OHS Body of Knowledge

Biological Hazards

Core Body of Knowledge for the
Generalist OHS Professional

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Biological Hazards

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Core Body of Knowledge for the Generalist OHS Professional

Biological Hazards

Abstract

Biological hazards present the Occupational Health and Safety (OHS) professional with complex challenges. Many and varied biological hazards may result from workplace exposure to organisms, or substances produced by organisms, that threaten human health. Although workers in health and community care, and agricultural and fishing occupations are at particular risk of exposure to hazardous biological agents, all workplaces harbour the potential for various forms of biological hazard exposure, particularly via person-to-person transmission of infectious disease. The COVID-19 pandemic has brought a heightened perspective to the management of biological hazards and the role of the OHS professional. This chapter outlines the knowledge required by the OHS professional to understand the nature of biological hazards and the principles of control. Armed with this knowledge, the generalist OHS professional can then facilitate a team approach to the identification, assessment and control and mitigation of biological hazards.

Keywords

biological hazard, biohazard, infection, vector, virulence, infectivity

Contextual reading

Readers should refer to 1 *Preliminaries* for a full list of chapters and authors and a synopsis of the OHS Body of Knowledge. Chapter 2, *Introduction* describes the background and development process while Chapter 3, *The OHS Professional* provides a context by describing the role and professional environment.

Terminology

Depending on the jurisdiction and the organisation, Australian terminology refers to 'Occupational Health and Safety' (OHS), 'Occupational Safety and Health (OSH) or 'Work Health and Safety' (WHS). In line with international practice this publication uses OHS with the exception of specific reference to the Work Health and Safety (WHS) Act and related legislation.

Jurisdictional application

This chapter includes a short section referring to the Australian model work health and safety legislation. This is in line with the Australian national application of the *OHS Body of Knowledge*. Readers working in other legal jurisdictions should consider these references as examples and refer to the relevant legislation in their jurisdiction of operation.

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1 Introduction

Biological hazards (biohazards) are “microorganisms and other carriers of plant or animal origin that can cause adverse health effects in workers” (EU-OSHA, 2019, p. 16). The wide ranging nature and variability in both their genomes and the diseases that they can inflict, the fact that they are can be found in any known environment and affect a wide range of hosts from plants to animals to humans, means they present the Occupational Health and Safety (OHS) professional with complex challenges.

In a review of occupational biological hazards, Dutkiewicz, Jablonski and Olenchock (1988) completed a detailed compilation of biological hazards showing how widespread the risks can be to workers across many occupations. They noted at least 193 important biological agents that show infectious, allergenic, toxic or carcinogenic activities in the working population. These agents include viruses, bacteria, fungi, plant substances, invertebrate animals and substances derived from vertebrate animals. They noted several occupations with risk of exposure, in addition to those traditionally thought to be high risk (agriculture, health-care and laboratory workers) (Table 1).

Table 1. Occupations with potential for exposure to biological hazards (modified from Dutkiewicz et al., 1988)

Occupation/Industry	Examples
Agriculture	Abattoirs, food packaging plants Cultivation and harvesting Breeding and tending animals Forestry Fishing Storage facilities: grain silos, tobacco and other processing\processing animal hair and leather Textile plants Wood processing: sawmills, paper mills, cork factories
Laboratory animal care	Breeding and tending animals Changing bedding, feeding animals Euthanising animals Handling and disposal of carcasses
Health care	Patient care: medical, dental
Pharmaceutical and herbal products	Compounding and manufacturing Packaging and dispensing
Personal care	Hairdressing
Clinical and research laboratories	Handling biological material or chemicals contaminated with biological material Manipulating DNA in bacteria, viruses, cells, plants or animals
Biotechnology	Production facilities
Day care centers	Feeding, toileting, interacting with sick/infectious children

	Cleaning surfaces touched by sick/infectious children
Building maintenance	"Sick" buildings
Sewage and compost facilities	Inspecting sewer pipelines Equipment maintenance Contact with untreated sewage
Industrial waste disposal systems	Handling material contaminated with biological matter Handling biological waste

Disturbingly, a study of biological hazard exposure in Australian workplaces revealed a "general lack of information on biological risks" and concluded that "effort should be made to raise the level of knowledge about biological hazards" (de Crespigny, 2011, p. 1.). This situation appears not to have improved with subsequent work by the European Agency for Health and Safety at Work identifying a lack of knowledge and awareness of workplace exposures to biological agents and related health problems and a lack of a systematic approach to workplace prevention for these hazards (EU-OSHA, 2019, p. 15). This lack of knowledge and of a systematic approach to prevention of biological hazards in the workplace was evident in the early stages of the COVID-19 pandemic and inhibited the early and effective intervention strategies. Consequently, this chapter is an important one for OHS professionals.

There is a vast variety of biological hazards. As has been evidenced with the emergence of the COVID-19 disease from the SARS-CoV-2 virus, both the range and nature of biological hazards is not static, emergent biohazards are constantly arising. Additionally the number of occupations that may be affected by biological hazards is very large and varied and crosses all industries and workplaces. While the COVID-19 pandemic has altered the way that people as a society collectively think and act in relation to biological hazards, this chapter is not about how to manage the risk of SARS-CoV-2 (the virus that causes COVID-19), in the workplace, nor is it intended to provide a comprehensive account of all biological hazards that may be encountered in the workplace, or for specific occupations. Rather, the intention is to heighten awareness of the need for constant vigilance, and to provide some guidance as to the types of biological hazards that can exist in Australian workplaces. Definitions for some key terms are provided in Appendix 1 with a summary of infective agents provided in Appendix 2.

2 Extent of the problem

Information on the prevalence or incidence of exposures to biological hazards is scarce and collection of data is further complicated by the fact that there may not be a clear link between exposure and the workplace (EU-OSHA, 2019). The Safe Work Australia publication *National Hazard Exposure Worker Surveillance* (NHEWS) report (de Crespigny, 2011) noted that Australian workers' compensation statistics indicate that each year approximately 1300 workers are compensated for diseases attributed to animal, human or biological factors (p. 1). However, the report queried the accuracy of this estimate as an indication of the extent of the impact of biological hazards as, “amongst other things, many workers in the Agriculture forestry and fishing industry are not covered by workers’ compensation schemes” (de Crespigny, 2011, p. 1).

In 2019, the European Agency for Safety and Health at Work (EU-OHSA) estimated worldwide, around 320,000 workers die each year from communicable diseases caused by work-related exposure to biological hazards (Jednyska, et al., 2019.) Illnesses from work-related infectious disease is expected to be higher, but the true extent of the matter is difficult to establish. There may be under-reporting due to the difficulty in determining the cause or route of infection and the perception that a worker may have contracted an infectious disease outside of the workplace.

Risks associated with biological hazards were brought into a heightened perspective in 2020 with the COVID-19 pandemic. As at 29th March 2021 the global figures indicate that more than 127 million people have been infected with more than 2.7 million deaths. Australia has experienced 29,255 people infected and 909 people dying. While 102 million people world-wide and 26,269 Australians are recorded as ‘recovered’, the long-term effects of COVID-19 infection are unknown. (Worldometer, 2021, March,29).

In some cases, links between workplaces, exposures and diseases are clear, for example:

- Healthcare workers are at highest risk of blood-borne and respiratory infections
- Sex workers are at risk of sexually transmissible infections
- Workers in agriculture, forestry or fishing industries are at risk of zoonotic infections. (EU-OSHA, 2019)

However, more research is needed on typical exposures for at-risk jobs, as well as research to establish the exact biological hazard causing the illness.

In 2015 the World Health Organization (WHO) identified the top eight emerging diseases likely to cause major pandemics with three other diseases designated as 'serious', requiring action by the WHO (WHO, 2015). The list included viral hemorrhagic fevers, antibiotic resistance, respiratory infections such as SARS, MERS or influenza, and zoonotic infections. Since 2016, there have been recurring outbreaks of Ebola (viral hemorrhagic fever) and the COVID-19 (SARS-type respiratory infection) global pandemic. With the emergence of the COVID-19 pandemic the WHO updated their list of priority diseases. Whilst noting that the list is not exhaustive the diseases listed are:

- COVID-19

- Crimean-Congo haemorrhagic fever
- Ebola virus disease and Marburg virus disease
- Lassa fever
- Middle East respiratory syndrome coronavirus (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS)
- Nipah and henipaviral diseases
- Rift Valley fever
- Zika
- “Disease X”. (WHO, 2020a)

The inclusion of ‘Disease X’ is interesting and emphasises the importance of OHS professionals having knowledge of biological hazards. WHO states that “Disease X represents the knowledge that a serious international epidemic could be caused by a pathogen currently unknown to cause human disease”.

OHS professionals not only need knowledge to manage risks of COVID-19 now, they need a greater understanding of biological hazards, methods of transmission and controls to help prevent exposure to emerging biological hazards.

The COVID-19 pandemic took many workplaces by surprise and as such they were not prepared for its impact. It is unlikely that this will be the last pandemic to challenge humanity, and moreover it is likely that workplaces will have to deal with a broadening range of biohazards in the future. For example:

- Green jobs, such as waste management and composting, are associated with exposures to specific allergens. The expected growth in green jobs in the future may result in more workers becoming sensitised to biomass-related allergens.
- Climate change may be a significant contributor to emerging risks due to the impact on the geographical distribution of vectors of some biological agents and the associated wider spread of disease. There is evidence that vector-borne diseases, particularly dengue is moving down the Australian eastern coast (Russell, et al., 2009).
- Changing travel patterns influence the spread of diseases. This influence is demonstrated when comparing the spread of Spanish Flu in 1918 with that of the COVID-19 pandemic in 2019-2021 where, while being a new virus in the human population, due to global travel it spread world-wide within three months. The impact of travel on the spread of the virus was also seen when closing borders, along with other restrictions on movement, helped to restrict the spread of the disease.
- Antibiotic resistance in many microorganisms is another emerging risk. First-line antibiotics for many pathogens are now ineffective due to increased antibiotic resistance placing workers exposed to those pathogens at greater risk.

Whilst being alert to this broadening range of biological hazards, workplaces also need to maintain vigilance over well-known diseases such as tuberculosis, Q-fever and influenza. To ensure they are kept under control so as to minimise their re-emergence.

3 Understanding biological hazards

Chan, Tsing and Koh (2011) noted occupational disease due to biological hazards can be prevented if the hazards are identified and controlled. This section describes the nature of biological hazards considering three types of biological agent – pathogens, allergens and zoonoses; it then outlines the various modes of transmission and the key risk factors. Appendix 1 provides some definitions useful for OHS professionals while Appendix 2 highlights the range of possible occupational infections and how to prevent them.

3.1 The nature of biological hazards

Safe Work Australia (SWA) provides a more expansive definition of biological hazards than that of the EU-OHSA (see section 1) to include:

> … organic substances that pose a threat to the health of humans and other living organisms. Biological hazards include pathogenic micro-organisms, viruses, toxins (from biological sources), spores, fungi and bio-active substances. Biological hazards can also be considered to include biological vectors or transmitters of disease. (de Crespigny, 2011, p. 1)

This chapter expands on this definition to consider three types of biological hazard:

- Pathogens
- Allergens
- Zoonoses.

A fourth type of biological hazards are prions, which are misfolded proteins with the ability to transmit their misfolded shape onto normal variants of the same protein. They characterise several fatal and transmissible neurodegenerative diseases in humans and many other animals (e.g. Creutzfeld-Jakob disease, Bovine spongiform encephalopathy, BSE, 'mad cow' disease), which can be associated with people working with brain and spinal cord tissue but are not addressed in this chapter.[1]

[1] For detailed information on prions, see, for example Centers for Disease Control and Prevention, https://www.cdc.gov/prions/index.html, National Institute of Allergy and Infectious Diseases, https://www.niaid.nih.gov/diseases-conditions/prion-diseases, or the World Health Organization, https://www.who.int/zoonoses/diseases/prion_diseases/en/.

3.1.1 Pathogens/infectious agents

Directive 2000/54/EC of the European Parliament and of the Council of 18 September 2000 (EU-OSHA, 2020) on the protection of workers from risks related to exposure to biological agents at work defines ‘biological agents’ as ‘microorganisms, including those which have been genetically modified, cell cultures and human endoparasites, which may be able to provoke any infection, allergy or toxicity’. It goes on to define a ‘microorganism’ as ‘a microbiological entity, cellular or non-cellular, capable of replication or of transferring genetic material’.

While microorganisms are a large and diverse group of organisms only a small subset of microorganisms – pathogens – cause disease in humans. There are four broad classes of microorganisms that can interact with humans –viruses, bacteria, fungi, and parasites – and examples of pathogens can be seen in each of the four classes. Pathogens can be hazardous to workers due to their wide distribution in the working environment.

OHS professionals involved in the management of biological hazards should have a basic understanding of the nature of these biological agents.[2] The following text box provides a very brief summary of the key characteristics of these biological agents and their role in disease.

[2] See *OHS BoK* 14 Foundation science.

Some basic biology of biological hazards

Viruses

A virus is a sub-microscopic infectious agent that replicates only inside the living cells of an organism. They are made up of a piece of genetic code, such as DNA or RNA protected by a coating of protein (the 'capsid'). Some viruses are surrounded by an outside envelope of lipids ('enveloped viruses').

When infected, a host cell is forced to rapidly produce thousands of copies of the original virus. These copies are then released from the host cell - usually damaging or destroying the host cell in the process. Some viruses can remain dormant for a time, while still viable, before multiplying again. This length of time depends on several factors the first of which being whether it is inside the host or in the external environment, if the latter the following are important:

- The surface the virus in on - porous, smooth or otherwise
- What the environment is like – temperature and humidity impact on the length of time a virus remains viable.

While some antiviral medicines have been developed, treatment for viral infections usually only helps with management of symptoms until the body's immune system can fight off the virus. Vaccines can prevent many viral diseases, but their efficacy and duration of protection is variable.

Bacteria

Bacteria are microscopic, single-celled organisms that can live anywhere. They are classified as prokaryotes, a simple internal structure that lacks a nucleus. They contain DNA that either floats freely in a twisted, thread-like mass called the nucleoid, or in separate, circular pieces called plasmids. Not all bacteria are harmful, some are necessary for healthy body function.

Bacteria are classified according to a range of criteria including the nature of their cell walls (i.e. gram positive or negative), their shape (i.e. round, cylindrical or spiral), or by differences in their genetic makeup.

Most bacteria multiply by a process called binary fission – a single bacterial cell makes a copy of its DNA, doubles its cellular content, and then splits apart pushing the duplicated material out creating two identical 'daughter' cells. Bacteria can introduce variation into themselves by integrating additional DNA, often from their surroundings, into their genome.

Bacteria can cause harm by directly invading and damaging tissue, others produce powerful chemicals known as toxins, which damage cells. Antibiotics are commonly used to treat bacterial infections, but some strains of bacteria have become resistant to antibiotics, making them difficult to treat. Antibiotic resistance can be transferred between bacterial strains through conjugation.

Fungi

Fungi can be found just about anywhere and include microorganisms such as yeasts and moulds. They are multicellular eukaryotic organisms (i.e. have a membrane-bound nucleus holding genetic material). There are millions of different fungal species, but just 300 or so are known to inflict illness.

Fungi are classified according to their morphology (e.g. characteristics such as spore colour or microscopic features) or physiology (function and mechanism). Fungi cells contain a nucleus and other components protected by a membrane and a thick cell wall (like plants), making them harder to kill than bacteria and viruses.

Many fungi are parasites on plants and animals (including humans) and can cause serious disease, which may be fatal if not treated. Mild fungal disease often results in skins rashes, more serious fungal disease can affect the brain or the blood. Fungal disease is more common in people with compromised immune systems. Fungal spores can also cause allergies.

Parasites

Parasites are organisms that live on or in a host organism at the expense of its host. There are three main classes of parasites that cause disease in humans:

- Protozoa – single-celled organisms that can live and multiply in the body
- Helminths – larger, multi-celled organisms that live inside or outside the body and are commonly known as worms e.g. tapeworm
- Ectoparasites – multi-celled organisms that live on or feed off skin, including some insects such as ticks and mosquitoes.

3.1.2 Allergens

Allergies develop when a person's immune system mistakenly identifies a substance (an allergen) as harmful. The allergen stimulates immune system cells to release chemicals, such as histamine, which then lead to allergy symptoms. Allergic reactions can affect the nose, eyes, sinuses, throat, skin, stomach, bowel and lungs. The severity varies from person to person and can range from minor irritation to anaphylaxis — a potentially life-threatening emergency. While most allergies can't be cured, treatments can help relieve allergy symptoms.

Contact with certain plants, plant materials or fungi may cause non-infectious poisoning, stinging, allergic reactions (e.g. anaphylaxis, mushroom workers' lung, and bagassosis in the sugar cane industry), and irritant-contact or allergic-contact dermatitis. Fungi may be responsible for a variety of diseases such as ringworm or tinea, which may affect, for example, athletes, military personnel in barracks, and staff of gymnasiums, veterinary practices and workers in laundries. Fungi such as moulds and yeasts can cause allergies that result in hypersensitivity or asthma among farm workers and food process workers. Aspergillus (a fungi) can cause aspergillosis among farm workers, handlers of veterinary waste, and workers in recycling and composting facilities. Absorption of toxic plant components may occur; for example, resulting in green tobacco sickness in tobacco plant workers (for more information see Frohne & Pfänder, 2004).[3]

3.1.3 Zoonoses

A third category of biological hazards is zoonoses which are infections transmitted to humans from animals. Zoonoses may be bacterial, viral, or parasitic e.g. tapeworms.

Zoonoses are infectious diseases caused by a pathogen that has crossed the species barrier from a non-human animal (usually a vertebrate) to a human. Zoonotic diseases are very common, scientists estimate that more than six out of every ten known infectious diseases in people can be spread from animals, and three out of every four new or emerging infectious diseases in people come from animals (CDC, 2017). It is important to note that zoonoses can include infections due to exposure to bacteria (e.g. leptospirosis, brucellosis and anthrax) or viruses (e.g. bat lyssavirus, Hendra virus, Zika virus or Q Fever) and do not necessarily require direct contact with animals to occur.

[3] For detailed information on lab animal allergens, see, for example, Acton and McCauley 2007; or https://www.labmanager.com/lab-health-and-safety/allergies-in-the-workplace-22882.

There are five common ways people can be infected with zoonotic pathogens: direct or indirect contact with animals or animal bodily fluids; vector borne; foodborne or waterborne exposures. These modes of transmission are discussed further in the next section.

3.2 Mode of transmission

Knowledge of mode of biological hazard transmission – another way of categorising biological hazards in the workplace – is vital to breaking the infection cycle. While some diseases can be transmitted in a variety of ways (e.g. hepatitis A can be transmitted through food as a result of poor hygiene or by occupational exposure through working in sewers), other diseases have very specific modes of transmission. Transmission of infection may be:

- *Direct:* which requires contact between an infected person and a susceptible person
- *Airborne:* where the susceptible person inhales droplets or particles released when the infected person breathes, coughs or sneezes
- *Indirect:* where the susceptible person is infected by contact with a contaminated surface, food or water, via a vector. (Figure 1.)

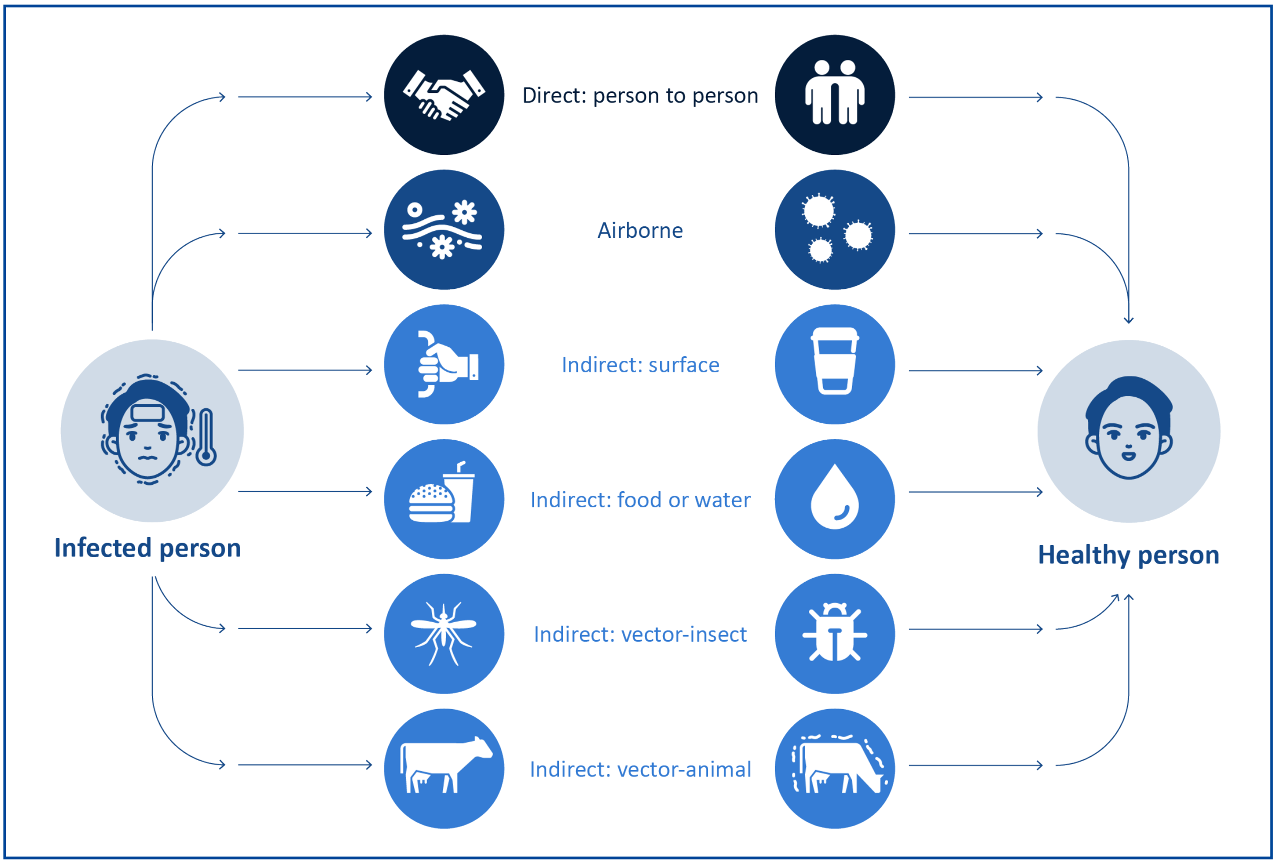

Figure 1: Modes of disease transmission

3.2.1 Direct person to person transmission

Direct contact transmission requires physical contact between an infected person and a susceptible person and the transfer of pathogens via touching, sexual contact, or contact with body fluids or lesions. Workers with a relatively high risk of direct person to person infection transmission are those exposed to blood or bodily secretions (e.g. medical and nursing staff, emergency workers, prison workers and sex workers). An example is needle stick injury which may cause percutaneous inoculation of blood-borne pathogens, such as HIV or hepatitis B.

3.2.2 Droplet/airborne contamination

Droplet or airborne contamination may occur from human or environmental sources. Mucus secretions emitted when a person coughs or sneezes are generally more contagious than infectious agents spread by direct contact (University of Arizona, 2009). Droplets can travel more than a metre in the air and can enter the respiratory tract. Diseases such as tuberculosis and measles are transmitted in this manner, as well as respiratory pathogens e.g. cold and flu viruses. Research on the transmission of respiratory viruses, during the COVID-19 pandemic has shown that the environment can dramatically impact droplet transmission, e.g. temperature, humidity and air-flow can all considerably impact the distance travelled by droplets. Human factors also impact on droplet transmission, including activities being undertaken e.g. running or singing can increase droplet distribution, as can coughing and sneezing.

Droplet infection from environmental sources such as water or soil sources may cause respiratory diseases such as legionella. Water-based cooling towers that are used as part of air conditioning systems are known to be a frequent source of *Legionella* bacteria, and from which the bacteria can be dispersed via aerosolised drift (CCOHS, 2006). Occupational gardeners may be exposed to a *species of Legionella, L. longbeachae* which has been found to cause clinical conditions indistinguishable from other *Legionella* species in people who are regular gardeners with a common feature of their gardens being the presence of ferneries with hanging baskets (O'Connor et al., 2007).

3.2.3 Indirect transmission

Indirect transmission occurs when there is an 'intermediary' between the infected person or animal and the susceptible person. Possible intermediaries include:

- Surfaces
- Food or water
- Insect or animal vectors.

Surface contact

Surface transmission occurs when an infected person or animal sneezes, coughs or otherwise excretes infectious droplets into the air that land on a surface and then another person comes into contact with the droplets on the surface and transfers those to their mucous membranes, inhales or ingests them.

Some infectious agents can survive on surfaces for extended periods of time:

- Infectious rhinovirus, responsible for about half of all colds, has been demonstrated as transmittable from surfaces for as long as 24 hours after surface contamination, highlighting the importance of surface disinfection (Winther, McCue, Ashe, Rubino & Hendley, 2011).
- SARS-CoV-2, the virus responsible for the COVID-19 pandemic, has been shown to survive for various lengths of time depending on the type of surface, ambient temperature and available lighting. (e.g. on soft surfaces such as paper bank notes cardboard, clothes, soft furniture, carpet etc., the virus has been reported to survive for up to 21 days; whereas on hard surfaces such as plastic or stainless steel, the virus has only been shown to survive for between 5-8 hours and up to 7 days (Riddel, S., Goldie, S. et al., 2020; van Doremalen et al., 2020).

Various factors relating to the pathogen affect how long they will survive on contaminated surfaces, it is therefore critically important to practice good personal hygiene (cover sneezes, disinfect hands thoroughly and frequently) to reduce the contamination of surfaces, as well as to thoroughly clean surfaces to control this risk.

Food-borne/water-borne toxins

Food and drinking water contaminated with pathogenic microorganisms or toxins can also be a source of infection.

Food-borne infections contracted through occupational exposure can affect, for example, food service workers, medical and hospital personnel, prison officers, military personnel and child-care workers. These infections are usually the result of faecal contamination of food through poor food handling, poor hygiene, contaminated water or contamination of the food chain, or by poor food storage allowing the multiplication of bacteria and the production of toxins.

While occupational exposure to water-borne infections may be low, the potential for infection from intentional or unintentional ingestion of water should be identified. One example is the infection of swimming pool water with *Cryptosporidium parvum*, a parasite excreted in the faeces of infected humans, cattle, and other mammals causing diarrhoea. The infectious form of the parasite (the ‘oocyst’) is too small to be seen without a microscope and is resistant to common forms of disinfection (DHHS, 2018). Also *E.coli* is often transmitted through improperly handled produce or undercooked meat.

Vector-borne diseases

A vector is an organism that carries disease-causing microorganisms from one host to another. As vectors are mobile, they can increase the range of the disease. The WHO estimates that vector-borne diseases account for more than 17% of all infectious disease, causing more than 700 000 deaths worldwide annually (WHO, 2020b). These are predominantly in tropical and subtropical areas, usually affecting the poorest populations, but can be found anywhere. Since 2014, there have been major outbreaks of dengue, malaria, chikungunya, yellow fever and Zika in many countries. Removing the vector, either by elimination or protecting the person from the vector, prevents infection.

Arthropod vectors, especially blood-sucking insects (e.g. mosquitoes and sandflies) can transmit diseases, including parasitic diseases (e.g. malaria), alphaviruses (e.g. Ross River virus), flaviviruses (e.g. dengue fever) and bunyaviruses (e.g. Rift Valley fever virus). A common factor among these diseases is that the vectors are blood-sucking insects. Susceptibility to such diseases depends on a variety of factors, including endemicity, location, specific arthropod species, populations of host species and protective measures.

Animals can also act as vectors transmitting zoonoses (see section 3.1.3). This can happen when an infected animal bites or scratches someone, or from handling animal waste. For example the *Toxoplasmosis gondii* parasite can be found in cat faeces. Pregnant women and people with compromised immune systems can become infected if they come into contact with these parasites. Workers coming into contact with blood and birthing fluids can become infected with the bacterium *Coxiella burnetii* resulting in Q Fever. Some animals are capable of causing or transmitting more than one disease. For example, while the bite of an ixodid tick may result in tick paralysis due to the effect of the tick's venom, some ixodid ticks are capable of transmitting vector-borne diseases including rickettsia (e.g. Queensland tick typhus), viral (e.g. Crimean-Congo haemorrhagic fever), bacterial (e.g. Lyme disease) and protozoan (e.g. babesiosis) diseases.[4]

3.3 Risk factors

Risks due to infectious biological hazards depends on a number of factors of the agent including:

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[4] For detailed information on such tropical diseases see Cook & Zumla, 2003.

- Its virulence
- Infectivity/transmissibility
- Survivability outside of the host (i.e. the external environment).

3.3.1 Virulence

Virulence refers to the aggressiveness or severity of the pathogen – its ability to cause damage to the host. Greater virulence does not necessarily mean greater infectivity. For example, although Hendra virus is a potentially life-threatening hazard for people who work with horses (i.e. highly virulent), the chances of contracting this virus are far less than the chances of contracting a range of other, less-virulent infections within the workplace, such as salmonellosis, cryptosporidiosis and leptospirosis,. This is because it has a lower ability to establish an infection (i.e. lower infectivity) than other pathogens.

3.3.2 Infectivity

Infectivity or transmissibility is the ability of a pathogen to produce, transmit or establish an infection – how frequently it spreads among hosts. Infectivity of pathogens is affected by the infectious period of a disease and by the route of transmission. Infectivity of pathogens can be represented by the term R_0 (R naught) – the average number of people who will contract a contagious disease from one person with that disease. Highly contagious infections like measles and mumps have high R_0 numbers (18 and 10 respectively), while more virulent infections like Ebola and Hepatitis C have lower R_0 numbers (2).

3.3.3 Survivability

Another factor to consider with biological hazards is their environmental stability. Some microorganisms, such as tetanus spores, can survive in the soil for long periods, and some viruses can survive outside the human body for hours (e.g. hepatitis B and HIV). Furthermore, while only a small dose of some biological hazards (e.g. the highly infectious Marburg virus) can cause infection, a much larger dose of the causative agent of some others (e.g. leprosy) is required to cause infection. (Walther & Ewald, 2004, pp. 849-869)

Knowledge of the survival period outside the body is very important as has been recently demonstrated with SARS-CoV-2 (COVID-19 causative agent). Evolving knowledge of the SARS-CoV-2 virus also demonstrated the complexity of viral survivability with indications that factors impacting surface survivability include surface material (van Doremalen et al., 2020), surface texture (Chin et al., 2020) and temperature (Kratzel, et al., 2020) with researchers urging caution on interpretation of laboratory test results on survivability of the SARS-CoV-2 virus (Krishan & Kancahn, 2020).

4 Occupational factors affecting impact of biological hazards

OHS professionals should be aware of specific biological hazards likely to affect workers in particular workplaces. These will vary according to the type of occupation, the nature of the work, the location, the environment and the pathogens or vectors known to occur in the region.

Some biological hazards can be detected early before clinical disease presents, by screening methods that can identify workers who have encountered the organism and may have been infected. However this is not always possible as there is no screening test for many occupational infections. Research and liaison with specialist advisors may be required to document the type and extent of the biological hazards relevant to a workplace, and to prepare a risk assessment and mitigation plan based on that assessment.

4.1 Type of occupation

Occupational contact with biological hazards may be:

- *Intrinsic to the specific occupation*, e.g. construction and maintenance workers at sewage treatment or wastewater plants are at increased risk of exposure to bacterial infection (see, for example, Garvey, 2005)
- *Incidental to work* (i.e. not an integral part of the work process), e.g. upper respiratory infections, infections due to contaminated water, or through food consumed at the workplace (see, for example, OSHA, 2009)
- *Contracted during the course of work* especially when living in, or travelling to or from, areas where there is an increased incidence of infectious or other diseases (see Mangili & Gendreau, 2005)
- *Not occupationally specific*, e.g. Legionella bacteria, responsible for Legionnaires' disease, is widely distributed in water and soil, and can, therefore, affect workers in a wide variety of occupations, such as water-system maintenance workers and air-conditioned office workers (see, for example, Comcare, 2008).

It has been demonstrated that workers in the Health and Community Services, and Agriculture Forestry and Fishing industries face a relatively high risk of exposure to biological hazards (de Crespigny, 2011). The potential for exposure to some work-intrinsic hazards are briefly considered below. However, generalist OHS professionals in all industries should ensure that knowledge of the nature and source of biological hazards informs their hazard identification activities.

4.1.1 Outdoor workers

Outdoor workers, such as wildlife rangers, forestry workers, gardeners, farm workers, construction workers, archaeologists and military personnel, may be exposed to a range of biological hazards specific to their occupation and the environment in which they work, including local species of microorganisms, animals, plants and fungi, and the nature of the work. Generally the nature of these biological hazards will vary from location to location. Forestry workers may face a variety of environmental/occupational hazards, including stinging plants and insect vectors of disease, which will vary depending on the species endemic to the location.

4.1.2 People who work with animals

People who work directly with, or are exposed to, animals or animal products are at risk of a wide range of possible biological hazards. These occupations include abattoir and meat workers, animal handlers, animal pound workers, aviary workers, customs officers, police officers, farmers, graziers, customs inspectors, laboratory workers, pet shop and quarantine kennel personnel, ranchers, shepherds, stockmen, veterinarians, wildlife rangers, wool sorters and zoo personnel. Biological hazards for these occupations include bacterial diseases (e.g. anthrax); viral diseases (e.g. orf, a disease of sheep and goats which also infects humans, Newcastle disease in poultry workers); rickettsia (e.g. *Coxiella burnetti,* Q fever); diseases transmitted by bites (e.g. lyssavirus), prion diseases (e.g. Creutzfeldt-Jakob, mad cow disease) and ectoparasitic diseases (e.g. scabies).

Some of these infections may be serious or even potentially life-threatening; for example, veterinarians and horse handlers may be at risk of Hendra virus or Australian Bat Lyssa Virus (ABLV), a rabies-like virus from horses or bats. Bats are also the natural host of Nipah virus, which can be transmitted by animal-human contact and also human-human contact, and may also cause severe illness in both humans and domestic animals (Wildlife Health Australia, 2017.)

4.1.3 Workers exposed to human blood and bodily fluids

Occupational groups that may be at increased exposure to human blood and body fluids include medical and hospital personnel, pathology and other laboratory workers, emergency workers, autopsy and mortuary workers, prison workers, professional sportspersons and sex workers. Sewerage workers and plumbers should also be considered in this category as they may be at risk from a range of pathogenic microorganisms carried in human faeces (Work Safe Queensland, 2020).

4.1.4 Workers in caring roles

Workers in caring roles may also face an increased risk of exposure to biological hazards, in addition to the traditional blood and bodily fluids risks. Caring roles include medical and hospital personnel as well as those in aged care and disability support services and funeral homes. Due to the nature of these roles there may be an increased risk due to the type of interactions (close contact with individuals, contact with multiple potential sources), as well as the potentially longer exposure these types of roles necessitate.

4.2 Location and environment

There may be an increased incidence of infectious or other diseases that can be contracted by occupational groups working within a specific locality or type of environment. The type of biological hazard may be specific to the particular work environment; for example, fishing trawler crew, professional divers, marine biologists and lifeguards might be at risk from infection of cuts and grazes by marine pathogens. Roofers, tilers, insulation layers and electricians who work in roof spaces may be indirectly exposed to animals or animal products that may result in infection (e.g. respiratory infections such as psittacosis). Sewer and municipal workers, plumbers, miners and forestry workers are likely to be at risk from infected urine from rodents and other animals. Those working in wet environments, such as meat processing plants or abattoirs are also likely to have an increased risk due to the high humidity environment which is often favourable for pathogens to grow and spread.

Location is also an obvious predisposing factor for certain vector-borne diseases (e.g. rabies and malaria) that are endemic to particular regions. The diversity of biological hazard distribution is related to species distribution and the environmental and social characteristics of specific geographic locations.

4.3 At-risk workers

The worker themselves must also be considered when assessing the risk of biological hazards in the workplace, as some groups of workers may be more vulnerable than others.

Here, three groups of at risk workers have been identified, who may be at particular risk of exposure to biological hazards or who may require special consideration when assessing the risk of exposure to biological hazards and the proposed workplace controls.

- Those with compromised health or immune systems e.g. immunocompromised workers, those with chronic health conditions or pregnant and breastfeeding women
- Those who work across multiple different workplaces e.g. maintenance workers and cleaners.

- Inexperienced and socially vulnerable workers e.g. young workers, trainees and sex workers.

To better protect these groups of workers it is recommended that any risk assessment and mitigation plan to control exposure to biological hazards considers these workers and any special circumstances or specific measures that may need to be implemented.

5 Legislation and guidance

The general duty under s 19 of the national model *Work Health and Safety Act* (WHSA) (SWA, 2019) requires a person conducting a business or undertaking (PCBU) to ensure, so far as is reasonably practicable, the health and safety of workers and others who may be put at risk by the conduct of the business or undertaking (SWA, 2019). This duty applies to all hazards including biological hazards. The model WHS regulations are silent on biological hazard control and de Crespigny (2011) has identified a dearth of Australian policy interventions relevant to biological hazards. [5]

The availability of guidance material for specific biological hazards changed dramatically when the advent of the COVID-19 pandemic saw workplaces fruitlessly searching for relevant information. Safe Work Australia responded by creating a range of resources and industry-specific information for complying with work health and safety legislative requirements and managing the risk of COVID-19 infections.[6]

6 Control of biological hazards

The National Hazard Exposure Worker Surveillance (NEWS) study (de Crespigny, 2011) found that of five biological hazard-control-measure categories – protective clothing; engineering; warnings; waste disposal; and training – Australian workplaces were most likely to provide workers exposed to biological hazards with protective clothing and least likely to provide training. This is in direct contrast to the recommendation of the hierarchy of controls that is touted throughout the OHS industry, where protective clothing is considered to be a last resort and more reliable methods should be employed in the first instance. (See section 6.2 for more detail on the hierarchy of controls as it applies to biological hazards.) Also, "workers exposed to living animals were least likely to be provided with any control measures" (de Crespigny, 2011). Of the two industries with the highest likelihood of

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[5] See section on *Resources and Guidance* for selected references.

[6] See https://www.safeworkaustralia.gov.au/covid-19-information-workplaces.

exposure to biological hazards, Health and Community Services had a higher level of control provision than Agriculture, Forestry and Fishing. Control provisions for biological hazards were revealed to be relatively "high for workers exposed to human bodily matter, laboratory cultures and biological hazard waste, sewerage and rubbish but relatively low for workers exposed to animals and animal products" (de Crespigny, 2011, p. 1). The study's recommendations included relevant policy development and improvement of training in the safe handling of biological hazards.

Biological hazards should be addressed by an analytical and preventive approach with a structured risk management process applied to address the residual risk. The complexity of the transmission and mechanism of action of biological hazards means that the biological hazard needs to be considered in the context of the workplace, the work and the worker. The nature of the controls will depend on the type of agent: its mode of transmission, virulence and infectivity; the nature of the task and the methods of exposure; the number of people potentially exposed and their susceptibility to the biological hazard. This can be represented as in Figure 2 which highlights that intervention for control can occur at different points in the triangle.

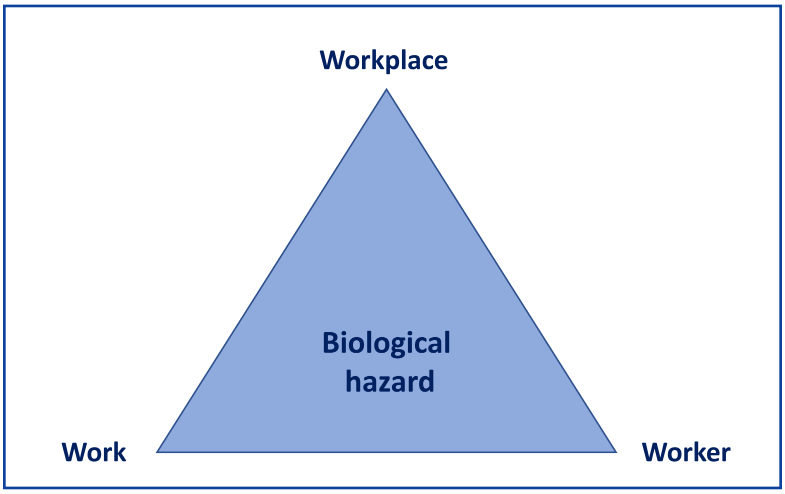

Figure 2: Points for intervention for control of biological hazards

6.1 Lessons from the COVID-19 pandemic

On 31 December 2019 the WHO were first alerted to cases of 'viral pneumonia' in Wuhan, People's Republic of China. On 5 January 2020, the WHO issued its first Disease Outbreak News report on the cases, the WHO's risk assessment and advice on public health measures. Four days later the WHO reported that Chinese authorities had determined that the outbreak was caused by a novel coronavirus (now identified as SARS-CoV-2). By late January, cases of the novel coronavirus were being reported in Europe and the Middle East (France and the United Arab Emirates respectively) (WHO, 2020c.) The first case of the novel coronavirus in Australia was confirmed on 25 January (Ministers, Department of Health, 2020). These cases marked the first of millions worldwide and saw the start of one of the largest global pandemics recorded. The WHO declared the COVID-19 outbreak a pandemic on 11 March 2020.

The COVID-19 pandemic exposed deficiencies in current knowledge of transition and appropriate control measures particularly for diseases spread by aerosols. A significant proportion of COVID-19 cases have related to occupational exposure. In a report published in August 2020, by the European Centre for Disease Prevention and Control observed that:

> The occupational settings where clusters were observed varied widely and included health and social care services, offices, construction sites, military and law enforcement institutions, industry, educational facilities and multiple other settings. Most clusters were reported in health and social care work settings, followed by food processing- related occupational settings, mines, and factories/manufacturing settings. (ECDC, 2020, p. 3.)

Victoria, Australia experienced a major second COVID-19 wave of infections. As at 29th March, 2021, of a total of 20,483 infections, 12.6% (2599) were acquired by healthcare workers in the course of their work (DHHS, 2020a; b). Healthcare work environments, especially hospitals, were generally thought to have good practices for infection control, but these standards are largely focused on the protection of the patients, rather than the workers. As the COVID-19 pandemic continues and strategies to limit and manage outbreaks have evolved lessons have been learned. Four particular learnings are relevant to OHS professionals involved in the management of biological hazards:

1 *Effective control requires knowledge of the mode of transmission.*

Initial advice on physical distancing and use of masks relied on advice on particulate and surface transmission that was later found to be incorrect, exposing people, especially healthcare workers to infection (Hendrie, 2020)

2 *Personal Protective Equipment (PPE) can only be a supplementary strategy and requires support systems to ensure effectiveness.*

While PPE can play an important role in breaking the transmission chain, the PPE must be appropriate to the mode of infection and to the physical requirements of the wearer. Effective use of PPE also requires administrative processes such as procurement, maintenance/cleaning and training in use of the PPE (see for example, McCauley, 2020)

3 *Behavioural controls rely on compliance by people.*

While this observation applies to all OHS hazards, compliance can be challenging when the hazard is ‘invisible’ as it is with most biological hazards. Compliance with behavioural controls such as distancing has proven problematic in the management of the COVID-19 pandemic especially as people experience ‘lockdown fatigue’ (Dave, 2020.)

4 *Where knowledge of the mode of transmission and the impact of infection is incomplete the 'precautionary principle' should apply*. (Hendrie, 2020)[7]

While these 'learnings' are not new to OHS professionals it is important that they are reinforced in any management strategy for biological hazards.

6.2 Control of biological hazards

As with other hazards, the concept of a hierarchy of control can be applied to biological hazards. Such a hierarchy is discussed below.

6.2.1 Elimination

As with other hazards the priority for control is elimination of the biological hazard. This may be by eliminating the source of the biological hazard (e.g. design of air conditioners to eliminate water as a reservoir for *Legionnella*); eliminating the biological hazard agent (e.g. use of pesticides to eliminate pest species or disinfectants to remove micro-organisms); eliminating the vector (e.g. elimination of vector species such as birds who act as vector for psittacosis). Where elimination is not possible (for example, due to wildlife protection legislation) then the hierarchy of control with engineering, administrative and PPE controls can be applied.

6.2.2 Engineering controls

Engineering controls such as ventilation systems, engineered safe needle devices and automated equipment can be effective at controlling risk of exposure to biological hazards, *when the hazard is clearly identified*. For example ventilation controls can be installed in biological research or pharmaceutical facilities where the hazard is easily recognised, or automated equipment in sewage treatment plants. Physical screens have been widely used during the COVID-19 pandemic to separate workers and also to separate workers from the public. However, such controls are not as easily implemented for occupational groups where the nature of the work is not conducive to such separation or for occupational groups such as grounds maintenance workers who may not be aware of the risks posed by contact with animal carcasses, for example.

Immunisation against vaccine-preventable diseases may also be considered an engineering control (along with the program to implement the vaccinations as an essential corresponding

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[7] See also *OHS BoK* 34.1 Prevention and Intervention.

administrative control). Prophylactic antiviral medications also provide similar individual protection and may be of use where the potential exposure is possible but not likely.

6.2.3 Administrative controls

Administrative control measures aimed to reduce the exposure of a worker to the biological hazard can be effective when appropriately implemented and monitored.

While quarantine and isolation (when properly implemented) have been shown to be effective public health control strategies, their role in workplace biological hazard management strategies should also be considered. Contact tracing during the COVID-19 pandemic showed that workplaces have a role in supporting such public health measures. These programs must be implemented at an organisational level to be truly effective.

Immunisation programs are an important administrative control where vaccines are available. Other measures such as infection control policies, safe work procedures and routine practices such as physical distancing and personal hygiene are important in breaking the transmission chain but require explanation and reinforcement through training and supervision.

Monitoring of the implementation and effectiveness of administrative controls is essential. In workplaces or occupations where there is routine work with biological material that may have a high risk of exposure, development of a health surveillance program for at-risk workers is recommended.

6.2.4 Personal protective equipment

Personal protective equipment is generally the last line of defence, when the biological hazard cannot be controlled by other methods. PPE such as gloves, protective clothing, eye protection, face protection, respiratory protection may be effective at protecting the individual worker, when the presence of the biological hazard cannot be avoided i.e. in healthcare or other caring roles where the person requiring care cannot be eliminated or isolated. The potential problems in relying on PPE as a control measure for biological hazards were demonstrated during the COVID-19 pandemic where failures occurred in:

- Availability of ongoing supply
- Limits to availability by employers
- Selection of inappropriate PPE
- Poor fit of PPE
- Inappropriate use of PPE including disposal.

PPE should be used in conjunction with other organisational controls.

6.2.5 A hierarchy of control for biological hazards

Table 2 summarises this section by providing a hierarchy of control.

Table 2: A hierarchy of control as applied to biological hazards

Elimination	• Design to remove environments that support breeding and spread of micro-organisms • Use of pesticides and disinfectants • Elimination of vectors
Engineering/Bioengineering controls	• Ventilation systems • Automated equipment • Engineered devices such as safe needle devices and protective screens • Vaccines • Prophylactic anti-viral medications
Administrative controls	• Quarantine and isolation procedures supported by contact tracing • Immunisation programs • Policies and procedures • Routine practices such physical distancing, personal hygiene and other safe work procedures • Training Supported by appropriate monitoring processes.
Personal Protective Equipment (PPE)	An integrated PPE program including selection, fit, maintenance and training in use of: • Gloves • Protective clothing • Eye protection • Face protection • Respiratory protection

Leptospirosis in farm workers

A cluster of three cases of leptospirosis on a New Zealand dairy farm were reported in 2014. Leptospirosis is a bacterial disease that can cause illness in humans and animals.

Most of the symptoms exhibited by the three workers were consistent with primary phase leptospirosis. All three cases had worked on the same dairy farm during their incubation period, where the highest risk environment was the milking shed and potential exposure to urine splashes from infected cattle. Inadequacies were found in the (cattle) herd vaccination programme. Due to the lack of human vaccine, vaccination of farm livestock for leptospirosis is an integral factor in preventing human cases.

McLean, Ruscoe, Kline, King & Nesdale, 2014

8 Implications for OHS practice

Recent international research (EU-OHSA, 2019) has echoed the Safe Work Australia report from 2011 (de Crespigny, 2011): “There is a lack of knowledge and awareness of workplace exposures to biological agents and related health problems" with EU-OSHA also noting a lack of a systematic approach to workplace prevention of these risk factors.

While the management of biological hazards has previously been thought to be the sole domain of the occupational health physician, this finding together with the lessons from the COVID-19 pandemic make it clear that the generalist OHS professional has a major and significant role in developing and implementing prevention and management processes for biological hazards.

While the focus is currently on the management of COVID-19 in the workplace, OHS professionals should be ensuring that their organisations recognise the risks associated with biological hazards and build on the strategies developed for COVID-19 to ensure rigorous processes for identifying and managing emerging biological risks as well as any resurgence of known biological hazards. To fulfil this role OHS professionals should have a good understanding of biological hazards, their mode of transmission, infectivity and virulence and the application of appropriate control measures.

The role of the generalist OHS professional in developing a management process for biological hazards will be determined, in part, by the nature of the hazard, the potential severity of impact and the nature of the work. Their role will include ensuring or facilitating:

- Policies and procedures are developed to identify biological hazards
- Policies and procedures are developed to manage identified biological hazards
- Risk-assessment processes include consideration of occupation, location and worker-specific factors that contribute to worker exposure
- That managers, supervisors and workers receive appropriate information and training on biological hazards including the role and use of PPE
- Where required, the selection, fitting, wearing, and maintenance of appropriate PPE
- Where required, policies and procedures are developed for a health surveillance program, in consultation with occupational health professionals
- Where required, engaging with an occupational health professional or occupational hygienist or biological safety specialist to ensure risk management practices proposed are effective for the identified biological hazards and likely exposures
- Where appropriate, application of the ‘precautionary principle’.

The generalist OHS professional needs to ensure that appropriate data gathering and research has been conducted to enable identification of biological hazard-exposure risks in their particular workplace. This may require liaison with an occupational hygienist who may undertake assessments to clarify the nature of the biological hazard and to identify the presence of any other hazards that may have synergistic or confounding effects. The resultant information provides a foundation for liaising with the medical practitioner or occupational health physician to conduct hazard identification and characterisation and risk assessments.

Lessons from the COVID-19 pandemic, especially in Victoria, revealed that when the management of a biological hazard is left to ‘infection control specialists’ the response may suffer from a narrow focus. The development and implementation of appropriate strategies for prevention and harm minimisation may require a team approach with an occupational hygienist providing advice on prevention and monitoring, health advice provided by a medical practitioner, engineering advice to inform the development of control measures and the generalist OHS professional ensuring the integration of the prevention, mitigation and monitoring strategies into the OHS management system.

9 Summary

Biological hazards include infective agents such as viruses, bacteria, protozoa and other microorganisms as well as animals and animal products, and plants and plant products that can cause infections, allergy, toxicity or otherwise create a hazard to human health. While potential risk is highly variable, biological hazards should be considered in the hazard profile for workplaces.

While particular industries and occupational groups have been identified as being at higher risk than others for biological hazards, the COVID-19 pandemic has demonstrated that biological hazards are a risk that requires management at all workplaces.

OHS professionals have a key role in ensuring organisational preparedness for biological hazards. This preparedness should encompass both known biological hazards as well as potential emerging hazards not yet specifically identified.

Control of biological hazards requires knowledge of the nature of transmission, infectivity and virulence of the biological agent that informs risk assessment and the systematic, analytical application of a hierarchy of control that takes account of the nature of the agent, the workplace, the nature of the work and the workers. The generalist OHS professional has an important role in the management of biological hazards by bringing a team approach to the management of biological hazards.

Resources and guidance

Some historical but still available guidance includes:

- *Diseases Acquired from Animals* (NOHSC, 1989)
- *National Code of Practice for the Control of Work-related Exposure to Hepatitis and HIV (Blood-borne) Viruses* (NOHSC, 2003)
- *Work-Related Infectious and Parasitic Diseases Australia (ASCC, 2006).*

More recent guidance particularly for healthcare is available in:

- AS 3816:2018 *Management of Clinical and Related Wastes* (SA, 2018)
- AS/NZS 2243.3 *Safety in Laboratories: Microbiological Safety and Containment* (SA/SNZ, 2019)
- *Australian Guidelines for the Prevention and Control of Infection in Healthcare (ACSQH, 2019)*

Other potentially useful sources include:

- Australian Public Health Laboratory Network which periodically publishes and endorses publications that may be relevant for biological and medical laboratories outside the public health network or for workplaces directly handling biological hazards.[8]
- World Health Organisation, see for example the Laboratory Biosafety Manual, Third edition (WHO, 2004).
- US Centres for Disease Control and Prevention (CDC) see for example Biosafety in Microbiological and Biomedical Laboratories (CDC 2009).
- Canadian Public Health Agency which periodically publish information on biosafety including general biosafety guides and information on specific pathogens which can be a valuable resource relevant to Australian workplaces. See for example Canadian Biosafety Standard, second edition (Canadian Public Health Agency, 2015);[9] and Pathogen Safety Data Sheets (Canadian Public Health Agency, periodically)[10]

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[8] See https://www1.health.gov.au/internet/main/publishing.nsf/Content/cda-cdna-phln-index.htm.

[9] See https://www.canada.ca/en/public-health/services/canadian-biosafety-standards-guidelines.html.

[10] See https://www.canada.ca/en/public-health/services/laboratory-biosafety-biosecurity/pathogen-safety-data-sheets-risk-assessment.html.

References:

Adler, J. (Ed.). (2011). Emergency medicine articles (including Plant poisoning, caladium, dieffenbachia, and philodendron; Mushroom toxicity; and various snake, spider and scorpion envenomation articles). WebMD. Retrieved from http://emedicine.medscape.com/emergency_medicine.

Acton, D., & McCauley, L. (2007). Laboratory Animal Allergy, An occupational hazard. *AAOHN Journal.* 55(6), 241-4.

ASCC (Australian Safety and Compensation Council). (2006). *Work-Related Infectious and Parasitic Diseases Australia*. Retrieved from http://www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Documents/415/Workrelated_Infectious_parastitic_disease_Australia.pdf.

ACSQH (Australian Commission on Safety and Quality in Healthcare). (2019). Australian Guidelines for the prevention and control of infection in healthcare. NH&MRC. Retrieved from https://www.nhmrc.gov.au/about-us/publications/australian-guidelines-prevention-and-control-infection-healthcare-2019#block-views-block-file-attachments-content-block-1.

CDC (Center for Disease Control and Prevention). (2009). *Biosafety in microbiological and biomedical laboratories (BMBL)* (5th ed.). Retrieved from https://www.cdc.gov/labs/pdf/CDC-BiosafetyMicrobiologicalBiomedicalLaboratories-2009-P.PDF.

CDC (Centres for Disease Control and Prevention). (2017). Zoonotic Diseases. Retrieved from https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html.

CDC (Centres for Disease Control and Prevention). (2020). Fungal diseases. Retrieved form https://www.cdc.gov/fungal/index.html

CCOHS (Canadian Centre for Occupational Health and Safety). (2006) Legionairre's Disease. Retrieved from http://www.ccohs.ca/oshanswers/diseases/legion.html

Chan, G., Tsing, C., & Koh, D. (2011). 10 Biological hazards. In Guidotti, T. L., *Global Occupational Health,* Oxford Scholarship Online.

Chin, A.W.H., Chu, J.T.S., Perera, M.H.A., Hui, K.P.Y., Yen, H-L., Chan, M.CW., … (2020). Stability of SARS-CoV-2 in different environmental conditions. *Lancet Microbe*, 1(1). Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7214863/.

Comcare. (2008). Legionnaires' disease. Retrieved from http://www.comcare.gov.au/forms__and__publications/fact_sheets/legionnaires_disease

Cook, G. C., & Zumla, A. (Eds.). (2003). *Manson's tropical diseases* (21st ed.). London: Saunders/Elsevier Science.

Covid19Info.live. (2020) Retrieved 1st November, 2020 from https://covid19info.live.

Dave, P. (2020). Google data shows lockdown fatigue in Australia. *The Canberra Times*. (May 2). Retrieved from https://www.canberratimes.com.au/story/6743178/google-data-shows-lockdown-fatigue-in-aus/?cs=14232.

de Crespigny, F. (2011). *National Hazard Exposure Worker Surveillance: Exposure to Biological Hazards and the Provision of Controls Against Biological Hazards in Australian Workplaces.* Canberra, ACT: Safe Work Australia. Retrieved from https://www.safeworkaustralia.gov.au/system/files/documents/1702/nhews_biologicalmaterials.pdf

Department of Health, (2020a). Coronavirus (COVID-19) current situation and case numbers. (1/11/20). Government of Australia. Retrieved from https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/coronavirus-covid-19-current-situation-and-case-numbers.

DHHS (Department of Health and Human Services). (2018). Cryptosporidium – What pool operators need to know. Victorian Government. Retrieved from https://www2.health.vic.gov.au/about/publications/factsheets/cryptosporidium-what-pool-operators-need-to-know.

DHHS (Department of Health and Human Services). (2020a). Victorian healthcare worker coronavirus (COVID-19) data. Victorian Government. Retrieved 2nd November, 2020 from https://www.dhhs.vic.gov.au/victorian-healthcare-worker-covid-19-data.

DHHS (Department of Health and Human Services). (2020b). Victorian coronavirus (COVID-19) data. Victorian Government. Retrieved 2nd November 2020 from https://www.dhhs.vic.gov.au/victorian-coronavirus-covid-19-data.

Dutkiewicz, J., Jabloński, L., & Olenchock, S. A. (1988). Occupational biohazards: A review. *American Journal of Industrial Medicine*, *14*(5), 605–623.

ECDC (European Centre for Disease Prevention and Control). (2020). COVID-19 clusters and outbreaks in occupational settings in the EU/EEA and the UK. (11 August, 2020).

EU-OSHA (European Agency for Safety and Health at Work). (2019). Biological agents and work-related diseases: results of a literature review, expert survey and analysis of monitoring systems. Retrieved from https://osha.europa.eu/en/publications/biological-agents-and-work-related-diseases-results-literature-review-expert-survey-and/view.

EU-OSHA (European Agency for Safety and Health at Work). (2000). Directive 2000/54/EC. Biological Agents at Work. (Updated 2020). Retrieved from https://osha.europa.eu/en/legislation/directives/exposure-to-biological-agents/77.

Frohne, D., & Pfänder, H. J. (2004). *Poisonous plants: A handbook for doctors, pharmacists, toxicologists, biologists and veterinarians* (2nd ed.) (English translation). Portland, Oregon: Timber Press.

Garvey, D. J. (2005). Exposure to biohazards: An emerging concern for construction workers in sewer lines and wastewater treatment plants. *Professional Safety Magazine*, *50*(8), 26–31.

Hendrie, D. (2020). Why are so many Victorian healthcare workers contracting COVID-19? *NewsGP*. (21 August.) Retrieved from https://www1.racgp.org.au/newsgp/clinical/why-are-so-many-victorian-healthcare-workers-contr.

Jedynska, A., Kuijpers, E., van den Berg, C., Kruizinga, A., Meima, M., & Spaan, S. (2019). *Biological agents and work-related disease: results of a literature review, expert survey and analysis of monitoring systems*. European Agency for Safety and Health at Work (EU-OHSA). Retrieved from https://osha.europa.eu/en/publications/biological-agents-and-work-related-diseases-results-literature-review-expert-survey-and/view.

Kratzel, A., Steiner, S., Todt, D., V'kovski, P., Brueggemann, Y., Steinmann, J., … (2020). Temperature-dependent surface stability of SARS-CoV-2. *Journal of Infections,* 81(3), 452-482. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7832219/

Krishan, K & Kanchan, T. (2020). Aerosol and surface persistence: Novel SARS-CoV-2 versus other coronaviruses. *Journal of Infection in Developing Countries,* 14(7), 748-749. Retrieved from https://jidc.org/index.php/journal/article/view/32794465/2307.

McCauley, D. (2020). 'Failure of leadership': Health workers denied access to PPE. The Sydney Morning Herald. (Sept 21.) Retrieved from https://www.smh.com.au/politics/federal/failure-of-leadership-health-workers-denied-proper-gear-20200918-p55x10.html.

McLean, M., Ruscoe, Q., Kline, T., King, C., & Nesdale, A. (2014). A cluster of three cases of leptospirosis in dairy farm workers in New Zealand. *The New Zealand Medical Journal*. 127(1388), 13-20.

Mangili, A., & Gendreau, M. A. (2005). Transmission of infectious diseases during commercial air travel. *Lancet*, *365*, 989–996.

Ministers, Department of Health, (2020). First confirmed case of novel coronavirus in Australia. (25/1/20) Government of Australia. Retrieved from https://www.health.gov.au/ministers/the-hon-greg-hunt-mp/media/first-confirmed-case-of-novel-coronavirus-in-australia.

NOHSC (National Occupational Health and Safety Commission). (1989). *Diseases Acquired from Animals.* Canberra, ACT: Australian Government Publishing Service.

NOHSC (National Occupational Health and Safety Commission). (2003). *National Code of Practice for the Control of Work-related Exposure to Hepatitis and HIV (Blood-borne) Viruses.* Canberra, ACT: Commonwealth of Australia.

O'Connor, B.A., Carman, J., Eckert, K., Tucker, G., Givney, R., Cameron, S. (2007). Does using potting mix make you sick? Results from *Legionella longbeachae* case-controlled study in South Australia. *Epidemiol Infect*. 135(1): 34–39.

OSHA (Occupational Safety and Health Administration). (2009). *Guidance on Preparing Workplaces for an Influenza Pandemic* (OSHA 3327–05R). US Department of Labor. Retrieved from https://www.osha.gov/Publications/influenza_pandemic.html

Riddel, S., Goldie, S., Hill, A, Eagles, D., & Drew, T. W. (2020). The effect of temperature on persistence of SARS CoV-2 on common surfaces. *Virology Journal*. 17,145.

Russell, R. C., Currie, B.J., Lindsay, M.D., Mackenzie, J. S., Ritchie, S.A., & Whelan, P.I. (2009). Dengue and climate change in Australia: predictions for the future should incorporate knowledge from the past. Med J Aust. Retrieved from https://www.mja.com.au/journal/2009/190/5/dengue-and-climate-change-australia-predictions-future-should-incorporate.

SWA (Safe Work Australia). (2019). Model Work Health and Safety Bill (Dec, 2019). Canberra, ACT: Safe Work Australia. Retrieved from https://www.safeworkaustralia.gov.au/doc/model-work-health-and-safety-act.

SA (Standards Australia). (2018). *Management of Clinical and Related Wastes*. Sydney: Standards Australia

SA/SNZ (Standards Australia/Standards New Zealand). (2019). *Safety in Laboratories. Part 3: Microbiological Safety and Containment.* Sydney and Wellington: Standards Australia and Standards New Zealand.

University of Arizona. (2009). How germs are spread. Retrieved from http://learnaboutgerms.arizona.edu/how_germs_spread.htm.

Van Dorenmalen, N., Bushmaker, T., Morris, D.H., Holbrook, M.G., Gamble, A., Williamson, B. N. …. et al., (2020). Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med,* 382(16), 1564-1567.

Walther B.A. and Ewald P. (2004) Pathogen survival in the external environment and the evolution of virulence, Biological Review, (2004), 79,

Wildlife Health Australia. (2017). Fact sheet: Hendra virus and Australian wildlife. Retrieved from https://www.wildlifehealthaustralia.com.au/Portals/0/Documents/FactSheets/Mammals/Hendra_virus_and_Australian_Wildlife.pdf.

Winther, B., McCue, K., Ashe, K., Rubino, J., & Hendley, J. O. (2011). Rhinovirus contamination of surfaces in homes of adults with natural colds: Transfer of virus to fingertips during normal daily activities. *Journal of Medical Virology*, *83*(5), 906–909.

WorkSafe Queensland. (2020). Infection risks from work with sewage. Retrieved from https://www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-exposures/biological-hazards/infection-risks-from-work-with-sewage#:~:text=Sewage%20can%20expose%20workers%20to,with%20respiratory%20and%20gastrointestinal%20symptoms.

WHO (World Health Organization). (2004). Laboratory Biosafety Manual. Third Ed. Retrieved from https://www.who.int/publications/i/item/9241546506.

WHO (World Health Organization). (2015). Blueprint for R&D preparedness and response to public health emergencies due to highly infectious pathogens, Workshop on prioritization of pathogens. Retrieved from https://www.who.int/medicines/ebola-treatment/WHO-list-of-top-emerging-diseases/en/.

WHO (World Health Organization). (2020a). Prioritizing diseases for research and development in emergency contexts. Retrieved from https://www.who.int/activities/prioritizing-diseases-for-research-and-development-in-emergency-contexts.

WHO (Word Health Organization). (2020b). Vector-borne diseases. Retrieved from https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases.

WHO (Word Health Organization). (2020c). Timeline: WHO's COVID-19 response. Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline.

Worldometer. (2021, Jan 23). Covid-19 Coronavirus pandemic. Retrieved from https://www.worldometers.info/coronavirus/

Appendix 1: Definitions

Biological hazard: Hazards of biological origin, whether from living organisms, or non-living biological material, which may create a hazard to human health.

Host: A species that develops a level of infection with a parasite that can be accessed and transmitted further by a vector.

Infectivity: The ability of a pathogen to spread rapidly from one host to another.

Microorganisms: Microscopic organisms, including bacteria, rickettsia, viruses, prions, protozoa and fungi.

Parasites: Bacteria, viruses, protozoa, helminths or arthropods which are dependent upon a host for survival.

Pathogen: An agent that causes infection or disease, particularly a microorganism.

Pathogenicity: The capacity of a pathogen to produce disease.

Vector: A host species that acquires the parasite from an infected host and transmits it to another host.

Vector-borne disease: A disease caused by a pathogenic agent which is transmitted by arthropods (e.g. mosquitoes, sandflies or ticks).

Venom: A toxic substance, produced by an animal in a specialised venom gland, and applied or injected into another animal by means of a venom apparatus (usually a bite or sting) for defence or acquisition or digestion of prey.

Virulence: Relative pathogenicity, that is, a quantitative measure of the severity of the disease that a group or species of microorganism is capable of causing.

Zoonoses: Diseases (including parasites) which can be passed from animals to humans, transmitted directly or via an intermediate host vector, but where the human host is not an essential part of the lifecycle.

Appendix 2: Summary of infective agents

Disease and agent	Exposure	Target organs	Preventative measures
Bacteria			
Anthrax *Bacillus anthracis*	Wool or hide handlers, butchers, agricultural workers, veterinarians, researchers	Skin, lung	Immunization, personal hygiene
Brucellosis *Brucella abortus, B. suis, B. canis, B. melitensis*	Abattoir workers, veterinarians, hunters	Systemic	Personal hygiene, vaccination of livestock, serologic surveillance of affected animals
Leptospirosis *Leptospira icterhaemorrhagiae, L.interrogans*	Abattoir workers, sewer workers, agricultural workers, fishermen, military	Liver, kidney, systemic	Personal hygiene, protective clothing, vaccination of livestock, doxycycline chemoprophylaxis
Meliodosis *B. pseudomallei*	Agricultural workers, military	Skin, systemic	Personal hygiene
Tetanus *Clostridium tetani*	Construction workers, agricultural workers, animal handlers	Nervous system	Immunization
Tuberculosis *Mycobacterium tuberculosis*	Health-care workers, laboratory workers	Lung, systemic	Immunization, post-exposure surveillance and chemoprophylaxis
Viruses			
Hepatitis A Hepatitis A virus	Sewer workers, travelers to endemic areas	Liver	Immunization, personal and food hygiene
Hepatitis B Hepatitis B virus	Health-care workers, sex workers, intravenous drug users	Liver	Personal hygiene, universal precautions, immunizations
Hepatitis C Hepatitis C virus	Health-care workers, sex workers, intravenous drug users	Liver	Personal hygiene, universal precautions, immunizations
Japanese Encephalitis Japanese Encephalitis virus	Travelers to endemic areas, military	Nervous system	Immunization, personal protective measures
Dengue	Construction workers	(One form causes hemorrhagic fever, bleeding and high fever)	Mosquito suppression by removal of standing water, personal protection
Nipah virus	Abattoir workers	Nervous system	Personal hygiene

Rabies Rabies virus	Laboratory workers, veterinarians, wild-animal handlers, travelers to endemic areas	Nervous system	Immunization, post-exposure prophylaxis with vaccine and immunoglobulins, avoidance of stray animals
AIDS HIV virus	Health-care workers, sex workers, intravenous drug users	Immune system	Universal precautions, post-exposure surveillance and prophylaxis
SARS SARS virus	Health-care workers	Respiratory system	Personal hygiene, universal precautions, respirators
Fungal			
Candidiasis *Candida albicans*	Dishwashers, cannery workers	Skin	Personal hygiene, keeping skin dry
Dermatophytoses *Trichophytom spp, Microsporium spp, Epidermophyton spp.*	Animal handlers, athletes, military	Skin	Personal hygiene, keeping skin dry
Parasite			
Malaria *Plasmodium falciparum, P. malaria, P. vivax, P.ovale*	Agricultural workers, business travelers to endemic areas, construction and other workers entering high-risk areas	Blood, liver, brain, kidneys, systemic	Mosquito suppression, protective barriers, e.g., long sleeves, mosquito nets, chemoprophylaxis
Toxoplasmosis *Toxoplasma gondii*	Veterinarians, laboratory workers, cat handlers	Reticuloendothelial system, eye, developing fetus	Personal hygiene