Pathogens are microorganisms or substances capable of causing disease. The main groups of pathogens include:
- parasites
- bacteria
- fungi
- viruses
- prions (e.g. mad cow disease)

Blood-borne pathogens (BBPs) are those that may be transmitted by blood and certain body fluids. A number of viruses and parasites, as well as newer agents like prions (e.g. mad cow disease) may be transmitted through blood products and body fluids (See Table 1); however, the three most common occupationally acquired blood-borne infections in North America are caused by hepatitis B virus (HBV), hepatitis C virus (HCV) and/or human immunodeficiency virus (HIV).

BBPs are transmitted from one individual to another when blood or body fluids from the infected individual enter the body of a previously uninfected individual.

**Pathogens Associated with Blood-borne Transmission**

**Table 1: Pathogens Associated with Blood-borne Transmission**

<table>
<thead>
<tr>
<th>Viral</th>
<th>Bacteria</th>
<th>Parasite</th>
</tr>
</thead>
<tbody>
<tr>
<td>hepatitis B virus (HBV)</td>
<td>Ehrlichiosis</td>
<td>malaria</td>
</tr>
<tr>
<td>hepatitis C virus (HCV)</td>
<td>Lyme disease</td>
<td>Chagas disease</td>
</tr>
<tr>
<td>hepatitis A virus (HAV)</td>
<td></td>
<td>toxoplasmosis</td>
</tr>
<tr>
<td>hepatitis D (HDV)</td>
<td></td>
<td>leishmaniasis</td>
</tr>
<tr>
<td>hepatitis E virus (HEV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>human immunodeficiency virus (HIV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>human T-lymphotropic viruses (HTLV-I and HTLV-II)</td>
<td></td>
<td>malaria</td>
</tr>
<tr>
<td>cytomegalovirus (CMV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epstein-Barr virus (EBV)</td>
<td></td>
<td>Chagas disease</td>
</tr>
<tr>
<td>human parvovirus B-19 (HPV)</td>
<td></td>
<td>toxoplasmosis</td>
</tr>
<tr>
<td>human herpes virus 6 (HHV6)</td>
<td></td>
<td>leishmaniasis</td>
</tr>
<tr>
<td>human herpes virus 8 (HHV8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rocky Mountain Spotted Fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>viral hemorrhagic fever (Ebola and Lassa)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Further information on any of these agents can be obtained from the Health Canada website:

**Fluids Capable of Transmitting BBP**

The specific body fluids capable of transmitting BBPs include:

- blood, serum, plasma and all biologic fluids visibly contaminated with blood
- tissues
- pleural, amniotic, pericardial, peritoneal, synovial and cerebrospinal fluids (CSF)
- cervical/vaginal secretions or semen (HCV)
- saliva contamination in bite wound

The risk of HBV, HCV, and/or HIV transmission via pleural, amniotic, pericardial, peritoneal, synovial and CSF is unknown. Insufficient studies have been conducted to accurately assess the risk of transmission through occupational exposure, although HIV and HBV have been detected in these body fluids and one case of HIV transmission has been reported following accidental injection of bloody pleural fluid.

Reference: Centers for Disease Control and Prevention (CDC). 1988. Perspectives in Disease Prevention and Health Promotion Update: Universal Precautions for Prevention of Transmission of Human Immunodeficiency Virus, Hepatitis B Virus, and Other Bloodborne Pathogens in Health-Care Settings. MMWR;37(24);377-388
http://www.cdc.gov/mmwr/preview/mmwrhtml/00000039.htm

Unless there is visible contamination with blood, the following body fluids are not associated with blood-borne pathogen transmission:

- feces
- nasal secretions
- sputa
- tears
- urine
- stomach contents (vomitus)

BBP Entry Routes

In order to cause infections, BBPs must bypass normal skin barriers or pass through the linings of the mucous membranes that have contact with the environment, most commonly those found lining the mouth, nose, eyes, and genital tract.

Blood-borne pathogens entry routes include:
- percutaneous (i.e. skin is pierced or cut) injection/inoculation
- contact with non-intact skin (cut, broken, abraded, chapped skin)
- mucous membrane (e.g., eyes, nose, mouth, or genital tract)

Significant exposure

Exposure occurs when individuals come into contact with body fluids containing blood-borne pathogens; however, exposure must be significant for transmission to be of concern.

The highest risk of transmission of HBV, HCV and HIV is associated with percutaneous exposure to blood. Percutaneous exposure is that which occurs following passage of a sharp object through the skin barrier. Percutaneous exposures includes sharps injuries, and/or needle-stick injury with an object that is contaminated with blood or body fluids, and is most likely to occur during injection or blood collection.

Intact skin generally prevents the transmission of BBPs. Blood, body fluids or tissue must bypass the normal skin barrier or enter the body through the mucous membranes. When skin becomes damaged (chapped, broken, wounds, etc), BBPs may gain entrance to the body.

Mucous membrane transmission can occur; however, transmission via mucous membranes is much less effective than percutaneous exposure. The Centers for Disease Control and Prevention (CDC) recommends barrier precautions (face shields, masks, gowns, etc.) to prevent contact with droplets and splashes of blood and body fluids.

Studies of nonsexual household contacts have failed to demonstrate HIV transmission following bites, percutaneous injections, or contamination of cuts and open wounds with HIV-infected saliva. Although the role of saliva in viral transmission remains unclear, it would appear at this time, that although possible, it is remote.

There are no known instances of transmission of a blood-borne pathogen by aerosols released into the air (coughs, sneezes, breathing). In studies conducted in dental facilities and hemodialysis centers, hepatitis B surface antigen could not be detected in the air during the treatment of hepatitis B carriers, even when
procedures were known to generate aerosols (i.e. drilling). Because the concentration of HIV in blood is generally lower than that of HBV in blood, risk of HIV transmission through aerosol exposure is probably unlikely and remains purely theoretical at this time.

Risk of occupational blood-borne pathogen transmission
Occupational exposure is exposure that occurs during the performance of routine work activities. Occupational transmission of BBPs refers to transfer of infection resulting from exposure to the infected individual’s blood and/or blood containing body fluids, during the performance of routine work activities. Blood is the single most important source of HIV, HBV, and other BBPs in the occupational setting; therefore, transmission is most likely to occur in workers involved in rescue or patient care activities, or during other interactions where workers are directly exposed to infected blood.

Infection occurs when the pathogen contained in the body fluid multiplies and causes disease. Exposure does not necessarily result in transmission, and transmission does not necessarily result in infection. A number of factors affect the risk of transmission and infection following exposure:

- Type of fluid exposure – blood poses a greater risk than saliva, for example
- Volume of fluid – a hollow bore needle such as one that is used for venipuncture contains more blood on average than a suture needle or lancet
- Probability of exposure – dependent on type of work performed
- Specific pathogen involved – on average, HBV infection is associated with greater numbers of viral particles in the patient’s blood and tissues at any one time than HCV or HIV
- Route of exposure – percutaneous exposure results in greater risk of infection than exposure through mucous membranes or non-intact skin
- Disease progression – viral particles may be found in much greater numbers in patients whose disease has progressed
- Virus concentration in fluid or tissue (viral load)

Although infection following transmission is not completely understood, it appears that a number of host and specific pathogen factors affect whether or not infection occurs following transmission.

Risks for Health Care Workers (HCW)
Health care workers (HCW) who handle blood and body fluids are at increased risk of infection with HBV, HCV and HIV – those most at risk include phlebotomists, nurses, clinical laboratory workers, and physicians. Exposure is most commonly associated with needle-stick injury or percutaneous injury
resulting from other sharp instruments (i.e. lancets, scalpel blades, suture needles, broken glass, etc.).

Other HCWs are at risk of injury from specific types of sharps—for example, surgeons (scalpels and suture needles) and dental workers, as well as housekeepers and laundry workers who are exposed due to discarded or lost needles in waste and laundry.

**Risks for Emergency Medical and Public Safety Workers**

Emergency medical service and public-safety workers are also at risk of occupational exposure to BBPs. Emergency medical technicians (EMTs), fire fighters, law officers and prison guards may be exposed during the performance of their duties. Because exposure is unpredictable and dependent on the situation, protective measures may be necessary in situations where there is no obvious risk. Control measures put in place to protect against expected and unexpected exposures should be simple, practical, and consistent in order to encourage worker compliance.


Law officers and prison guards also risk bite wounds from suspects and prisoners. In addition to routine medical treatment and tetanus vaccination status, HIV and HBV infection should be considered. HBV infected saliva has been shown to contain much lower concentrations of virus; therefore, the risk of infection via a bite wound is considerably less than injection/inoculation of infected blood, plasma or serum (*Reference: WHO*).

Occupational transmission of HIV, HBV and HCV in health care and public service settings is most commonly associated with injuries involving needles or other sharp instruments. Of the nearly 35,000,000 HCW worldwide, approximately 3,000,000 percutaneous blood-borne pathogen exposures occur each year - 90% of these infections occur in developing countries. Most HCW blood-borne pathogens exposure occurs due to percutaneous sharps injury (~40% of HBV and HCV infections; 2.5% of HIV infections). (*Reference: WHO*)

Although vaccine protection is available for HBV, there is currently no effective immunization or prophylactic treatment for HCV or HIV.
Table 3: Seroconversions following percutaneous exposure

<table>
<thead>
<tr>
<th>Viral Agent</th>
<th>Number of exposures</th>
<th>Number of infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBV</td>
<td>2,000,000</td>
<td>70,000</td>
</tr>
<tr>
<td>HCV</td>
<td>900,000</td>
<td>15,000</td>
</tr>
<tr>
<td>HIV</td>
<td>170,000</td>
<td>500</td>
</tr>
</tbody>
</table>

In the U.S., the Occupational Safety and Health Administration (OSHA) estimates that more than 5.6 million workers in healthcare and related occupations are at risk of occupational exposure to BBPs, including HIV, HBV, HCV, and other potentially infectious agents. In the United States, approximately 800,000 needle-stick injuries occur in hospitals annually – one injury every 10 seconds. However, the number of occupational exposures is likely much higher than this, as it is suggested that as many as 50% of injuries go unreported in both health-care and public safety settings (Health Canada [HC]).

Fifty percent (50%) of 326 registered nurses surveyed from a random sampling in Alberta reported having one or more needle-stick injuries in the previous year, accounting for 630 injuries (HC, 1992). Operating rooms also have significant numbers of percutaneous exposures, and it is estimated that less than 5% of the injuries were reported to occupational health services.

Worldwide, unsafe injections are estimated to account for 30% of HBV infection, 31% of HCV infection, 28% of liver cancer, 24% of cirrhosis and 5% of HIV infections (WHO). Approximately, 500,000 deaths (0.9%) result from unsafe injection practices in medical settings.

In South-East Asia, areas of the Western Pacific Region (Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People’s Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Viet Nam), and areas of the Eastern Mediterranean Region (Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen), unsafe injections result in about 0.7 – 1.5% of all disease burden (WHO).

Reuse of syringes and needles in the absence of sterilization exposes millions of people to infection – in some countries reuse of injection equipment is estimated at approximately 70%. Syringes and needles are often just rinsed in a pot of tepid (luke-warm) water between injections. Disposal of dirty injection equipment also results in significant HCW exposure, and in some countries unsafe disposal of used equipment may lead to re-sale on the black market.

BBP infections are preventable in many cases. Prevention strategies include training of health care workers, HBV immunization, post-exposure prophylaxis and improved waste management.
In the following modules, we will examine the effect of HBV, HCV, and HIV on the human body, and discuss ways to minimize the risk of infection.