reports of rotavirus vaccine accidentally administered to infants with SCID, leading to chronic diarrhoea and failure to thrive.^{15, 16, 17} In infants with milder immune deficiency, rotavirus vaccine may cause prolonged shedding of the vaccine virus, but it is unlikely to cause harm.

There is little data on rotavirus vaccination in infants born to mothers on immunosuppressive therapies. Certain immunosuppressive medications, such as disease-modifying anti-rheumatic drugs (DMARDs), readily cross the placenta and can be detectable some months later.¹¹ Infants of mothers who received DMARDs during pregnancy that are monoclonal antibodies (eg, adalimumab/Humira) should not be vaccinated with live rotavirus vaccines until theoretical concerns about safety are clarified.¹⁸ See Table 4.3 for a list of the highly immunosuppressive medications that readily cross the placenta.

BCG vaccine

BCG, being a live bacterial vaccine against TB, can cause disseminated disease in certain rare immune deficiencies. In the past few years, eligibility criteria for neonatal BCG have been restricted (see chapter 20) and universal antenatal human immunodeficiency virus (HIV) screening introduced, thus reducing the risk of BCG being given to a child with an undiagnosed immune deficiency.

For infants whose mothers received DMARDs during pregnancy that are monoclonal antibodies (eg, adalimumab, infliximab; see Table 4.3), BCG vaccination should be delayed until the infant is at least 8 months old.¹⁹

(See also section 4.3.)

4.2.7 Infants with HIV

Infants with HIV infection who do not have severe immunosuppression should follow the routine Schedule (replacing PCV10 with PCV13) and are eligible to receive funded meningococcal, varicella (two doses) and influenza vaccines, plus pneumococcal polysaccharide vaccine from age 2 years. (See 'HIV infection' in section 4.3.3.)

4.2.8 Other conditions

All infants with the following conditions should receive the routine Schedule vaccines, plus the additional vaccines as described.

- Cystic fibrosis or other chronic lung diseases: influenza vaccine from age 6 months (funded; see section 10.5); PCV13 (funded) replaces PCV10 on the Schedule for these infants, and pneumococcal polysaccharide vaccine is recommended and funded from age 2 years (see section 15.5).
- Metabolic and endocrine disorders (eg, congenital diabetes or adrenal insufficiency).
 - Diabetes: influenza vaccine from age 6 months (funded; see section 10.5); PCV13 (funded) replaces PCV10 on the Schedule for these infants, and pneumococcal polysaccharide vaccine is recommended and funded from age 2 years (see section 15.5).
 - Inborn errors of metabolism at risk of major metabolic decompensation: influenza and varicella (two doses) vaccines (funded; see sections 10.5 and 21.5).
 - Other endocrine disorders: VV is recommended for a variety of endocrine disorders – discuss with the specialist.
- Sickle cell disease (not trait): these infants should be treated as for functional asplenia (see section 4.3.4).
- Other haemoglobinopathies that may result in splenectomy or functional asplenia: influenza vaccine from age 6 months (funded; see section 10.5); pneumococcal polysaccharide vaccine is recommended from age 2 years (see section 15.5).
- Cochlear implants or intracranial shunts, and infants with Down syndrome: influenza vaccine from age 6 months (funded; see section 10.5); PCV13 (funded) replaces PCV10 on the Schedule for these infants, and pneumococcal polysaccharide vaccine is recommended and funded from age 2 years (see section 15.5).
- Infants who may be exposed to TB are eligible for BCG vaccine (see sections 4.4.2 and 20.5). However, if the infant's mother received DMARDs during pregnancy that are monoclonal antibodies (eg, adalimumab, infliximab; see Table 4.3), BCG vaccination of the infant should be delayed until age 8 months (see section 20.6).

4.3 Immunocompromised individuals of all ages

Individuals with chronic conditions, an immune deficiency, or who are immunosuppressed for underlying disease control are at increased risk or severity of infectious diseases. These individuals should be immunised as a matter of priority. Special care is required with some live vaccines. When considering immunising such individuals, seek advice from their specialist. See also the 'Contraindications and precautions' section in each disease chapter and the vaccine data sheets.

The following definitions are used in this *Handbook*:

- **Immunocompromise** – a broad definition for the large group of conditions and their treatments that can reduce the individual's ability to mount an immune response and to fight off infection. A patient may be mildly to severely immunocompromised, and this is often a subjective measure.
- **Immunodeficiency** – refers to specific primary (eg, agammaglobulinaemia) and secondary (eg, HIV) diseases characterised by reduced ability to mount an immune response and fight off infection.
- **Immunosuppression** – refers to treatments such as chemotherapy, immunotherapies and medications that suppress the ability to mount an immune response and fight off infection.

It is important to ensure that the household contacts of these individuals are immune to vaccine-preventable diseases wherever possible.

4.3.1 Introduction

The nature and degree of immunocompromise determines the safety and effectiveness of vaccines. Immune deficiency conditions can be divided into primary and secondary. Primary immune deficiencies that present in childhood are generally inherited, and include antibody deficiency (disorders of B lymphocytes or antibody production), defects of cell-mediated immunity (disorders of T lymphocytes, which most often present as combined defects affecting antibody production as well), and defects of complement and phagocytic function²⁰ (see

section 4.3.2). Secondary immune deficiencies are acquired, and occur in people with HIV, people with malignant neoplasms, in organ transplant recipients, and in people receiving immunosuppressive treatment, chemotherapy or radiotherapy.²⁰

Live parenteral vaccines (these include MMR, varicella, HZV and BCG) should not in general be given to individuals who are severely immunocompromised, because of the risk of disease from vaccine strains. Subunit and inactivated vaccines are safe to administer, although the response of immunocompromised individuals to these inactivated vaccines may be inadequate. For comment on rotavirus vaccine see section 4.2.6 above.

Specific serum antibody titres can be determined to guide immunisation requirements for some vaccines and the future management of disease exposures.

Certain immune deficiencies result in specific disease susceptibility. For example, pneumococcal and meningococcal vaccines are recommended for those with poor or absent splenic function or certain complement deficiencies, because of increased infection risk from encapsulated bacteria. Influenza and varicella vaccines are recommended for individuals with splenic dysfunction, asplenia and phagocyte function deficiencies, both to prevent the diseases and to reduce the risk of secondary bacterial infections. See section 4.3.4 for recommendations for individuals with splenic dysfunction or asplenia.

Household contacts

Immune-competent siblings and household contacts may receive all the Schedule vaccines. It is important to ensure that close household contacts are immune for the added protection of the immunocompromised individual.

Infants in the household should receive rotavirus vaccine at the usual Schedule ages: there are no reported cases of symptomatic infection in immunocompromised contacts.²¹ There is no risk of transmission of MMR vaccine viruses to the immunocompromised individual.

VV or age-appropriate HZV can be given safely to the household contacts of immunocompromised individuals. VV is funded for non-immune household contacts of patients who are immunocompromised

or undergoing a procedure or treatment leading to immunocompromise. If the household contact is immune to varicella (previous history of infection or vaccination) and aged 50 years and older, give HZV (funded at age 65 years with a catch-up, until 31 March 2020, for those aged 66–80 years inclusive; unfunded if aged 50–64 years). If a vaccinated person develops a varicella- or zoster-like rash, they should cover the rash and avoid contact with persons who are immunocompromised for the duration of the rash.²²

4.3.2 Primary immune deficiencies

Live vaccines are contraindicated for all individuals with T lymphocyte-mediated immune deficiencies and combined B- and T-lymphocyte disorders.²⁰ Most of these individuals will be on intravenous immunoglobulin (IVIG) replacement therapy, which provides passive protection against most vaccine-preventable infections. (See also section 22.6 for contraindications to HZV.)

Hib, PCV13, 23PPV and Td vaccines may be used in testing for primary immune deficiencies, on the recommendation of an internal medicine physician or paediatrician.

Influenza vaccine is funded for all immune-deficient individuals. Regardless of their age, all immune-deficient individuals who receive influenza vaccine for the first time are recommended to receive two vaccine doses at least four weeks apart, and one dose annually after that.²³

Once an immunodeficiency is recognised, PCV13 should replace PCV10 in the routine schedule (see sections 15.5.2 and 15.5.3).

Below is a summary of the appropriate immunisations for individuals with primary immune deficiencies.²⁰ Seek specialist advice. (See also Table A6.1 in Appendix 6 of this *Handbook*.)

B lymphocyte deficiencies (humoral)

(Humoral means the development of circulating antibody.)

X-linked, agammaglobulinaemia and common variable immune deficiency

The efficacy of any vaccine that is dependent on a humoral response, such as 23PPV, is doubtful, but all inactivated vaccines are safe.

- Influenza vaccine is recommended.
- BCG and HZV are contraindicated.
- MMR and VV are not required because the individual is on IVIG. IVIG provides passive protection and would interfere with the response to these vaccines.

Selective IgA deficiency

All vaccines are probably effective.

- Influenza vaccine is recommended.
- There are no specific contraindications or precautions.

Lymphocyte deficiencies (cell-mediated and humoral)

Complete defects (eg, SCID) and partial defects (eg, Wiskott–Aldrich syndrome, most patients with DiGeorge syndrome)

The efficacy of any vaccine depends on the degree of immune deficiency.

- Pneumococcal (PCV13 and 23PPV), meningococcal and influenza vaccines are recommended.
- BCG, MMR, VV and HZV are contraindicated.
- Rotavirus vaccine is contraindicated in SCID.

Complement deficiencies

Deficiency of early components (C1, C4, C2, C3)

All routine vaccines are probably effective.

- Influenza, PCV13, 23PPV and meningococcal vaccines are recommended.
- There are no specific contraindications or precautions.

Deficiency of late components (C5–9), properdin, factor B

All routine vaccines are probably effective.

- Influenza, meningococcal and pneumococcal conjugate and polysaccharide vaccines are recommended.
- There are no specific contraindications or precautions.

Phagocytic function deficiencies

Chronic granulomatous disease, leukocyte adhesion defect, myeloperoxidase deficiency

All routine vaccines are probably effective.

- Influenza vaccine is recommended.
- BCG is contraindicated.
- Live viral vaccines are safe in chronic granulomatous disease⁹ but discuss individuals with other conditions with specialist.

4.3.3 Secondary (acquired) immune deficiencies

The following sections provide recommendations for individuals with diseases or therapy causing immunocompromise.

The ability of individuals with secondary immune deficiency to develop an adequate immunological response depends on the type of immune deficiency and/or and the intensity of immunosuppressive therapy.

Before commencing a therapy that would be expected to cause significant immunosuppression, a full vaccination history should be obtained. Then, if circumstances permit, such as prior to commencing immunosuppressive therapy for rheumatological disease or prior to solid organ transplant, vaccination should be completed (including HPV from age 9 years) and additional non-routine vaccines (eg, varicella for children or zoster vaccine for certain adults [see section 22.5]; and meningococcal) may be appropriate. Similarly, in diseases such as chronic renal failure, where immune impairment is likely to be progressive, early administration of vaccines may result in better antibody responses. If immediate treatment is required it should not be delayed to allow for vaccination.

Live viral vaccines (MMR and VV) should only be given if the patient is non-immune, is not severely immunocompromised and is four or more weeks prior to commencement of immunosuppressive therapy. VV may be given at a shorter interval at the discretion of the specialist. Checking varicella serostatus is recommended in this situation:²² if VZV-seronegative, give VV (funded); if VZV-seropositive and aged 50 years and older, give HZV (funded at age 65 years with a catch-up, until 31 March 2020, for those aged 66–80 years inclusive; unfunded if aged 50–64 years).

When immunosuppressive therapy is discontinued, immune recovery usually takes between 3 and 12 months.

Influenza vaccine is funded for immunocompromised individuals before each influenza season, and is recommended three to four weeks after chemotherapy for malignant neoplasm is completed, once both the peripheral granulocyte and lymphocyte counts are $>1.0 \times 10^9/L$. Regardless of their age, all immunocompromised individuals who receive influenza vaccine for the first time are recommended to receive two vaccine doses at least four weeks apart, and one dose annually after that.²³

Individuals receiving corticosteroids

The minimum amount of corticosteroid administration sufficient to cause immunosuppression is not well defined, and is dependent on dose, duration and the underlying disease. Many clinicians consider a daily dosage equivalent to 2 mg/kg prednisone or greater, or a total daily dosage of 20 mg or greater, particularly when given for 14 days or more, is sufficient to raise concern about the safety of live virus vaccines.

The following guidelines may be used for the safe administration of live virus vaccines to individuals on corticosteroids. Table 4.2 provides a summary of the guidelines for individuals on high-dose corticosteroids (see also Table 22.2 for HZV recommendations).

Live virus vaccines *can be* administered to:

- individuals on topical therapy or local injections of corticosteroids, including on the skin or respiratory tract (by aerosol), or intra-articular, bursal or tendon injections, because such therapies do not usually result in immunosuppression

- individuals on maintenance *physiological* doses of corticosteroids
- individuals on low to moderate doses of systemic steroids given daily or on alternate days (this includes children receiving less than 2 mg/kg per day prednisone, or less than 20 mg/day if they weigh more than 10 kg, or an equivalent dose of another short-acting systemic corticosteroid)
- individuals receiving high-dose corticosteroids for fewer than 14 days (eg, children receiving 2 mg/kg of prednisone, or up to 20 mg if the child weighs more than 10 kg) can receive live virus vaccines immediately on discontinuation of treatment (some experts would delay immunisation for two weeks if possible).

Live virus vaccines *should not* be administered to:

- individuals receiving high-dose corticosteroids daily or on alternate days for more than 14 days (eg, individuals receiving 2 mg/kg of prednisone, or 20 mg or more if the individual weighs more than 10 kg) until the corticosteroid therapy has been discontinued for at least four weeks
- individuals who have a disease process that causes immunosuppression, and who are being treated with either systemic or locally administered corticosteroids, except in special circumstances (discuss with the individual's specialist).

Note: These guidelines are intended to ensure safety of administration of the live virus vaccine; optimal vaccine immunogenicity may not be achieved.

Table 4.2: Guidelines for live virus vaccine administration for individuals on high-dose corticosteroids

	Infants and children <10 kg	Children ≥10 kg and adults	Administration of live viral vaccines after cessation of corticosteroids ²⁴
High dose <14 days	>2 mg/kg Daily or on alternate days	>20 mg/day	Can be given immediately on discontinuation, but delay 2 weeks if possible
High dose >14 days	>2 mg/kg Daily or on alternate days	>20 mg/day	Delay for 4 weeks

Source: IMAC

Other immunosuppressive agents (eg, for autoimmune diseases, rheumatological diseases, inflammatory bowel disease)

In recent years there has been rapid development of immunosuppressive agents, particularly targeted biological therapies, and an increasing number of patients are receiving such therapies.¹⁸ Table 4.3 lists the categories of agents available, according to their potential for immunosuppression.

As a general guide, low-level immunosuppression includes treatment with prednisone <2 mg/kg with a maximum of 20 mg/day; methotrexate ≤0.4 mg/kg/week; azathioprine ≤3 mg/kg/day; or 6-mercaptopurine ≤1.5 mg/kg/day. High-level immunosuppression regimens include treatment regimens with higher than the above doses, and those on biological agents such as tumour necrosis factor antagonists or rituximab. Combination therapies increase the level of immunosuppression.

See also Table 22.2 for HZV recommendations. For children aged under 18 years, see the Starship Clinical Guideline *Immunosuppression and Infection in Rheumatology Patients* (available at www.starship.org.nz/for-health-professionals/starship-clinical-guidelines/i/immunosuppression-and-infection-in-rheumatology-patients/). For adults, see the IMAC factsheet *Immunisation for adults with immune-mediated inflammatory disease (IMID)* (available for download from: www.immune.org.nz/resources/written-resources).

Table 4.3: Immunotherapy agents for immune-mediated inflammatory disease

Note: This is not an extensive list of immunotherapy agents; new agents are continually being developed. Seek specialist advice. See also ‘Oncology patients being treated with immune checkpoint inhibitors (immunostimulants)’ below.

Corticosteroids	Immunosuppressive agents Disease modifying anti-rheumatic drugs (DMARDs)		Targeted biological therapies	Cytotoxics
Prednisone Prednisolone Methyl-prednisolone	DMARDs I Hydroxy-chloroquine Leflunomide Methotrexate Sulphasalazine	DMARDs II Azathioprine Cyclosporin Mycophenolate mofetil	Biological DMARDs Abatacept Anakinra Rituximab Tocilizumab Ustekinumab Anti-tumour necrosis factor DMARDs Adalimumab Etanercept Infliximab	Cyclo-phosphamide

When these agents are used singly



Source: IMAC

Oncology patients

This section provides general guidelines for vaccination after cancer treatment. Specific vaccination questions should be discussed with an expert paediatrician, infectious diseases physician or oncologist. With the exception of patients receiving immune checkpoint inhibitors, annual influenza vaccine is recommended and can be given even while a patient is on treatment (two doses four weeks apart in the first year).

Household contacts may be safely given MMR (funded; see section 11.5.3), VV (funded; see section 21.5) or age-appropriate HZV (funded if aged 65 years and older, unfunded if aged 50–64 years; see section 22.5); annual influenza vaccination is also recommended (not funded) for contacts (see section 10.5). See also ‘Household contacts’ in section 4.3.1.

Note: patients being treated with immune checkpoint inhibitors are the exception to these guidelines, where immunisation is relatively contraindicated. See ‘Oncology patients treated with immune checkpoint inhibitors (immunostimulants)’ below.

Vaccination after chemotherapy

Booster dose(s) of a diphtheria/tetanus/pertussis-containing vaccine, and hepatitis B, polio (IPV) and pneumococcal vaccines (PCV13 followed by 23PPV) should be given, starting not less than three months after chemotherapy has ended, when the lymphocyte count is $>1.0 \times 10^9/L$.

Parenteral live viral vaccines should be delayed for at least six months after chemotherapy, but MMR and VV or age-appropriate HZV should then be given. Serological confirmation of previous VZV infection is recommended before administering HZV.²² If VZV-seronegative, give VV (funded); if VZV-seropositive and aged 50 years and older, give HZV (funded at age 65 years with a catch-up, until 31 March 2020, for those aged 66–80 years inclusive; unfunded if aged 50–64 years). The interval may need to be extended according to:

- the intensity and type of therapy
- radiation therapy
- receipt of blood products or IG (see Table A6.1 in Appendix 6)
- underlying disease
- other factors.

For children aged under 18 years, suggested age-appropriate schedules and worksheets are available on the Starship website (www.starship.org.nz/media/199142/immunisation-2018-amended-version.pdf). For adults, see the IMAC factsheet *Immunisation for adults post-chemotherapy who are not taking immunosuppressive disease modifying drugs* (available for download from: www.immune.org.nz/resources/written-resources).

Vaccination after haematopoietic stem cell transplant (HSCT)/bone marrow transplant

Many factors can affect a transplant recipient's immunity to vaccine-preventable diseases following a successful marrow transplant. These include the donor's immunity, the type of transplant and the interval since the transplant, the continuing use of immunosuppressive drugs, and graft versus host disease. Some recipients acquire the immunity of the donor, but others lose all serological evidence of immunity.

Complete re-immunisation is recommended, starting with routine Schedule inactivated vaccines 12 months after bone marrow transplant (use Tdap for tetanus, diphtheria and pertussis immunisation if the child is aged 10 years or older).

Pneumococcal vaccines (PCV13 followed by 23PPV), meningococcal (conjugate C and quadrivalent conjugate), hepatitis B and a booster dose of Hib and IPV are all recommended.

Healthy recipients of bone marrow transplant who are immune competent can be given VV or age-appropriate HZV not less than two years after transplant, with MMR given four weeks later if VV/HZV tolerated. Serological confirmation of previous VZV infection is recommended before administering HZV. If VZV-seronegative, give VV (funded); if VZV-seropositive and aged 50 years and older, give HZV (funded at age 65 years with a catch-up, until 31 March 2020, for those aged 66–80 years inclusive; unfunded if aged 50–64 years). Second doses of MMR and VV should be given four weeks or more after the first doses, unless serological response to measles and varicella is demonstrated after the first dose. The vaccines should not be given to individuals suffering from graft versus host disease because of a risk of a resulting chronic latent virus infection leading to central nervous system sequelae.

For children aged under 18 years, suggested age-appropriate schedules and worksheets are available on the Starship website (www.starship.org.nz/media/199142/immunisation-2018-amended-version.pdf). For adults, see the IMAC factsheet *Immunisation for adults post-haematopoietic stem cell transplantation (HSCT)* (available for download from: www.immune.org.nz/resources/written-resources).

Oncology patients treated with immune checkpoint inhibitors (immunostimulants)

Specialist advice must be sought before administering any vaccine to patients who are currently being treated with immune checkpoint inhibitors, as well as those who have discontinued treatment within the past 6 months.

As this is a rapidly evolving therapy area, there are currently no international consensus statements on the use of vaccines in patients being treated with immune checkpoint inhibitors. Caution is advised, particularly with live vaccines.

Immune checkpoint inhibitors are immunostimulants, monoclonal antibodies that are used to treat several forms of advanced or metastatic cancer.²⁵ These medicines include PD-1 inhibitors (eg, pembrolizumab [Keytruda], nivolumab [Opdivo]), PD-L1 inhibitors (eg, atezolizumab [Tecentriq]) and CTLA-4 inhibitors (eg, ipilimumab [Yervoy]). Immune checkpoint inhibitors target proteins ('checkpoints') on T-cells.²⁶ By blocking these checkpoints, they allow the immune system to boost the immune response against cancer cells. A theoretical side effect of these medicines is an autoimmune-induced condition and, importantly, the autoimmune condition could occur weeks to months after stopping treatment.

While there is currently no clear safety data on the use of vaccines (live or subunit) in patients being treated with one or more immune checkpoint inhibitors, there is a theoretical risk that vaccines may trigger an autoimmune condition in these patients. There have been reports of fatal myositis, myocarditis and rhabdomyolysis in patients being treated with ipilimumab with nivolumab and administered influenza vaccine.²⁷ A prospective study of patients currently being treated with nivolumab or pembrolizumab and administered trivalent influenza vaccine found an increase in immune-related adverse events compared to unvaccinated patients being treated with these medicines.²⁸

The Cancer Institute of New South Wales (Australia) cautions that in patients receiving combination ipilimumab and nivolumab, there have been reported cases of fatal myocarditis, myositis and rhabdomyolysis shortly after administration of the influenza vaccine. Whilst a causative

relationship to the use of influenza vaccine has not been demonstrated, caution is advised.²⁷

The British Columbia Cancer Agency (Canada)²⁹ recommends:

- patients receiving PD-1 or PD-L1 inhibitors may receive the inactivated influenza vaccine. Live attenuated influenza vaccine (not currently available in New Zealand) should not be used in these patients
- patients on ipilimumab monotherapy or combination checkpoint inhibitors (eg, ipilimumab plus nivolumab) should not receive any vaccines within 6–8 weeks of starting treatment or within 6–8 weeks of the last dose
- patients on maintenance nivolumab following combination therapy should discuss the timing of vaccination with their doctor.

Alberta Health Services (Canada)³⁰ recommends:

- patients currently receiving ipilimumab alone or in combination with other anti-cancer agents, as well as those who have discontinued ipilimumab in the past six months should not receive the influenza vaccine
- patients receiving nivolumab or pembrolizumab alone or in combination with other anti-cancer agents may be immunised with the inactivated influenza vaccine; the timing of the immunisation is not clearly studied in this population, but can be considered one week post-administration of these agents. Patients should be advised to monitor themselves closely, and to report any adverse events to their oncologist.

Chronic kidney disease (CKD)

Immune response and duration of protection after immunisation decrease with advancing kidney disease, so routine Schedule and other recommended vaccines should be given as soon as kidney disease is recognised.

Individuals immunised during the early stages of CKD generally respond to immunisation, but the magnitude of response and/or more rapid waning of immunity have an influence on how well protected they are from infection or severe disease following immunisation. Cases of children developing a disease for which they have serological evidence of immunity have been reported.³¹

Patients should receive routine Schedule vaccines and annual influenza vaccine. Live viral vaccines are considered safe for individuals with CKD and minimal immunocompromise, but they are generally not recommended for individuals on immunosuppressive medicines because of the risk of vaccine virus disease.³² However, a number of small studies suggest that the risk of disseminated VV-related disease is small and can be managed with antiviral therapy, and that varicella immunisation carries a significantly lower risk for immunosuppressed individuals than wild-type varicella disease.²⁴

Individuals with nephrotic syndrome, kidney failure or end-stage kidney disease (CKD stages 4–5) have an increased risk of developing bacterial peritonitis and/or sepsis. Additional pneumococcal vaccines, a Hib booster, conjugate meningococcal vaccines and annual influenza vaccine are recommended. These individuals are also at increased risk of zoster, and may receive HZV upon specialist advice. Serological confirmation of previous VZV infection is recommended before administering HZV. If VZV-seronegative, give VV (funded if prior to transplant); if VZV-seropositive and aged 50 years and older, give HZV (funded at age 65 years with a catch-up, until 31 March 2020, for those aged 66–80 years inclusive; unfunded if aged 50–64 years).

Dialysis patients must be hepatitis B immune, with administration of repeated courses of HepB, of higher strength if required: the higher strength 40 µg HepB (HBvaxPRO) is funded for dialysis patients.

There is no relationship between immunisation and deterioration of renal function or a reduction in the efficacy of dialysis.³¹

A recommended immunisation schedule and worksheet for paediatric CKD stages 4–5 and dialysis patients is available on the Starship website (www.starship.org.nz/media/286703/vaccination-record-for-paediatric-ckd-august-2017-.pdf). For adults, see the IMAC factsheet *Immunisation for adults with end-stage kidney disease, on dialysis, or*

pre-post-kidney transplant (available for download from: www.immune.org.nz/resources/written-resources).

Solid organ transplants

Specialist advice should be sought in these situations.

An accelerated immunisation schedule is recommended for individuals likely to be listed for solid organ transplant. See Table 4.1 for infant recommendations. For adults, see the IMAC factsheet *Immunisation for adults pre-/post-solid organ transplantation (excluding kidney transplantation)* (available for download from: www.immune.org.nz/resources/written-resources).

Individuals older than 12 months who have been scheduled for solid organ transplantation should receive MMR and VV or age-appropriate HZV at least four weeks before the transplant. Serological confirmation of previous VZV infection is recommended before administering HZV.²² If VZV-seronegative, give VV (funded); if VZV-seropositive and aged 50 years and older, give HZV (funded at age 65 years with a catch-up, until 31 March 2020, for those aged 66–80 years inclusive; unfunded if aged 50–64 years). Measles antibody titres should be measured one to two years after the transplant; immunisation may be repeated if titres are low, but only if the level of immunosuppression permits. It is advisable to check other antibody titres annually and re-immunise where indicated.

The use of passive immunisation with IG after exposure to measles or chickenpox should be based on the documentation of negative antibody titres, or where immune status is unknown. See chapter 15 for further information on pneumococcal immunisation for these individuals. VV is also funded for non-immune household contacts of transplant patients (see section 21.5).

In patients undergoing organ transplantation, pneumococcal vaccine (PCV13 first followed by 23PPV 8 weeks later, both funded) should be given at least two weeks before the transplant. Hepatitis A, hepatitis B, HPV, influenza, meningococcal conjugate and varicella vaccines are funded for transplant patients. (Re-)vaccination with age-appropriate DTaP-IPV-HepB/Hib, DTaP-IPV, Tdap and Hib vaccines is also funded. (See the relevant disease chapters.)

HIV infection

All HIV-positive children, whether symptomatic or asymptomatic, are recommended to receive the routine Schedule vaccines, including MMR (if CD4+ \geq 15%), rotavirus (infants only) and HPV (three doses from age 9 years). Asymptomatic children who are not severely immunocompromised are recommended to receive MMR vaccine at age 12 months to provide early protection against the three diseases.

The efficacy of any vaccine may be reduced in HIV-positive individuals, and antibody levels may wane faster than in individuals who are HIV-negative. Although antiretroviral therapy may improve immune responses, it is unlikely these individuals will achieve the levels of antibodies seen in individuals who are HIV-negative. Serological testing and the need for additional doses (eg, of HepB, see section 8.5.7) should be discussed with the individual's specialist.

VV or age-appropriate HZV may be given upon specialist advice to HIV-positive adults (if CD4+ lymphocyte count is \geq 200 cells/mm³). Serological confirmation of previous VZV infection is recommended before administering HZV.²² If VZV-seronegative, give VV (funded); if VZV-seropositive and aged 50 years and older, give HZV (funded at age 65 years with a catch-up, until 31 March 2020, for those aged 66–80 years inclusive; unfunded if aged 50–64 years).

Passive immunisation with IG may be required for individuals with HIV infection who are exposed to chickenpox or measles.

Tables 4.4 (children aged under 5 years when diagnosed), 4.5 (children aged 5 to under 18 years) and 4.6 (adults aged 18 years and older) summarise the additional vaccine recommendations and schedules for HIV-positive individuals. For adults, see also the IMAC factsheet *Immunisation for adults with HIV infection* (available for download from: www.immune.org.nz/resources/written-resources).

Table 4.4: Children aged under 5 years when diagnosed with HIV: additional vaccine recommendations

Note: HIV-positive children should receive the routine Schedule vaccines, including rotavirus vaccine for infants, but see the MMR recommendations below. BCG should not be given. Vaccinators are advised to refer to the Pharmaceutical Schedule (www.pharmac.govt.nz) for any changes to funding decisions.

Age at diagnosis	Vaccine (trade name)	Recommended vaccine schedule
Infants aged under 12 months when diagnosed	PCV13 (Prevenar 13)	<p>PCV13^a at ages 6 weeks, 3, 5 and 15 months or age-appropriate catch-up schedule:</p> <ul style="list-style-type: none"> if commencing immunisation at ages 7–11 months, give 2 doses of PCV13 at least 4 weeks apart, followed by a booster dose at age 15 months for children aged 7–11 months who have completed the primary course with PCV10, give 1 dose of PCV13, followed by the scheduled PCV13 booster at age 15 months.
	23PPV (Pneumovax 23)	<p>Following the completion of the PCV course, give 1 dose of 23PPV at age ≥ 2 years. There must be at least 8 weeks between the last PCV dose and the 23PPV dose.</p> <p>Revaccinate once with 23PPV, 5 years after the first 23PPV.</p>
	Influenza (Fluarix Tetra)	<p>Annual immunisation from age 6 months.</p> <p>In the first year, give 2 doses 4 weeks apart, then 1 dose in each subsequent year.</p>
	MenCCV (NeisVac-C) and MCV4-D (Menactra)	<p>Use the age-appropriate MenCCV schedule:</p> <ul style="list-style-type: none"> if aged under 6 months at diagnosis, give 2 doses 8 weeks apart, with a booster at age 12 months if aged 6–11 months at diagnosis, give 1 dose, with a booster at age 12 months. <p>At age 2 years, give 2 doses of MCV4-D^b 8 weeks apart, then a booster after 3 years, then 5-yearly.</p>

Continued overleaf

Age at diagnosis	Vaccine (trade name)	Recommended vaccine schedule
Children aged 12 months to under 5 years when diagnosed	PCV13 (Prevenar 13)	The PCV13 ^{a,c} age-appropriate catch-up schedule is: <ul style="list-style-type: none"> if commencing immunisation at ages 12 months or older, give 2 doses of PCV13,^c 8 weeks apart children aged >17 months who have completed the primary course of PCV10 but not received PCV13, give 1 dose of PCV13.^{c,d}
	23PPV (Pneumovax 23)	Following the completion of the PCV course, give 1 dose of 23PPV at age ≥2 years. There must be at least 8 weeks between the last PCV dose and the 23PPV dose. Revaccinate once with 23PPV, 5 years after the 1st 23PPV.
	Influenza (Fluarix Tetra if aged <3 years; Influvac Tetra if aged ≥3 years)	Annual immunisation. In previously unvaccinated children, give 2 doses 4 weeks apart, then 1 dose in each subsequent year.
	MMR ^e (Priorix)	If CD4+ lymphocyte percentage is ≥15%: <ul style="list-style-type: none"> give the 1st MMR dose at age 12 months, followed by the 2nd dose 4 weeks later.
	Varicella ^{e,f} (Varilrix)	If CD4+ lymphocyte percentage is ≥15%: <ul style="list-style-type: none"> give 2 doses (starting 4 weeks after the 2nd MMR), at least 3 months apart.
	MenCCV (NeisVac-C) and MCV4-D (Menactra)	If aged 12–23 months at diagnosis, give 1 dose of MenCCV; followed by MCV4-D ^b at age 2 years, 2 doses 8 weeks apart; then a booster of MCV4-D after 3 years; then 5-yearly. If aged ≥2 years at diagnosis, give 2 doses of MCV4-D ^b 8 weeks apart; then a booster of MCV4-D after 3 years; then 5-yearly.

- a PCV13 replaces PCV10 (Synflorix) on the Schedule.
- b Give MCV4-D at least 4 weeks after PCV13^{13, 14} (see section 12.4.4).
- c If 23PPV has already been given (prior to any doses of PCV13) to children aged under 18 years, wait at least 8 weeks before administering PCV13.
- d There are no safety concerns, regardless of the interval between the last dose of PCV10 and the 1st dose of PCV13.
- e Only a single viral vaccine is recommended at each visit for individuals with HIV infection. A minimum interval of 4 weeks is required between live vaccine doses administered at different visits.
- f Give VV on the advice of an HIV specialist.

Source: Starship Children's Health.

Table 4.5: Children aged 5 to under 18 years when diagnosed with HIV: additional vaccine recommendations

Note: HIV-positive children should receive the routine Schedule vaccines, but see the MMR recommendations below. BCG should not be given. Vaccinators are advised to refer to the Pharmaceutical Schedule (www.pharmac.govt.nz) for any changes to funding decisions.

Vaccine (trade name)	Recommended vaccine schedule
HPV9 (Gardasil 9)	From age 9 years, give 3 doses of HPV at 0, 2 and 6 months. ^{a,b}
PCV13 (Prevenar 13)	For children who have not previously received PCV13, give 1 dose of PCV13. ^c
23PPV (Pneumovax 23)	1 dose of 23PPV at least 8 weeks after the PCV13 dose. Revaccinate once with 23PPV, 5 years after the 1st 23PPV.
Influenza (Influvac Tetra)	Annual immunisation. Regardless of age, if previously unvaccinated, give 2 doses ^d 4 weeks apart. Then give 1 dose in each subsequent year.
MMR ^e (Priorix)	If aged ≤13 years and CD4+ lymphocyte percentage is ≥15%, or if aged ≥14 years and CD4+ lymphocyte count is ≥200 cells/mm ³ : <ul style="list-style-type: none"> give 2 MMR doses at least 4 weeks apart.
Varicella ^{e,f} (Varilrix)	If no history of varicella disease or immunisation, and if aged ≤13 years and CD4+ lymphocyte percentage is ≥15%, or if aged ≥14 years and CD4+ lymphocyte count is ≥200 cells/mm ³ : <ul style="list-style-type: none"> give 2 doses (starting 4 weeks after 2nd MMR), at least 3 months apart.
MCV4-D (Menactra)	Give 2 doses of MCV4-D ^g 8 weeks apart, and: <ul style="list-style-type: none"> if the 1st MCV4-D dose was given at age <7 years, give a booster after 3 years, then 5-yearly, or if the 1st MCV4-D dose was given at age ≥7 years, give a booster dose every 5 years.

- a Individuals who started with HPV4 may complete their remaining doses with HPV9.
- b HPV9 is registered for use from age 9 years.
- c If 23PPV has already been given (prior to any doses of PCV13) to children aged under 18 years, wait at least 8 weeks before administering PCV13.
- d The 2nd dose of influenza vaccine is not funded for individuals aged 9 years and older.
- e Only a single viral vaccine is recommended at each visit for individuals with HIV infection. A minimum interval of 4 weeks is required between live vaccine doses administered at different visits.
- f Give VV on the advice of an HIV specialist.
- g Give MCV4-D at least 4 weeks after PCV13^{13, 14} (see section 12.4.4).

Source: Starship Children's Health.

Table 4.6: Adults aged 18 years and older when diagnosed with HIV: additional vaccine recommendations

Note: HIV-positive individuals should receive the routine Schedule vaccines, but see the MMR and HZV recommendations in the table below. BCG should not be given. Vaccinators are advised to refer to the Pharmaceutical Schedule (www.pharmac.govt.nz) for any changes to funding decisions.

Vaccine (trade name)	Recommended vaccine schedule
HPV9 (Gardasil 9)	For individuals aged 26 years and under: 3 doses of HPV9 at 0, 2 and 6 months. ^a
PCV13 (Prevenar 13)	1 dose of PCV13. ^b
23PPV (Pneumovax 23)	Give a maximum of 3 doses of 23PPV in a lifetime, a minimum of 5 years apart. The 1st 23PPV dose is given at least 8 weeks after PCV13, the 2nd a minimum of 5 years later, the 3rd dose at age ≥65 years.
Influenza (Influvac Tetra)	Annual immunisation. If previously unvaccinated, give 2 doses ^c 4 weeks apart. Then give 1 dose in each subsequent year.
MMR ^d (Priorix)	If born in 1969 or later and has no record of 2 previous MMR doses and CD4+ lymphocyte count is ≥200 cells/mm ³ : <ul style="list-style-type: none"> give 1 or 2 MMR doses 4 weeks apart (so individual has 2 documented doses of MMR).
Varicella ^{d,e} (Varilrix) or Herpes zoster ^{d,e,f} (Zostavax)	If VZV-seronegative and CD4+ lymphocyte count is ≥200 cells/mm ³ : <ul style="list-style-type: none"> give 2 doses of VV at least 4 weeks apart. If aged 50 years and older ^f and VZV-seropositive and CD4+ lymphocyte count is ≥200 cells/mm ³ : <ul style="list-style-type: none"> give 1 dose of HZV.^f
Hepatitis B (HBvaxPRO 10 µg or Engerix-B 20 µg)	If previously unvaccinated, give 4 doses, at 0, 1, 2 and 12 months. ^g
MCV4-D (Menactra)	Give 2 doses of MCV4-D 8 weeks apart, then 1 dose every 5 years. ^{h,i}

a Individuals who started with HPV4 may complete their remaining doses with HPV9.

b If 23PPV has already been given (prior to any doses of PCV13) to adults aged 18 years and older, wait at least 1 year before administering PCV13.

c The 2nd dose of influenza vaccine is not funded for individuals aged 9 years and older.

d Only a single viral vaccine is recommended at each visit for individuals with HIV infection. A minimum interval of 4 weeks is required between live vaccine doses administered at different visits.

e Give VV or HZV on the advice of an HIV specialist. Serological confirmation of previous VZV infection is recommended before administering HZV.²²

- f HZV is registered for use in adults from age 50 years. Funded for adults at age 65 years (with a catch-up, until 31 March 2020, for ages 66–80 years, inclusive). Unfunded for adults aged 50–64 years.
- g Consider screening for seroconversion after vaccination (see section 8.5.7). The 40 µg HepB dose may be recommended but is not funded.
- h Give MCV4-D at least 4 weeks after PCV13^{13, 14} (see section 12.4.4).
- i MCV4-D is registered for individuals aged 9 months to 55 years, but there are not expected to be any safety concerns when administered to adults older than 55 years.

Source: Starship Children's Health.

4.3.4 Asplenia

There are three main reasons why an individual may not have a functioning spleen:

- surgical removal (eg, post-trauma)
- disease (eg, sickle cell disease, thalassaemia)
- congenital asplenia or polysplenia (eg, with congenital heart disease).

All splenic individuals are at increased risk of fulminant bacteraemia, which is associated with a high mortality rate. The risk is greatest for infants, and probably declines with age and with the number of years since onset of asplenia.

The degree of risk of death from sepsis is also influenced by the nature of the underlying disease: it is increased 50 times (compared with healthy children) in asplenia after trauma and 350 times in asplenia with sickle cell disease, and the risk may be even higher post-splenectomy for thalassaemia.

Streptococcus pneumoniae is the pathogen that most often causes fulminant sepsis in these individuals. Other less frequent pathogens are *Neisseria meningitidis*, *Haemophilus influenzae* type b, other streptococci, *Staphylococcus aureus*, *Escherichia coli* and other gram-negative bacilli (eg, *Klebsiella*, *Salmonella* species and *Pseudomonas aeruginosa*). There is an increased fatality from malaria for asplenic individuals.

More information about asplenia is available on the Starship website (www.starship.org.nz/for-health-professionals/starship-clinical-guidelines/a/asplenia/).

Immunisation of asplenic individuals

No vaccines are contraindicated for individuals with functional or anatomical asplenia. It is important to ensure that the individual is up to date with the routine immunisations according to the National Immunisation Schedule, especially pneumococcal, Hib and MMR.

In addition to the routine Schedule vaccines, including VV at age 15 months or 11 years and HPV vaccine for individuals aged 26 years and under, the following vaccines are funded and/or recommended as soon as the asplenic condition is recognised. The immunisation schedules are age-dependent and are provided in Table 4.7 below.

- Pneumococcal conjugate and polysaccharide vaccines are funded for asplenic children and adults (see also chapter 15). If children have commenced immunisation with PCV10, they can complete it with PCV13, followed by 23PPV at the appropriate age.
- Meningococcal conjugate vaccine is funded for all asplenic individuals (see also chapter 12). Meningococcal C conjugate vaccine (MenCCV; NeisVac-C) is recommended for children aged under 2 years, followed by quadrivalent meningococcal vaccine (MCV4-D; Menactra) at age 2 years. MCV4-D is recommended for individuals aged 2 years and older.
- Hib vaccine – because of an increased risk of infection, it is particularly important that all asplenic individuals receive the Hib vaccine (funded) (see also chapter 6).
- Annual influenza vaccine is recommended for all asplenic individuals from 6 months of age (funded for individuals pre- and post-splenectomy) (see also chapter 10).
- Age-appropriate pertussis-containing vaccine is funded for (re-)vaccination of individuals pre- or post-splenectomy (see chapter 14).

For elective splenectomy, immunisations should be commenced as soon as possible and at least two weeks pre-operatively. For emergency splenectomy, commence immunisations two weeks post-operatively.

Prior to commencing immunisation, discuss with the individual's specialist.

Table 4.7: Additional vaccine recommendations (funded and unfunded) and schedules for individuals with functional or anatomical asplenia

Note: Individuals with functional or anatomical asplenia should receive the routine Schedule vaccines, including varicella at age 15 months or 11 years and HPV for individuals aged 9–26 years, following recommended catch-up schedules if necessary. Funded vaccines are in the shaded rows, however vaccinators are advised to refer to the Pharmaceutical Schedule (www.pharmac.govt.nz) for any changes to funding decisions.

Age at diagnosis	Vaccine (trade name)	Recommended vaccine schedule
Aged under 12 months when diagnosed with functional asplenia or pre- ^a or post-splenectomy	PCV13 (Prevenar 13)	PCV13 at ages 6 weeks and 3, 5 and 15 months. If commencing immunisation at ages 7–11 months, give 2 doses of PCV13 at least 4 weeks apart, followed by a booster dose at age 15 months.
	23PPV (Pneumovax 23)	Following the completion of the PCV course, give 1 dose of 23PPV at age ≥2 years. There must be at least 8 weeks between the last PCV dose and the 23PPV dose. Revaccinate once with 23PPV, 5 years after the 1st 23PPV.
	MenCCV (NeisVac-C) and MCV4-D (Menactra)	Age-appropriate MenCCV schedule: <ul style="list-style-type: none"> • if aged under 6 months at diagnosis, give 2 doses 8 weeks apart, with a booster at age 12 months • if aged 6–11 months at diagnosis, give 1 dose, with a further dose at age 12 months. At age 2 years, give 2 doses of MCV4-D ^b 8 weeks apart, then a booster dose after 3 years, then 5-yearly.
	Influenza (Fluarix Tetra)	Annual immunisation ^c from age 6 months. In the first year, give 2 doses 4 weeks apart, then 1 dose in each subsequent year.

Continued overleaf

Age at diagnosis	Vaccine (trade name)	Recommended vaccine schedule
Aged 12 months to under 18 years when diagnosed with functional asplenia or pre- ^a or post-splenectomy	PCV13 (Prevenar 13)	PCV13 ^d age-appropriate catch-up schedule: <ul style="list-style-type: none"> • previously unimmunised children aged ≥ 12 months to under 5 years require 2 doses of PCV13,^d 8 weeks apart • previously unimmunised children aged 5 years to under 18 years require 1 dose of PCV13^d • children aged >17 months who have completed the primary course of PCV10 but have not received PCV13, give 1 dose of PCV13.^e
	23PPV (Pneumovax 23)	Following the completion of the PCV13 course, give 1 dose of 23PPV at age ≥ 2 years. There must be at least 8 weeks between the last PCV13 dose and the 23PPV dose. Revaccinate once with 23PPV, 5 years after the 1st 23PPV.
	MenCCV (NeisVac-C) and MCV4-D (Menactra)	If aged 12–23 months at diagnosis, give 1 dose of MenCCV, followed by MCV4-D ^b at age 2 years, 2 doses 8 weeks apart; then a booster of MCV4-D after 3 years, then 5-yearly. If aged ≥ 2 years at diagnosis, give 2 doses of MCV4-D ^b 8 weeks apart, and: <ul style="list-style-type: none"> • if the 1st MCV4-D dose was given at age <7 years, give a booster after 3 years, then 5-yearly, or • if the 1st MCV4-D dose was given at age ≥ 7 years, give a booster dose every 5 years.
	Hib (Hiberix)	If aged 12–15 months, give 1 dose at age 15 months as per the National Immunisation Schedule. ^f If aged 16 months to under 5 years and has not received a single Hib dose after age 12 months, give 1 dose. ^f If aged 5 years and older, give 1 dose, even if fully vaccinated. ^f

Continued overleaf

Age at diagnosis	Vaccine (trade name)	Recommended vaccine schedule
Aged 12 months to under 18 years when diagnosed with functional asplenia or pre- ^a or post-splenectomy (continued)	Influenza (Fluarix Tetra if aged under 3 years; Influvac Tetra if aged 3 years and older)	Annual immunisation. ^c In previously unimmunised children aged under 9 years, give 2 doses 4 weeks apart, then 1 dose in each subsequent year.
	Varicella (Varilrix)	Give 1 dose at age 15 months, as per the National Immunisation Schedule. ^{g,h} If no history of varicella disease or immunisation, give 1 dose at age 11 years. ⁱ
	Varicella (Varilrix or Varivax)	For susceptible children who do not meet the eligibility criteria for funded vaccine: <ul style="list-style-type: none"> • if aged under 13 years, give 1 dose^h • if aged 13 years and older, give 2 doses, at least 6 weeks apart.
Aged ≥18 years when diagnosed with functional asplenia or pre- ^a or post-splenectomy	PCV13 (Prevenar 13)	1 dose of PCV13. ^j
	23PPV (Pneumovax 23)	Give a maximum of 3 doses of 23PPV in a lifetime, a minimum of 5 years apart. The 1st 23PPV dose is given at least 8 weeks after PCV13; the 2nd a minimum of 5 years later; the 3rd dose at age ≥65 years.
	MCV4-D (Menactra)	Give 2 doses of MCV4-D, 8 weeks apart, then 1 dose every 5 years. ^{b,k}
	Hib (Hiberix)	Give 1 dose of Hib, regardless of previous vaccination history.
	Tdap (Boostrix)	If partially immunised or unimmunised: <ul style="list-style-type: none"> • give up to 3 doses^l of Tdap, 4 weeks apart to complete a 3-dose primary course. If fully immunised: <ul style="list-style-type: none"> • give 1 dose of Tdap.
	Influenza (Influvac Tetra)	Annual immunisation. ^c
	Varicella (Varilrix or Varivax)	If no history of varicella disease or immunisation, give 2 doses, at least 6 weeks apart.

a Where possible, the vaccines should be administered at least 2 weeks before elective splenectomy. For emergency splenectomy, the vaccines should be administered 2 weeks post-operatively.

b Give MCV4-D at least 4 weeks after PCV13^{13, 14} (see section 12.4.4).

c Influenza vaccine is recommended but not funded for individuals with functional asplenia.

- d If 23PPV has already been given (prior to any doses of PCV13) to children aged under 18 years, wait at least 8 weeks before administering PCV13.
- e There are no safety concerns, regardless of the interval between the last dose of PCV10 and the 1st dose of PCV13.
- f Hib is not required if the child is being revaccinated with DTaP-IPV-HepB/Hib.

Continued overleaf

- g Funded for children who were born on or after 1 April 2016.
- h A second VV dose is not currently funded but may be purchased for those who wish to reduce the risk of breakthrough disease.
- i Funded for previously unvaccinated children who are turning 11 years old on or after 1 July 2017 who have not previously had a varicella infection.
- j If 23PPV has already been given (prior to any doses of PCV13) to adults aged 18 years and older, wait at least 1 year before administering PCV13.
- k MCV4-D is registered for individuals aged 9 months to 55 years, but there are not expected to be any safety concerns when administered to adults older than 55 years.
- l Although Tdap is not registered for use as a primary course, there are expected to be no safety concerns.

Source: Starship Children's Health.

4.3.5 Other high-risk individuals

Individuals with chronic lung diseases should receive influenza and pneumococcal vaccines. See chapters 10 and 15.

4.3.6 (Re-)vaccination following immunosuppression

All vaccines on the National Immunisation Schedule are funded for (re-)vaccination of individuals following immunosuppression. Note that the period of immunosuppression due to steroid or other immunosuppressive therapy must be longer than 28 days. The timing and number of doses should be discussed with the individual's specialist.

See also the individual disease chapters.

4.4 Immigrants and refugees

4.4.1 Introduction

Adults and children who enter New Zealand as refugees or immigrants will need an assessment of their *documented* vaccination status and an appropriate catch-up programme planned.

Regardless of their immigration and citizenship status, all children aged under 18 years are eligible to receive Schedule vaccines, and providers can claim the immunisation benefit for administering the vaccines (see the 'Eligibility for publicly funded vaccines' section in the Introduction to this *Handbook*). All children are also eligible for Well Child Tamariki Ora services, regardless of immigration and citizenship status. For more information about eligibility for publicly funded services, see the Ministry of Health website (www.health.govt.nz/eligibility).

Children who have been previously immunised in low-income country may have received BCG, three doses of DTwP and oral polio vaccine (and/or IPV) in the first six months of life, and a dose of measles vaccine between 9 and 15 months of age. However, they are unlikely to have received Hib, pneumococcal, HepB, MMR or VV. Many countries, including European countries, do not have HepB included in their national childhood immunisation schedule. For immigrant children a catch-up immunisation plan may be needed.

If a refugee or immigrant has no valid documentation of vaccination, an age-appropriate catch-up programme is recommended (see Appendix 2). The programme may require modification for any **documented** doses: only clearly documented doses should be considered as given.

Details of immunisation schedules of other countries can be found on the WHO website (http://apps.who.int/immunization_monitoring/globalsummary/schedules). See also the *Recommendations for Comprehensive Post-Arrival Health Assessment for People from Refugee-like Backgrounds (2016 edition)*, available on the Australasian Society for Infectious Diseases website (www.asid.net.au/resources/clinical-guidelines).

4.4.2 Tuberculosis

TB is an important public health problem for refugees and immigrants. Figures from the US show that approximately 1–2 percent of refugees are suffering from active TB on arrival, and about half have positive tuberculin skin tests. The number who have received BCG immunisation is unknown. In New Zealand there is a significant increasing trend in the number of TB cases in overseas-born people.

Suspected TB must be appropriately investigated. If individuals are known to have been recently exposed but tests are negative, they should be tested again three months later to identify recently acquired infection. Previous BCG immunisation should be considered when interpreting tuberculin skin test results (see chapter 20).

In New Zealand, the policy is to offer BCG vaccination to infants at increased risk of TB who:

- will be living in a house or family/whānau with a person with either current TB or a history of TB
- have one or both parents or household members or carers who within the last five years lived for a period of six months or longer in countries with a rate ≥ 40 per 100,000
- during their first five years will be living for three months or longer in a country with a rate ≥ 40 per 100,000 (see Appendix 8 for a list of the high-incidence countries).

4.4.3 Hepatitis B

If a member of an immigrant or refugee family is found to have chronic HBV infection, it is recommended that all the family be screened and immunisation offered to all those who are non-immune. Even if no one in the family has chronic HBV infection, it is recommended that all children aged under 18 years be vaccinated against hepatitis B. See chapter 8 for more information and Appendix 2 for catch-up schedules.

4.4.4 Varicella

People who have grown up in the tropics are less likely to have had chickenpox and may be non-immune adolescents and adults. Because adult chickenpox can be severe, if there is no history of chickenpox, VV should be offered (although it is currently not funded).

4.5 Travel

All travellers should be encouraged to consider vaccination requirements well in advance of overseas travel. For example, information on diphtheria, MMR, influenza and hepatitis A vaccination for adults is included in the appropriate sections of this *Handbook*. Up-to-date information on overseas travel requirements (eg, for typhoid, yellow fever, rabies, Japanese encephalitis) can be obtained from the Centers for Disease Control and Prevention (wwwnc.cdc.gov/travel) or the WHO (www.who.int/ith/en/).

4.6 Occupational and other risk factors

Certain occupations result in increased risk of contracting some vaccine-preventable diseases. Some infected workers, particularly health care workers and those working in early childhood education services, may transmit infections such as influenza, rubella, measles, mumps, varicella and pertussis to susceptible contacts, with the potential for serious outcomes.

Where workers are at significant occupational risk of acquiring a vaccine-preventable disease, the employer should implement a comprehensive occupational immunisation programme, including immunisation policies, staff immunisation records, information about the relevant vaccine-preventable diseases and the management of vaccine refusal. Employers should take all reasonable steps to encourage susceptible workers to be immunised.

The vaccines in Table 4.8 are recommended for certain occupational groups and in Table 4.9 for those with other risk factors. In addition to the vaccines listed below, all adults should be up to date with routinely recommended vaccines, such as MMR (see section 2.1.7 or Appendix 2).

If a non-immune individual is exposed to a vaccine-preventable disease, post-exposure prophylaxis and control measures should be administered where indicated (see the relevant disease chapters and the *Communicable Disease Control Manual 2012*³³).

Table 4.8: Recommended vaccines, by occupational group

Occupation	Recommended vaccines
Health care workers	
Medical, nursing, lead maternity carers, other health professional staff and students	Hepatitis B (if susceptible) MMR (if susceptible) Influenza, annually Varicella (if susceptible) Hepatitis A (if work with children) Tetanus, diphtheria and pertussis (Tdap) (if work with children)
Individuals who work with children	
Early childhood education services staff	Hepatitis A Hepatitis B (if susceptible) MMR (if susceptible) Influenza, annually Varicella (if susceptible) Tdap
Other individuals working with children, including:	Influenza, annually MMR (if susceptible) Tdap Varicella (if susceptible)
<ul style="list-style-type: none"> • correctional staff working where infants/children live with mothers • school teachers (including student teachers) • outside school hours carers • child counselling services workers • youth services workers 	
Carers	
Health care assistants, long-term facility carers, nursing home staff	Hepatitis A (if exposed to faeces) Hepatitis B (if susceptible) Influenza, annually MMR (if susceptible) Tdap Varicella (if susceptible)

Continued overleaf

Occupation	Recommended vaccines
Emergency and essential service workers	
Police and emergency workers	Hepatitis B (if susceptible) Influenza, annually Tetanus (Td or Tdap)
Armed forces personnel	Hepatitis B (if susceptible) Influenza, annually MMR (if susceptible) Tetanus (Td or Tdap) Hepatitis A (if deployed to high-risk countries) Meningococcal C conjugate or quadrivalent meningococcal conjugate (if living in close quarters) Quadrivalent meningococcal conjugate, yellow fever, rabies, typhoid, Japanese encephalitis (as appropriate, if deployed to high-risk countries)
Staff of correctional facilities	Hepatitis B (if susceptible) Influenza, annually MMR (if susceptible)
Staff of immigration/refugee centres	Hepatitis B (if susceptible) Influenza, annually MMR (if susceptible)
Laboratory staff	
Laboratory staff	Hepatitis B (if susceptible) MMR (if susceptible) Influenza, annually Hepatitis A (if exposed to faeces) IPV
Laboratory staff regularly working with <i>Neisseria meningitidis</i>	Quadrivalent meningococcal conjugate vaccine
Individuals who work with animals	
Veterinarians, veterinary students, veterinary nurses	Influenza, annually BCG (if exposed to infected animals)

Continued overleaf

Occupation	Recommended vaccines
Zoo staff who work with primates	Hepatitis A Influenza, annually
Poultry workers and others handling poultry, including those who may be involved in culling during an outbreak of avian influenza, and swine industry workers	Influenza, annually
Other individuals exposed to human tissue, blood, body fluids or sewage	
Workers who perform skin penetration procedures (eg, tattooists, body-piercers)	Hepatitis B (if susceptible)
Funeral workers, embalmers and other workers who have regular contact with human tissue, blood or body fluids and/or used needles or syringes	Hepatitis B (if susceptible)
Sewage workers, plumbers or other workers in regular contact with untreated sewage	IPV Hepatitis A
Sex workers	Hepatitis B (if susceptible) HPV

Table 4.9: Recommended vaccines for those with other risk factors

Risk factor	Recommended vaccines
Individuals living in hostels or other close quarters (eg, university hostels, boarding schools)	Hepatitis B (if susceptible) MMR (if susceptible) Influenza, annually Meningococcal C conjugate or quadrivalent meningococcal conjugate*
Individuals in correctional facilities	Hepatitis B (if susceptible) MMR (if susceptible) Influenza, annually Meningococcal C conjugate
Men who have sex with men	Hepatitis B (if susceptible) Hepatitis A HPV
Intravenous drug users	Hepatitis B (if susceptible) Hepatitis A Influenza, annually

* Quadrivalent meningococcal conjugate vaccine is recommended if future travel is likely.

References

1. Eick AA, Uyeki TM, Klimov A, et al. 2011. Maternal influenza vaccination and effect on influenza virus infection in young infants. *Archives of Pediatrics and Adolescent Medicine* 165(2): 104–11.
2. Marshall H, McMillan M, Andrews RM et al. 2016. Vaccines in pregnancy: the dual benefit for pregnant women and infants. *Human Vaccines & Immunotherapeutics* 12(4): 848–56. DOI: 10.1080/21645515.2015.1127485 (accessed 24 September 2016).
3. Zaman K, Roy E, Arifeen SE, et al. 2008. Effectiveness of maternal influenza immunization in mothers and infants. *New England Journal of Medicine* 359(15): 1555–64.
4. Esposito S, Tagliabue C, Tagliaferri L, et al. 2012. Preventing influenza in younger children. *Clinical Microbiology and Infection* 18(Suppl 5): 42–9.
5. Tamma PD, Ault KA, del Rio C, et al. 2009. Safety of influenza vaccination during pregnancy. *American Journal of Obstetrics and Gynecology* 201(6): 547–52.

6. Regan A, Moore HC, de Klerk N, et al. 2016. Seasonal trivalent influenza vaccination during pregnancy and the incidence of stillbirth: population-based retrospective cohort study. *Clinical Infectious Diseases* 62(10): 1221–7. DOI: 10.1093/cid/ciw082 (accessed 17 November 2016).
7. Bednarczyk RA, Adjaye- Gbewonyo D, Omer SB. 2012. Safety of influenza immunization during pregnancy for the fetus and the neonate. *American Journal of Obstetrics and Gynecology* 207(3 Suppl): 38–46.
8. Amirthalingam G, Andrews N, Campbell H, et al. 2014. Effectiveness of maternal pertussis vaccination in England: an observational study. *The Lancet* 384(9953): 1521–8. DOI: [http://dx.doi.org/10.1016/S0140-6736\(14\)60686-3](http://dx.doi.org/10.1016/S0140-6736(14)60686-3) (accessed 10 August 2015).
9. Amirthalingam G, Campbell H, Ribeiro S, et al. 2016. Sustained effectiveness of the maternal pertussis immunization program in England 3 years following introduction. *Clinical Infectious Diseases* 63(Suppl 4): S236–43. DOI: <https://doi.org/10.1093/cid/ciw559> (accessed 18 February 2018).
10. Donegan K, King B, Bryan P. 2014. Safety of pertussis vaccination in pregnant women in the UK: observational study. *British Medical Journal* 349(11 July): g4219. DOI: 10.1136/bmj.g4219 (accessed 10 August 2014).
11. Department of Health and Ageing. 2016. Rotavirus. In: *The Australian Immunisation Handbook* (10th edition; updated August 2016). URL: <http://www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/Handbook10-home~handbook10part4~handbook10-4-17> (accessed 29 September 2016).
12. Lee J, Robinson JL, Spady DW. 2006. Frequency of apnea, bradycardia, and desaturations following first diphtheria-tetanus-pertussis-inactivated polio-*Haemophilus influenzae* type B immunization in hospitalized preterm infants. *BMC Pediatrics* 20(6): 20. DOI: 10.1186/1471-2431-6-20 (accessed 11 October 2013).
13. Centers for Disease Control and Prevention. 2013. Prevention and control of meningococcal disease: recommendations of the Advisory Committee on Immunization Practices (ACIP). *Morbidity and Mortality Weekly Report: Recommendations and Reports* 62(2): 1–28. URL: www.cdc.gov/mmwr/pdf/rr/rr6202.pdf (accessed 27 September 2013).
14. Pina LM, Bassily E, Machmer A, et al. 2012. Safety and immunogenicity of a quadrivalent meningococcal polysaccharide diphtheria toxoid conjugate vaccine in infants and toddlers: three multicenter phase III studies. *Pediatric Infectious Disease Journal* 31(11): 1173–83.

15. Bakare N, Menschik D, Tiernan R, et al. 2010. Severe combined immunodeficiency (SCID) and rotavirus vaccination: reports to the Vaccine Adverse Events Reporting System (VAERS). *Vaccine* 28(40): 6609–12. DOI: 10.1016/j.vaccine.2010.07.039 (accessed 23 December 2016).
16. Morillo-Gutierrez B, Worth A, Valappil M, et al. 2015. Chronic infection with rotavirus vaccine strains in UK children with severe combined immunodeficiency. *Pediatric Infectious Disease Journal* 34(9): 1040–1. DOI: 10.1097/INF.0000000000000788 (accessed 23 December 2016).
17. Klinkenberg D, Blohn M, Hoehne M, et al. 2015. Risk of rotavirus vaccination for children with SCID. *Pediatric Infectious Disease Journal* 34(1): 114–15. DOI: 10.1097/INF.0000000000000507 (accessed 23 December 2016).
18. Østensen M. 2014. Safety issues of biologics in pregnant patients with rheumatic diseases. *Annals of the New York Academy of Sciences* 1317(1): 32–8. DOI: 10.1111/nyas.12456 (accessed 20 December 2016).
19. Cheent K, Nolan J, Shariq S, et al. 2010. Case report: fatal case of disseminated BCG infection in an infant born to a mother taking infliximab for Crohn’s disease. *Journal of Crohn’s and Colitis* 4(5): 603–5.
20. American Academy of Pediatrics. 2015. Immunization in special clinical circumstances – immunization in immunocompromised children. In: Kimberlin DW, Brady MT, Jackson MA, et al (eds). *Red Book: 2015 Report of the Committee on Infectious Diseases* (30th edition). Elk Grove Village, IL: American Academy of Pediatrics.
21. Rubin LG, Levin MJ, Ljungman P, et al. 2013. 2013 IDSA Clinical Practice Guideline for vaccination of the immunocompromised host. *Clinical Infectious Diseases* 58(3): e44–e100. DOI: 10.1093/cid/cit684 (accessed 5 December 2013).
22. Australian Technical Advisory Group on Immunisation (ATAGI). 2017. Zoster (herpes zoster). In: *The Australian Immunisation Handbook* (10th edition; 2017 update). Canberra: Australian Government Department of Health. URL: <http://www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/Handbook10-home~handbook10part4~handbook10-4-24> (accessed 16 January 2018).
23. Department of Health and Ageing. 2016. Vaccination for special risk groups. In: *The Australian Immunisation Handbook* (10th edition; updated August 2016). URL: <http://www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/Handbook10-home~handbook10part3> (accessed 1 September 2016).

24. Gedalia A, Shetty AK. 2004. Chronic steroid and immunosuppressant therapy in children. *Pediatrics in Review* 25(12): 425–34.
25. Medsafe. 2017. New anti-cancer therapy – immune checkpoint inhibitors. *Prescriber Update* 38(4): 50. URL: <http://www.medsafe.govt.nz/profs/PUArticles/December2017/NewAntiCancerTherapy.htm> (accessed 19 December 2017).
26. Medsafe Pharmacovigilance Team. 2017. *Review of Immune Checkpoint Inhibitors in the New Zealand Context*. Presented at the 171st meeting of the Medicines Adverse Reactions Committee, 14 September 2017. URL: <http://www.medsafe.govt.nz/committees/marc/reports/171-Review%20of%20immune%20checkpoint%20inhibitors%20in%20the%20NZ%20context.pdf> (accessed 19 December 2017).
27. Cancer Institute NSW. 2017. *Melanoma Metastatic Ipilimumab and Nivolumab (induction)*. eviQ Cancer Treatments Online. ID: 1694 v.2. URL: <https://www.eviq.org.au/medical-oncology/melanoma/metastatic/1694-melanoma-metastatic-ipilimumab-and-nivolumab#15627>
28. European Lung Cancer Conference (ELCC) 2017. 2017. *Press Release: Annual Flu Jab May Pose Greater Risk for Lung Cancer Patients Under Immunotherapy*. URL: <http://www.esmo.org/Conferences/Past-Conferences/ELCC-2017-Lung-Cancer/News-Press-Releases/Annual-Flu-Jab-May-Pose-Greater-Risk-for-Lung-Cancer-Patients-Under-Immunotherapy>
29. British Columbia Cancer Agency. 2017. *Influenza Vaccine Guideline*. URL: http://www.bccancer.bc.ca/nursing-site/Documents/BC_Cancer_Provincial_Systemic_Therapy_Committee-Flu_Vaccine_Guidelines.pdf (accessed 19 December 2017).
30. Alberta Health Services. 2017. *Influenza Immunization for Adult and Pediatric Patients Undergoing Cancer Treatment*. Clinical Practice Guideline Supp-002, Version 9. URL: <https://www.albertahealthservices.ca/assets/info/hp/cancer/if-hp-cancer-guide-supp002-vaccination.pdf> (accessed 19 December 2017).
31. Neuhaus TJ. 2004. Immunization in children with chronic renal failure: a practical approach. *Pediatric Nephrology* 19(12): 1334–9.
32. Gipson DS, Massengill SF, Yao L, et al. 2009. Management of childhood onset nephrotic syndrome. *Pediatrics* 124(2): 747–57.
33. Ministry of Health. 2012. *Communicable Disease Control Manual 2012*. URL: <http://www.health.govt.nz/publication/communicable-disease-control-manual-2012> (accessed 15 November 2016).