

# Invasive Meningococcal Disease

Revision history			
Version	Date	Revised by	Changes
1	July 2014		Developed by the IMD SoNG Working Group
1.1	April 2015		Updated reference to Therapeutic Guidelines: Antibiotic 2014
1.2	Feb 2017	CDB	Alteration to Section 3 Vaccination refer to Immunisation Handbook
1.3	Feb 2018	CDNA	Document updated for currency. A new section added with a description of available and funded vaccines and new reference to the fact that schedules change. Specific advice on vaccination for confirmed IMD cases, and for higher-risk contacts eligible for vaccination added.

The Series of National Guidelines ('the Guidelines') have been developed by the Communicable Diseases Network Australia (CDNA) and noted by the Australian Health Protection Principal Committee (AHPPC). Their purpose is to provide nationally consistent guidance to public health units (PHUs) in responding to a notifiable disease event.

These guidelines capture the knowledge of experienced professionals, and provide guidance on best practice based upon the best available evidence at the time of completion.

Readers should not rely solely on the information contained within these guidelines. Guideline information is not intended to be a substitute for advice from other relevant sources including, but not limited to, the advice from a health professional. Clinical judgement and discretion may be required in the interpretation and application of these guidelines.

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# Invasive Meningococcal Disease

## CDNA National Guidelines for Public Health Units

### 1. Summary

#### ***Public health priority***

Urgent

#### ***Case management***

Isolate case and practise standard and droplet precautions for 24 hours after initiation of appropriate antibiotic treatment. Exclude from child-care, school, other educational institution or work until 24 hours of antibiotics completed.

#### ***Contact management***

Provide information to identified contacts and urgently arrange for clearance antibiotics to be given to eligible higher-risk contacts. Vaccination is advised for eligible higher-risk contacts if case confirmed to be caused by some vaccine preventable serogroups (A, C, W or Y).

### 2. The disease

#### ***Infectious agent***

*Neisseria meningitidis* is a Gram-negative diplococcus. There are 13 serogroups of *N.meningitidis*, with six serogroups (A, B, C, W, X and Y) accounting for the majority of cases of invasive meningococcal disease (IMD) worldwide.<sup>1</sup> From 2002 to 2015 the predominant meningococcal serogroup in Australia was serogroup B.<sup>2</sup> Notifications of serogroup W (MenW) increased nearly five-fold between 2014 and 2016, and in 2016, MenW was the predominant meningococcal serogroup notified in Australia.<sup>3</sup>

#### ***Reservoir***

*N. meningitidis* is a commensal of humans, the only natural host. The bacteria normally colonise the mucosa of the upper respiratory tract without causing disease. The mean duration of carriage, in settings where prevalence is stable, has been estimated as about 21 months.<sup>4</sup> The carriage rate varies from around 3–25 percent of the population, depending primarily on age.<sup>5</sup> In European and North American studies carriage rates have been shown to be very low in the first years of life and then to sharply increase in teenagers, reaching a maximum in those aged between 20 and 24 years.<sup>6</sup> Meningococcal carriage is also associated with male gender, coincident viral or bacterial respiratory tract infections, low socio-economic status, smoking, frequency of intimate kissing and the number and closeness of social contacts.<sup>6,7</sup>

#### ***Mode of transmission***

Transmission is primarily by respiratory droplets from the upper respiratory tract. Saliva has been shown to inhibit the growth of meningococci and salivary contact (e.g. by sharing drink bottles) is not considered to be a significant means of transmission.<sup>8</sup>

## ***Incubation period***

Usually from 1 to 7 days (rarely up to 10 days). Individuals who become asymptomatic carriers of meningococci are very unlikely to develop IMD<sup>1</sup>.

## ***Infectious period***

Until the organisms are no longer present in discharges from the nose and throat. With effective antibiotic therapy meningococci usually disappear from the nasopharynx within 24 hours.<sup>9</sup>

## ***Clinical presentation and outcome***

Invasive infections due to *N. meningitidis* can present as a spectrum of clinical illness, with meningitis and septicaemia, or a combination of the two, being the most common. Disease expression can also include pneumonia, septic arthritis, epiglottitis, pericarditis, gastrointestinal symptoms, conjunctivitis and urethritis.<sup>10</sup> Meningococcal meningitis typically presents with fever, meningeal signs (e.g. headache, neck stiffness, photophobia) and altered mental status.<sup>10</sup>

Septicaemia, with or without meningitis, can have a fulminant and rapidly fatal course (sometimes less than 24 hours) with initial symptoms that are nonspecific (e.g. fever, muscle aches, vomiting), especially in children.<sup>11</sup> The septicaemic form can be difficult to diagnose before the onset of the characteristic haemorrhagic (ie. petechial or purpuric) rash that does not blanch under pressure. Appearance of a rash can be relatively late (median onset 13-22 hours)<sup>12</sup> or there may be no rash at all. Additionally, in the early stages of illness there is sometimes a maculopapular rash that blanches under pressure. This rash may progress to become haemorrhagic and non-blanching or may fade away.<sup>13</sup>

Leg pain, cold extremities, and abnormal skin colour – described as pallor or mottling – are frequently reported in the first 12 hours of meningococcal disease (median onset 7-12 hours), particularly in children and adolescents.<sup>12</sup>

Infrequently, chronic meningococcal septicaemia can also occur.

Overall mortality for IMD is approximately 5-10 percent of infected individuals.<sup>14</sup> An increase in case fatality rate (CFR) has been associated with a range of factors, including age,<sup>15, 16</sup> the *N. meningitidis* serogroup,<sup>17, 18</sup> concurrent HIV infection<sup>19</sup> and whether cases are associated with an outbreak.<sup>20</sup> Most deaths occur in the first 24 hours<sup>21</sup> and early diagnosis and treatment is associated with reduced CFR.<sup>22, 23</sup>

Long term sequelae affect 10-20 percent of recovered IMD cases, including deafness, other neurological deficits, skin loss requiring grafts and partial or full amputation of limbs.<sup>1</sup>

## ***People at increased risk of disease***

Transmission from a symptomatic case is uncommon – the vast majority of cases are sporadic with transmission assumed to have occurred from prolonged close contact with an asymptomatic carrier in the network of close contacts.

## ***Household contacts***

The contacts most at risk of meningococcal disease are other members of the household of a case of IMD, during the first week after the case is detected.<sup>24</sup> Studies carried out in Europe and America before the routine use of clearance antibiotics showed that household contacts

of a case of IMD had a 500 to 800-fold greater risk of meningococcal disease than the general population. <sup>24, 25</sup> The risk was highest in the first week after onset of illness in the case and fell rapidly thereafter. <sup>24</sup>

### ***Intimate contacts***

The frequency of intimate kissing, involving close contact with respiratory droplets from the nasopharynx, increases the risk of both carriage <sup>7, 26</sup> and disease. <sup>27, 28</sup> However, contact with saliva *per se*, such as through sharing drinks or superficial mouth kissing, is not thought to significantly increase risk of carriage or disease. <sup>8</sup>

### ***Child-care contacts***

There is limited evidence in favour of providing clearance antibiotics to child-care contacts of sporadic cases of IMD. A Belgian study found that the relative risk of secondary IMD among day-care (aged under three years) and pre-school contacts (aged two to five years) was much less than that for similarly aged household contacts of an index case. <sup>24</sup> A British study of pre-school settings (including day care, play-groups and other pre-school groups) (most were aged less than four years) found that the relative risk of a cluster of cases in pre-school in the four weeks after an index case was 27.6 and the absolute risk was 49/100,000 contact children. <sup>29</sup>

### ***School and university contacts***

United States (US) and United Kingdom (UK) studies have demonstrated a modestly increased risk of further cases in schools attended by index cases. <sup>30, 31</sup> However, subsequent cases do not necessarily occur in the same classroom as the index case, with others occurring, for example, in contacts who share extracurricular activities with index cases. <sup>30</sup> In the US the relative risk of further cases among school students (5-18 years of age) was 2.3. <sup>30</sup>

### ***Healthcare workers and others with close contact with a case after onset of symptoms***

Even though transmission from a symptomatic case is uncommon there is, however, a small increased risk of disease in people who have very close contact with a symptomatic case prior to completion of 24 hours of antibiotic therapy. Those healthcare workers who have unprotected close airway exposure to large particle respiratory droplets (e.g. during airway management) from a case of IMD around the time of admission, are at increased risk of disease in the 10-day period after exposure. <sup>32</sup> However, the risk is very low; in one study absolute risk was estimated to be 0.8/100,000, <sup>33</sup> far below the risk in household contacts.

### ***Other groups/individuals at higher risk***

Laboratory personnel who work with *N. meningitidis* are at increased risk of IMD. <sup>34, 35</sup> Other risk factors for IMD include congenital or acquired immunoglobulin deficiencies and complement deficiencies, anatomic or functional asplenia, travel to or residence in countries where meningococcal disease is hyperendemic or epidemic, <sup>36</sup> exposure to cigarette smoke, <sup>37, 38</sup> concurrent respiratory tract infections <sup>39, 40</sup> and crowded living conditions or recreation spaces. <sup>41, 42, 43</sup> Indigenous Australians are at significantly increased risk compared to the non-indigenous population. <sup>23, 44</sup>

### ***Disease occurrence and public health significance***

IMD is endemic in Australia but the incidence has varied dramatically over time, with major epidemics following both world wars. More recently, incidence increased through the 1990s,

but declined to historically low levels following a peak around the early 2000s. <sup>45, 46</sup> Cases occur throughout the year, but there is a marked seasonality, with the highest number of notifications and hospitalisations occurring between June and September each year. <sup>47</sup> All age groups can be affected, but there is a bimodal age distribution, with the highest rates of disease in children aged under 5 years and a second peak in adolescents and young adults aged 15-19 years. <sup>2</sup>

While the overall incidence and mortality associated with IMD is low, the clinical and public health management of the disease can be demanding. This is related to the often dramatic course of the disease, the potential for deaths and serious complications, the fact that incidence is highest in young children, teenagers and young adults, and that clusters of cases may occur, albeit infrequently. Hence, it is essential that the public health follow-up of IMD is undertaken as a priority, that guidelines are followed closely, and that information provided to families of those affected, contacts and the media is consistent and evidence-based.

Universal childhood vaccination using the conjugate serogroup C vaccine, introduced in 2003, along with catch-up vaccination of children and adolescents through school based programs, has been associated with a marked reduction in serogroup C IMD cases in Australia. <sup>2, 16</sup>

### **3. Routine prevention activities**

#### ***Vaccination***

Vaccines are available in Australia for serogroups A, B, C, W and Y meningococcal disease.

The [Australian Immunisation Handbook 10<sup>th</sup> Edition](#), updated online version provides current guidance on meningococcal immunisation.

Meningococcal C conjugate vaccine (MenCCV) - Available through the National Immunisation Program. Recommended for all children at 12 months of age. From July 2018 this will be replaced with 4vMenCV.

Meningococcal B vaccine (MenBV) - Available on private script. Recommended for infants and young children, adolescents, young adults living in close quarters, some laboratory personnel and individuals with certain medical conditions.

Quadrivalent meningococcal vaccines (4vMenCV and 4vMenPV) which protect against serogroups A, C, W and Y. Available on private script. Recommended for occupational exposures, some travel and certain medical conditions. This can be also offered to those who wish to protect themselves or their family from these serogroups of meningococcal disease.

Check the [National Immunisation Schedule](#) and the relevant jurisdictional schedule for up-to-date information on currently funded vaccines, as schedules change from time to time. For example, in early 2017, some states implemented a time-limited adolescent ACWY vaccination program to address the changing epidemiology of serogroup W disease.

#### ***Risk mitigation***

The main aims of public health measures for meningococcal disease are:

- to provide information to contacts to allay anxiety and provide advice on the action to take should they develop symptoms consistent with IMD; and

- to identify and provide clearance antibiotics and vaccination where indicated to "higher risk" contacts of cases in order to reduce the risk of further cases resulting from transmission of a virulent strain of the organism.

#### 4. Surveillance objectives

- To promptly identify cases and their close contacts in order that appropriate public health action can be taken
- To identify clusters of cases and outbreaks in order that appropriate public health action can be taken
- To monitor the epidemiology of the disease, including the impact of immunisation, to inform prevention strategies
- To monitor the effectiveness of current control measures and to provide an evidence base for further review of national guidelines.

#### 5. Data management

Probable and confirmed cases of meningococcal disease should be entered onto the notifiable diseases database within one working day of notification. Ensure that data on Aboriginal or Torres Strait Islander status and vaccination history are collected and entered into the jurisdictional database. Serogroup, subserogroup and case outcome should be added to the database when available.

#### 6. Communications

Where applicable in a jurisdiction the laboratory or clinician notifies the state/territory communicable diseases branch or public health unit (PHU) of the case's age, sex, date of onset, clinical status, laboratory findings and vaccination history (if relevant).

#### 7. Case definition

Probable and confirmed cases of invasive meningococcal disease are notifiable.

##### ***Confirmed case***

A confirmed case requires either:

1. Laboratory definitive evidence

**OR**

2. Laboratory suggestive evidence **AND** clinical evidence.

##### ***Laboratory definitive evidence***

1. Isolation of *Neisseria meningitidis* from a normally sterile site

**OR**

2. Detection of specific meningococcal DNA sequences in a specimen from a normally sterile site by nucleic acid amplification testing.

### **Laboratory suggestive evidence**

1. Detection of Gram-negative diplococci in Gram stain of specimen from a normally sterile site or from a suspicious skin lesion

**OR**

2. High titre IgM or significant rise in IgM or IgG titres to outer membrane protein antigens of *N. meningitidis*

### **Clinical evidence (for a confirmed case)**

Disease which in the opinion of the treating clinician is compatible with invasive meningococcal disease.

### **Probable case**

A probable case requires **clinical evidence** only.

### **Clinical evidence (for a probable case)**

A probable case requires:

1. The absence of evidence for other causes of clinical symptoms

### **AND EITHER**

2. Clinically compatible disease including haemorrhagic rash

**OR**

3. Clinically compatible disease AND close contact with a confirmed case within the previous 60 days.

The current surveillance case definition can be located at the [Australian national notifiable diseases and case definitions web page](http://www.health.gov.au/casedefinitions): (www.health.gov.au/casedefinitions).

Although meningococcal conjunctivitis is not included in the IMD surveillance case definition, cases should still be notified in order to enable a public health response as, on occasion, it may precede invasive disease <sup>48</sup> or IMD in a contact <sup>49</sup> (refer to *Section 12*).

## **8. Laboratory testing**

### **Testing guidelines**

All patients with suspected meningococcal infection should have blood collected as soon as possible for culture, polymerase chain reaction (PCR) testing, C-reactive protein and full blood count. Where appropriate, a sample of cerebrospinal fluid (CSF) should be collected for PCR, microscopy and culture. For meningococcal conjunctivitis (refer to *Section 12*.special situations).

For further details of specimen collection, handling requirements and availability of testing, which may vary between locations, contact the relevant laboratory (Appendix 4: National Neisseria Network (NNN) laboratories).

## ***Molecular testing by Polymerase Chain Reaction (PCR)***

PCR-based diagnosis provides confirmation of IMD from blood, CSF or other normally sterile sites with validity comparable to that of culture-based diagnosis. Additionally, PCR methods can provide diagnostic information pertinent to patient care and public health management. For these reasons it is recommended that CSF and/or EDTA blood samples from which DNA was extracted for PCR-based diagnosis as well as the remaining DNA extract, both be sent to the appropriate NNN laboratory (refer to Appendix 4: National Neisseria Network (NNN) laboratories).

Early antibiotic therapy has contributed to PCR, particularly in blood specimens, now being the most common means of laboratory diagnosis of IMD. PCR-based assays are generally directed at the *ctrA* gene. Test sensitivity is >95 percent for CSF using *ctrA* gene PCR <sup>50</sup> and approximately 87 percent when testing blood samples. <sup>51</sup> Data are not available for skin lesions.

PCR tests for serogroup determination should be performed both from a confirmatory and epidemiological point of view. Serogroup identification can guide the public health response, particularly vaccination recommendations. PCR-assays for detecting regions in the *siaD* gene specific for serogroups B, C, W and Y are widely performed in Australia.

Although meningococcal DNA can be detected up to 72 hours after initiation of systemic antibiotics, caution should still be taken when interpreting negative PCR results. In probable cases results should be assessed in conjunction with clinical presentation, duration and severity of disease and the timing of the initiation of systemic antibiotics in relation to collection of the specimen. <sup>51</sup>

## ***Microscopy***

Detection of Gram-negative diplococci by Gram stain of CSF or specimens from other normally sterile sites constitutes laboratory suggestive evidence in the CDNA case definition. In conjunction with a clinically compatible illness, this fulfils criteria for a confirmed case of IMD. The reported sensitivity of Gram stain on CSF is about 62 percent <sup>52, 53</sup> and of skin lesion aspirates or biopsies about 50 percent. <sup>53, 54</sup> Prior use of antibiotics reduces the likelihood of a positive Gram stain and culture.

## ***Culture***

Culture of *N. meningitidis* from blood, CSF or other normally sterile sites confirms a diagnosis of IMD. Additionally, cultures provide isolates for strain differentiation and antibiotic susceptibility testing. When meningitis is present CSF offers the best chance of yielding an organism for culture, but sensitivity is reported to decline from 72 percent to 42 percent after antibiotic treatment. <sup>52</sup> The sensitivity of blood culture is reported to vary from 24-47 percent <sup>52, 55</sup> but falls to 5 percent or less if antibiotics have been given before collection. <sup>52</sup>

## ***Nasopharyngeal (throat) swabs***

The collection of throat swabs is not recommended for either cases of IMD or their contacts.

## ***Serology***

Serum antibody tests for the diagnosis of IMD are not routinely available, but are performed in some laboratories. Serological diagnosis is based on the demonstration of a single elevated level of IgM antibody or seroconversion to outer membrane protein (OMP) antigens.



As the OMP antigens amongst the *Neisseria* genus cross-react, the test may be positive in disseminated gonococcal infection.

An assay to detect IgM antibody to serogroup C capsule is also available and will detect an antibody response to recent C capsule vaccination or invasive infection with serogroup C *N. meningitidis*.

Serological diagnosis is retrospective but may be useful in circumstances where IMD was suspected clinically and when other tests were negative or not performed; it is not recommended for clinical diagnosis of acute cases.

### **Strain differentiation**

Strain differentiation or typing can assist in establishing linkages between cases or cases and carriers that are identified epidemiologically. Laboratory typing results can exclude true relatedness of apparently linked cases if they emerge as being distinct. Also, if the method used is highly discriminating and the prevalence of particular types is taken into account, detection of indistinguishable case isolates can provide quite strong evidence of relatedness.

Isolates and samples for typing are referred to NNN Laboratories (refer to Appendix 4). Historically, phenotyping (serotyping) has been used to separate isolates into serogroups (using capsular polysaccharides), serotypes and subserotypes (using OMP).

Genotyping (molecular) techniques are now used by most state laboratories to type strains in addition to serotyping. Techniques available include pulsed-field gel electrophoresis (PFGE), *porA/porB*, or *fetA* sequencing and multi-locus sequence typing (MLST).<sup>56</sup> Whole genome sequencing, where available, can also be used to establish strain relatedness of cases and guide public health interventions.

Further information is available from the [Public Health Laboratory Network \(PHLN\) case definition website](http://www.health.gov.au/internet/main/publishing.nsf/Content/laboratory+case+definitions-1):  
([www.health.gov.au/internet/main/publishing.nsf/Content/laboratory+case+definitions-1](http://www.health.gov.au/internet/main/publishing.nsf/Content/laboratory+case+definitions-1))

## **9. Case management**

### **Response times**

Public health action should commence immediately where the clinical picture is consistent with IMD – in the opinion of the treating clinician – or definitive or suggestive laboratory evidence is received. Begin investigation and response on the same day of notification of a probable or confirmed case of IMD or of confirmed meningococcal conjunctivitis.

Although meningococcal conjunctivitis is not included in the surveillance case definition for IMD, cases should still be notified in order to enable a public health response as, on occasion, it may precede invasive disease<sup>48</sup> or IMD in a contact<sup>49</sup> (refer to section 12 special situations).

### **Response procedure**

#### **Case investigation**

The response to a notification will usually be carried out in collaboration with the case's medical team. Ensure that action has been taken to:

- Discuss with the treating doctor the need to interview the case or the relevant care-giver in order to provide information and seek a contact history
- Establish what the case or the relevant care-giver has already been told about the diagnosis before beginning the interview
- Confirm the onset date and symptoms/signs of illness and assess whether the clinical evidence is consistent with a diagnosis of IMD
- Confirm results of existing relevant laboratory tests, or recommend that the tests be done
- Review case and contact management undertaken to date. For instance, establish if the treating team has provided clearance antibiotics to household contacts
- Facilitate the support of the case and/or family with a social worker, Aboriginal or Torres Strait Islander Liaison Officer or interpreter as required.

### ***Case treatment***

Treatment is the responsibility of the treating doctor. For antibiotic treatment recommendations refer to the current edition of [Therapeutic Guidelines: Antibiotic](#). Some antibiotics, including penicillin, do not reliably clear nasopharyngeal carriage of meningococci <sup>1</sup> so appropriate clearance antibiotics must also be used (refer to **Table 2**).

### ***Vaccination***

Vaccination of cases is not recommended unless the case has underlying risk factors as outlined in the [Australian Immunisation Handbook](#).

### ***Isolation and restriction***

Droplets and nasopharyngeal secretions are considered to be infectious from the onset of the acute illness until completion of 24 hours treatment with effective systemic antibiotics. <sup>9</sup> Hence, during this period both standard and droplet precautions should be practised for suspected, probable or confirmed cases, especially while undertaking airway management during resuscitation.

### ***Active case finding***

Contacts (refer to below) who develop symptoms consistent with IMD should be advised to seek medical advice urgently and to inform the PHU.

A single case of serogroup A meningococcal disease in an Aboriginal or Torres Strait Islander person may be the sentinel event of a community outbreak and requires appropriate action.

## **10. Control of environment**

None routinely required (refer to Section 12 special situations).

## 11. Contact management

### *Identification of contacts*

The aim of identifying contacts is to:

- Clarify their degree of contact with the case
- Provide them with information about meningococcal infection and their level of risk aimed at both allaying unnecessary anxiety and advising them of what action to take if they develop symptoms
- Recommend clearance antibiotics and vaccination if indicated (**Table 1**).

### *Contact definition*

Public health follow-up focuses on identifying the subset of 'higher-risk' contacts who require information and clearance antibiotics and vaccination in some instances. Other lower-risk contacts groups may be given information only.

In establishing the timing and degree of contact with a case, the time period of interest is from 7 days prior to the onset of symptoms in the case to the time the case has completed 24 hours of appropriate antibiotic treatment.

Higher-risk contacts fall into the following groups:

1. Household or household-like contacts: of a case are those who lived in the same house (or dormitory-type room) or were having an equivalent degree of contact with the case in the 7 days prior to the onset of the case's symptoms until completion of 24 hours of appropriate antibiotic treatment.
2. Intimate kissing and sexual contacts: in the 7 days prior to the onset of the case's symptoms until completion of 24 hours of appropriate antibiotic treatment.
3. Child-care: To be considered a higher-risk contact, children and staff in childcare should have an equivalent degree of contact with the case as a household contact. An exposure assessment should be conducted to assess the degree of contact at the childcare centre. As a guide, two full days (where one full day is approximately 6-8 hours) of attendance in the same care group as the case **or** a cumulative of around 20 hours in the same care group as the case in the 7 days prior to onset of case symptoms should be considered a higher-risk contact. Other childcare contact is considered lower-risk. Child-care includes any situation where children under 5 years of age are cared for with other children away from home. This setting includes kindergartens and pre-schools (pre-primary).
4. Passengers: seated immediately adjacent to the case during long distance travel (>8 hours duration) by aeroplane, train, bus or other vehicle.<sup>57</sup>
5. Healthcare workers who have had unprotected close exposure of their airway to large particle respiratory droplets of a case during airway management (e.g. suctioning, intubation), or mouth to mouth resuscitation up until the case has had 24 hours of appropriate antibiotic treatment.<sup>33, 48</sup>

**Table 1: Public health responses in defined settings in which a single case of invasive meningococcal disease (or meningococcal conjunctivitis) has occurred<sup>1</sup>**

<b>Settings</b>	<b>Clearance antibiotics<sup>2</sup></b>	<b>Vaccination<sup>3</sup></b>	<b>Information<sup>4</sup></b>
Household and other higher- risk contacts of a case (refer to Contact definition in Section 11)	Yes	Yes	Yes
Schools and universities	<b>Only</b> students who are household-like contacts of a case – refer to Contact definition Section 11	<b>Only</b> students who are household-like contacts of a case – refer to Contact definition Section 11	Yes - all other students in the same classroom (schools) or tutorial groups (universities)
Passengers in seats directly beside a case during long duration travel (>8 hours)	Yes	No	Yes
Childcare facilities	<b>Only</b> children and staff who are household-like contacts of a case – refer to section 11 Contact management	<b>Only</b> children and staff who are household-like contacts of a case – refer to Vaccination Section 11	Yes
Those exposed to a case after the onset of symptoms	No, unless meet other criteria for higher-risk contacts	No	Yes
Healthcare workers	Only healthcare workers who have performed airway management (e.g. suctioning, intubation) of a case without wearing a mask	No	Yes
Sporting team and work contacts (including both shared office or open air settings)	No	No	Yes

<sup>1</sup> Response for probable and confirmed cases of invasive meningococcal disease plus confirmed meningococcal conjunctivitis

<sup>2</sup> Only those in close and prolonged contact with a case in the 7 days prior to the onset of symptoms, and only very close contacts after the onset of the case's symptoms, and prior to completion of 24 hours of appropriate treatment, require clearance antibiotics

<sup>3</sup> Vaccination recommendations only apply when IMD is caused by serogroups A, C, W and Y, but not to B. Refer to Vaccination section below

<sup>4</sup> For lower-risk contacts, information should be provided as soon as possible and by no later than the end of the next business day

## ***Clearance antibiotics***

The main rationale for provision of clearance antibiotics is to eliminate meningococci from any carrier within the network of contacts close to each case, thereby reducing the risk of further transmission of what may be a more virulent strain of the organism within the social network and preventing further cases of invasive disease. Clearance antibiotics given to household contacts was estimated to be 89 percent effective in preventing secondary cases. <sup>58</sup>

Clearance antibiotics should also be provided for contacts of meningococcal conjunctivitis because secondary cases of IMD have occurred. <sup>49</sup>

Wider provision of clearance antibiotics outside the recommended groups should be avoided due to the risk of doing more harm than good, including elimination of protective flora, risk of side effects and development of antibiotic resistance. Following even a single case of IMD there may be considerable demands and pressure from parents or others for clearance antibiotics to be administered more widely than is recommended. It is important that public health personnel do not acquiesce to these demands, but rather provide reassurance on the low risk of IMD in contacts and carefully explain the purpose for clearance antibiotics.

All identified contacts, regardless of whether or not they are eligible to receive clearance antibiotics, should be advised to remain alert for symptoms and to seek medical review if appropriate.

The current (November 2017 edition) [Therapeutic Guidelines: Antibiotic](#) lists ciprofloxacin, ceftriaxone and rifampicin as suitable agents. Characteristics of these agents are shown below in Table 2. Clearance antibiotics should be given to contacts of confirmed cases of IMD as soon as possible after the contact is identified. However, there is no purpose in administering antibiotics if more than four weeks have elapsed since the most recent contact with the case.

**Table 2: Characteristics of agents used for nasopharyngeal clearance of meningococci**

Agent	Ciprofloxacin	Ceftriaxone	Rifampicin
Preferred agent for	Adults and children of all ages  Women taking the oral contraceptive pill (OCP)	Pregnant women  Situations where access to and/or compliance with rifampicin may be poor, such as in remote Indigenous communities	Young children
Dosage	Adult or child ≥12 yrs: 500 mg orally, as 1 dose  Children aged 5–12 years: 250 mg stat  Children under 5yrs: 30mg/kg up to maximum of 125 mg stat  *Ciprofloxacin suspension contains 250mg/5ml	Child under 12 years: 125 mg IM as 1 dose  Adult: 250 mg IM, as 1 dose	Child: Neonate <1 month: 5 mg/kg orally, 12-hourly for 2 days  Child ≥ 1 month: 10 mg/kg up to 600 mg orally, 12- hourly for 2 days.  Adult: 600 mg orally, 12-hourly for 2 days
Advantages	91-100% effective in elimination of nasopharyngeal carriage <sup>57</sup>  Single dose  Oral	97-98% effective in elimination of nasopharyngeal carriage <sup>59</sup>  Well tolerated  Single dose  No adverse reactions or drug interactions of importance	81-98% effective in elimination of nasopharyngeal carriage <sup>59</sup>  Oral, available in syrup
Contraindications	Previous allergy  Pregnancy  Drug interaction	Not for use in infants less than 4 weeks old.	Severe liver impairment;  Alcohol abuse;  Pregnancy
Disadvantage	Allergic reactions, including anaphylaxis  Compatible with breastfeeding but can cause diarrhoea in the infant	IM Administration:  • Painful and may require concomitant local anaesthetic  • Compatible with breastfeeding but can cause diarrhoea in the infant	2-day course could reduce compliance:  • Compatible with breastfeeding but may cause diarrhoea in infants. Monitoring of infants for jaundice is recommended  • Side effects; orange discolouration of soft contact lenses, tears and urine; gastrointestinal disturbance, dizziness, drowsiness, headache  • Drug interactions including hormonal contraceptives, anticoagulants and anticonvulsants

## **Vaccination**

Meningococcal vaccination may be offered to higher-risk contacts to further reduce the small risk of secondary cases. The rationale for vaccination in this context is to protect individuals from infection with an invasive strain of meningococcus that may still be circulating in their social network, including among persons who did not receive clearance antibiotics.

In addition to clearance antibiotics, vaccination with an appropriate vaccine is indicated for unimmunised household-like contacts of cases of IMD and meningococcal conjunctivitis confirmed to be caused by serogroup C, A, W or Y.

Public health units should facilitate access to appropriate vaccine either directly or through existing jurisdictional arrangements with primary care or immunisation providers.

*Contacts should be informed that, depending on their age, further doses may be required if they wish to have long term protection against meningococcal A, C, W and Y disease [[Australian Immunisation Handbook](#)]. Completion of the vaccination course, if necessary, is at the discretion of the contact and can be arranged via their primary care provider.*

Vaccination with 4CMenB vaccine, however, is not recommended after a single case of IMD caused by serogroup B, primarily because it is a multi-dose course, and a single (first) dose is unlikely to confer protection to the contact during the period of higher risk of disease.

Vaccination of household contacts with 4CMenB vaccine should, however, be considered if a second serogroup B case occurs in the same household (even if >30 days later), as this may indicate increased susceptibility of family members to IMD and/or ongoing transmission within the household.

## **Education**

Following confirmation of IMD, provide information to the network of contacts (or to the responsible guardians of children in the network) about the disease and how it is spread. For lower-risk contacts, information should be provided as soon as possible and by no later than the end of the next business day. A fact sheet, appropriate to the cultural and literacy needs of recipients, should be provided (refer to example at Appendix 2: Meningococcal disease: Information for the public). This information should include the message that contacts, or anyone close to them, who develop symptoms consistent with meningococcal disease, should seek urgent medical attention.

## **Isolation and restriction**

None required

## 12. Special situations

### ***Outbreaks***

Outbreaks of meningococcal disease can be particularly challenging for public health authorities due to the intense public concern and media interest they generate, <sup>23</sup> the potential for significant morbidity and mortality and the limited published evidence to guide best practice. <sup>60</sup>

The term 'outbreak' is taken to mean the occurrence of more cases than expected for the population or group under consideration. The objective of public health management of outbreaks of IMD is to interrupt transmission and prevent further cases. Once an outbreak is either suspected or recognised there is an immediate need to initiate a coordinated response. Elements of this response include:

- A situation review to determine if there is an outbreak and its extent;
- The establishment of a response team(s) and, if appropriate, a site visit;
- Establishment of heightened surveillance;
- Determination of the population at risk and calculation of age-specific and region-specific attack rates where indicated;
- Decisions on what action is to be taken, tailored to the setting;
- Provision of adequate information to all contacts and other people as indicated, including healthcare providers, affected communities or groups, the media and the wider public;
- Ensuring the provision of clearance antibiotics (and immunisation where indicated) as required for the setting; and
- Review of all actions taken and the preparation and dissemination of final documentation and a report.

### ***Definitions***

Sporadic case - a single case in the absence of previous known close contact with another case (refer to Contact definition above).

Primary (index) case - a case that occurs in the absence of previous known close contact with another case and is subsequently associated with a co-primary or secondary case.

Co-primary case - a close contact who develops disease within 24 hours of onset of illness in a primary case.

Secondary case - a close contact who develops disease more than 24 hours after onset of illness in a primary case where the available microbiological characterisation of the organisms is the same.



Organisation-based outbreak - two or more probable or confirmed (where the available microbiological characterisation of the organisms is the same) cases with onset in a four week interval, among people who have a common organization-based affiliation (such as attending the same high school, extended families and/or social groups) but no close contact with each other, in a grouping which makes epidemiological sense.

Community outbreak - three or more confirmed or probable cases of IMD where there is no direct epidemiologic link between the cases, with onset in a 3 month interval among persons residing in the same area and the primary attack rate is at least 10 per 100,000. <sup>57</sup> Rate calculations should not be annualised. This is not an absolute threshold and should be considered in the context of other factors, e.g. completeness of case reporting, whether there is continuing occurrence of cases after recognition of a suspected outbreak and population vaccination coverage where relevant.

### ***Identification of outbreaks***

The following changes in epidemiology of meningococcal disease are suggestive of an outbreak. <sup>61</sup>

- An increased rate of disease. In small populations it may be more useful to focus on the number of cases rather than the rate;
- Clustering of cases in an age group or a shift in the age distribution of cases; and
- Phenotypic and/or genetic similarity among strains causing disease in the population.

Suspected outbreaks should be reviewed in order to identify the microbiological features of the cases and any epidemiologic links between cases. Microbiological investigation should focus on confirmation of the diagnosis and rapid characterisation of organisms in as much detail as locally possible. Cases that occur closely in time and place, but are infected with different serogroups (or serotypes, serosubtypes or genotypes if known), should be managed as sporadic cases. <sup>62</sup> The identification of possible epidemiological links should include a search for contacts in common, particularly in childcare, educational institutions or other groupings or organisations. <sup>30, 63, 64, 65, 66</sup> Examples include attendance at nightclubs or parties. <sup>67</sup>

### ***Organisation-based outbreaks***

In settings such as childcare centres and aged care facilities, the population at risk is a natural grouping that makes epidemiological sense. Identification of populations at risk may be more difficult in other organisational settings, such as schools, universities and workplaces; or in extended families or social groups.

Clearance antibiotics should be considered for a wider group than household-like contacts, even though the evidence for preventing further cases is not strong. <sup>29, 68</sup> Co-primary or secondary cases should not be counted when determining whether criteria for provision of organisation-based clearance antibiotics have been met. This is because they are the household-like contacts.

If cases have occurred in a household-like setting, then this may not meet criteria for an organisational outbreak. For example, two cases in university students in the

same class who share accommodation do not define a university-based outbreak, since the risk is assumed to arise from the household-like setting of the shared accommodation.

The use of meningococcal vaccine in addition to clearance antibiotics should be considered if the outbreak is due to a vaccine-preventable serogroup. [62](#), [67](#), [69](#), [70](#), [71](#)

### **Community outbreaks**

These outbreaks are difficult to define and manage. At-risk populations are usually defined geographically by using natural or administrative boundaries that most closely fit the residence data for the majority of the outbreak cases. However, physical or administrative boundaries do not limit factors that contribute to the increasing risk of meningococcal disease and accurate identification of the at-risk population should not be inappropriately constrained by them.

Assess carefully all available epidemiological information, including both confirmed and probable cases, serotyping and/or genotyping data, dates of onset, direct and indirect links between cases, the size of the population or identifiable sub-population containing the cases and meningococcal vaccine uptake rates (where relevant). [54](#)

From an epidemiologic perspective, when determining if the criteria for an outbreak are met, secondary and co-primary cases should be counted as one case [57](#) for the purpose of calculating community attack rates.

Vaccination of the population at risk should be considered if an outbreak of a vaccine preventable serogroup is identified, as defined above. Other factors should be taken into account, including logistic and financial considerations. The decision to vaccinate a large population is a difficult one for several reasons:

- when the issue is first raised, there is usually a small number of cases with a relatively low attack rate in the total population;
- cases may be widely dispersed in time and space, making it difficult to determine whether this is an outbreak or a fluctuation within expected limits for sporadic disease; and
- the costs of the vaccine and other resources required to vaccinate the group are considerable.

Community-wide clearance antibiotics should not be used. The widespread use of clearance antibiotics in community outbreaks has not been shown to be of value. It may result in:

- the eradication of benign strains of *N. meningitidis* and bacteria of other species that induce protective antibodies;
- the generation of drug resistant strains; and
- an increase in the prevalence of drug-related adverse events.

### **Aboriginal and Torres Strait Islander communities**

Based on outbreaks reported in the 1980s and early 1990s, the risk of sustained transmission of IMD in Aboriginal and Torres Strait Islander communities, is

probably higher than in the general community.<sup>72</sup> For this reason a low threshold should be used to initiate disease control measures. Action targeted to all community members should be considered if there are 2 or more cases in a remote Aboriginal or Torres Strait Islander community within a 4 week period and where available characterisation indicates they are the same strain. The nature of any action will depend on factors including the size of the community and the serogroup of the organism.

Clusters of serogroup W disease occurred in Aboriginal communities in some states in 2016/17, and population-based vaccination interventions were undertaken in response.

### ***Meningococcal Conjunctivitis***

Primary meningococcal conjunctivitis may also precede invasive disease in a case or in a close contact.<sup>48, 49</sup> Hence, it is recommended that contacts of individuals with meningococcal conjunctivitis receive information and clearance antibiotics as for contacts of IMD cases.

Conjunctival swabs should be collected from suspect cases of meningococcal conjunctivitis as soon as possible for microscopy and culture. Gram staining of conjunctival exudate or scrapings from suspect cases of meningococcal conjunctivitis consistently reveals Gram-negative diplococci and abundant polymorphonuclear leukocytes. This provides a preliminary diagnosis of meningococcal conjunctivitis (with *N. gonorrhoeae* and *M. catarrhalis* considered in differential diagnosis), but culture is essential for diagnostic confirmation, strain characterization and antibiotic susceptibility testing.<sup>49</sup>

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## **14. Appendices**

Appendix 1: PHU Checklist for meningococcal

Appendix 2: Meningococcal disease: Information for the public

Appendix 3: Sample Meningococcal Disease questionnaire form

Appendix 4: National Neisseria Network (NNN) laboratories



## **Appendix 1: PHU Checklist for meningococcal cases**

### **Contact the patient's doctor to:**

- Obtain patient's history
- Confirm results of relevant pathology tests

### **Contact the patient's care giver to:**

- Confirm onset date and symptoms of the illness
- Recommend exclusions and restrictions
- Identify contacts and obtain contact details
- Complete *Meningococcal Disease Case Questionnaire Form*
- Provide with *Meningococcal Disease Information Sheet*

### **Contact Australian Childhood Immunisation Register (ACIR) to:**

- Verify immunisation status

### **Confirm case:**

- Assess information against case definition

### **Contact patient's contacts to:**

- Assess risk of meningococcal disease
- Determine current symptoms
- Recommend antibiotics/vaccination or not
- Explain symptoms and restrictions (child care)
- Provide with *Meningococcal Disease Information Sheet*

### **Other issues:**

- For a death, report details to state/territory CDB
- Assess and arrange best method for delivering intervention to contacts
- Where defined groups of people have been exposed (e.g. schools, childcare), contact the person in charge to explain the situation and to provide letters to exposed people
- Enter case data onto notifiable diseases database

## **Appendix 2: Meningococcal disease: Information for the public**

(This information sheet can be adapted to different settings)

### ***What is meningococcal disease?***

Meningococcal disease is a rare but very serious illness that usually appears as meningitis or septicaemia. 'Meningitis' means an inflammation of the protective coverings of the brain and spinal cord. 'Septicaemia' means blood poisoning, which is a more widespread infection throughout the body. Meningococcal disease is caused by bacteria called 'meningococci'. There are a number of different groups of meningococci. In Australia most disease is caused by Serogroup B. Serogroup C was common but is now rare due to immunisation.

### ***How serious is meningococcal disease?***

Although meningococcal disease is uncommon, it is a very serious disease. The infection can develop very quickly and can be fatal in 5-10 percent of cases. Most people make a complete recovery if the infection is diagnosed early and antibiotic treatment commenced promptly.

About a quarter of people who recover experience after-effects. Some of the more common after-effects include headaches, deafness in one or both ears, tinnitus (ringing in the ears), blurring and double vision, aches and stiffness in the joints and learning difficulties. Most of these problems get better with time. Some people may have more serious complications, such as requiring skin grafts or amputations of fingers/toes or limbs.

### ***Where do meningococci come from?***

Meningococci are common bacteria and around 10-20 percent of people carry them at the back of the nose and throat without showing any illness or symptoms. Carriers are more often young adults and less often children and older people. Meningococci are only found in people and never in animals or the general environment.

### ***What is a meningococcal 'carrier'?***

Almost all adults and children can carry these bacteria without ill effects. Research shows that being a carrier usually protects people against dangerous meningococci. People become carriers without knowing they have caught the germ and will get rid of it naturally, without treatment, after a few weeks or months.

### ***Who catches meningococcal disease?***

Meningococcal disease can occur at any age, but babies and children less than five years of age are most at risk. Teenagers and young adults aged 15–24 years and people of any age regularly exposed to active or passive tobacco smoking are also at increased risk.

For people who become sick the average time between being infected and becoming ill is about three to five days, but can be up to seven days. Rarely, small outbreaks may occur affecting more than one person, but usually each case is unrelated to any others.

### ***What are the symptoms?***

Someone with meningococcal disease will become very ill, usually feeling sicker than they have ever felt before. There are many symptoms of meningococcal disease, although a few are especially important. Most cases may have only a few of these symptoms and they hardly ever happen all at once. Signs and symptoms sometimes appear very quickly and people with meningococcal disease can get much worse within a few hours.

The symptoms of meningococcal disease include:

In infants and young children:

- fever
- disinterest in feeding
- irritability/fretfulness
- extreme tiredness or floppiness
- dislike of being handled
- vomiting and/or diarrhoea
- turning away from light
- drowsiness
- convulsions or twitching
- rash of red-purple pinprick spots or larger bruises

In older children and adults:

- headache
- photophobia (dislike of bright lights)
- fever
- vomiting and/or diarrhoea
- neck stiffness or aching
- backache
- joint pains, sore muscles, cold hands and leg pain
- general malaise, off food
- drowsiness, confusion
- rash of red-purple pinprick spots or larger bruises.

Young children may not complain of symptoms, so fever, pale or blotchy complexion, vomiting, lethargy (blank staring, floppiness, inactivity, hard to wake, or poor feeding) or rash are important signs.

In meningococcal septicaemia a rash is a very important sign. The rash can appear anywhere on the body and may vary from just one or a few small spots, especially early on, to later covering large areas of the skin.

You know your family and best friends better than anybody else. If somebody close to you has some of these signs and appears to you to be much sicker than usual, seek medical help immediately. Children and young adults should not be left alone if they are sick. Early diagnosis and treatment is vital.

If you are sent home by the doctor or hospital, it is important to return promptly for further assessment if symptoms get worse or do not improve.

### ***How is meningococcal disease spread?***

The disease is difficult to spread. The bacteria cannot live outside a human body and they cannot be picked up from surfaces, water supplies, swimming pools, buildings, food, drinks, pets or other animals. Spread of the bacteria is associated with regular close, prolonged and intimate contact.

The bacteria are passed between people in the secretions from the back of the nose and throat. This generally requires close and prolonged contact with a person carrying the bacteria who is usually completely well. Meningococcal bacteria are not easily spread by sharing drinks, food or cigarettes.

If a case of meningococcal disease occurs, people who live in the same household, sexual and other intimate contacts and close contacts in residential accommodation, such as student halls of residence and military camps, are at greater risk of infection than usual, although the overall level of risk remains very low.

### ***How is meningococcal disease treated?***

If a case of meningococcal meningitis or septicaemia is suspected, an antibiotic is given immediately by injection and the patient is admitted to hospital.

### ***Can meningococcal disease be prevented?***

Six serogroups of meningococcal bacteria (A, B, C, W, X and Y) account for most cases of meningitis or septicaemia due to meningococcal bacteria. Vaccines are available in Australia for serogroups A, B, C, W and Y meningococcal disease. The Australian Immunisation Handbook 10<sup>th</sup> Edition, updated online version provides current guidance on meningococcal immunisation.

- Meningococcal C conjugate vaccine (MenCCV) - Available through the National Immunisation Program. Recommended for all children at 12 months of age.
- Meningococcal B vaccine (MenBV) - Available on private script. Recommended for infants and young children, adolescents, young adults living in close quarters, some laboratory personnel and individuals with certain medical conditions.
- Meningococcal vaccines (4vMenCV and 4vMenPV) protect against serogroups A, C, W and Y. Available on private script. Recommended for occupational exposures, travel and certain medical conditions. This can be also offered to those who wish to protect themselves or their family from these serogroups of meningococcal disease.

Check the [National Immunisation Schedule](#) and the relevant jurisdictional schedule for up to date information on currently funded vaccines, as schedules change from time to time. For example, in early 2017, some states implemented a time-limited adolescent ACWY vaccination program although the duration and target group for each program differs.

### ***What happens when a case occurs?***

Public health authorities identify very close contacts of a case who are offered antibiotics to help prevent further spread of infection. These people are members of the same household, intimate contacts (e.g. boyfriends and girlfriends), and anyone who has spent a lot of time in the same dwelling as the case in the seven days before the case became unwell. Other contacts, such as friends and work colleagues, do not usually need treatment. Whenever a case occurs, public health authorities will advise what should be done, and will make sure all close contacts are treated with the right antibiotics to stop the infection spreading.

Once a person has recovered from meningococcal disease he/she will not be infectious and can safely return to childcare, school, or work. There are no restrictions on contacts of a case attending work, school or childcare, whether or not it is recommended that they take preventive antibiotics.

Antibiotics are given to close contacts to eliminate the bacteria from the throat and prevent the bacteria from being transmitted to others, just in case the contact may be an innocent carrier of the strain that caused illness. Clearance antibiotics are different to the antibiotics used to treat the infection and people who receive clearance antibiotics are still at some risk of developing the disease and therefore need to remain alert for any signs and symptoms.

### ***What should I do if I or my child has had contact with meningococcal disease?***

The disease is not normally spread through schools or work-places. Watch carefully for any sign of illness and seek attention immediately if you are concerned.

### ***More information***

The following websites provide further information:

[The Amanda Young Foundation](http://www.amandayoungfoundation.org.au/) (www.amandayoungfoundation.org.au/)

[Meningitis Centre Australia](http://www.meningitis.com.au/) (www.meningitis.com.au/)

[Better Health Channel](http://www.betterhealth.vic.gov.au) (www.betterhealth.vic.gov.au)

### **Appendix 3: Sample Meningococcal Disease questionnaire form**

[Invasive Meningococcal Disease SoNG webpage](#)

([www.health.gov.au/internet/main/publishing.nsf/Content/cdna-song-IMD.htm](http://www.health.gov.au/internet/main/publishing.nsf/Content/cdna-song-IMD.htm)).

*(This page contains form/s that are intended to be paper based that you can download and complete. If you are using any assistive technology and are unable to use the form please contact us using the [Online form](#) and feedback).*

## **Appendix 4: National Neisseria Network (NNN) laboratories**

### **Australian Capital Territory**

Microbiology Department The  
Canberra Hospital Yamba Drive

Garran ACT 2605

Telephone: +61 2 6244 2514

Facsimile: +61 2 6244 4646

### **New South Wales**

Microbiology Department, SEALS  
The Prince of Wales Hospital  
Barker Street, Randwick NSW

2031 Telephone: +61 2 9382 9084

Facsimile: +61 2 9382 9310

Department of Microbiology and  
Infectious Diseases

SSWPS

Locked Mail Bag 7090 Liverpool  
BC NSW 1871 Telephone: +61 2  
9828 5124

Facsimile: +61 2 9828 5129

### **Northern Territory**

Microbiology Laboratory, NTGPS  
Royal Darwin Hospital

Tiwi NT 0810

Telephone: +61 8 8922 8167

Facsimile: +61 8 89227788

### **Queensland**

Public Health Microbiology  
Queensland Health Scientific  
Services 39 Kessels Road

Coopers Plains Qld 4108  
Telephone: +61 7 3274 9101

Facsimile: +61 7 3274 9175

### **Tasmania**

Department of Microbiology and  
Infectious Diseases

Royal Hobart Hospital 48 Liverpool  
Street

Hobart Tasmania 7000

Telephone: +61 3 6222 8656

Facsimile: +61 3 62228574

### **South Australia**

Microbiology Laboratory SA  
Pathology

Frome Road Adelaide SA 5000

Telephone: +61 8 8222 3000

Facsimile: +61 8 8222 3543

### **Victoria**

Microbiological Diagnostic Unit  
Public Health Laboratory (MDU  
PHL)

Peter Doherty Institute

792 Elizabeth St, Melbourne VIC  
3000

Telephone: +61 3 8344 5701

Facsimile: +61 3 8344 7833

### **Western Australia**

Department of Microbiology

PathWest

Queen Elizabeth II Medical Centre,  
PP block

Hospital Avenue, NEDLANDS WA  
6009

T: +61 (0)8 6383 4501