



FACTSHEET

HIV Transmission: An Overview

The Human Immunodeficiency Virus (HIV) is the virus that causes Acquired Immunodeficiency Syndrome (AIDS). HIV transmission is a complex process. The degree of risk for transmission of HIV in any situation depends on a variety of biological and social risk factors for both partners. This fact sheet addresses some of the biological factors that need to be considered when thinking about HIV transmission and the risk of being infected with HIV.

This is one of a series of fact sheets that review the specific biological factors that make it more or less likely that HIV can be sexually transmitted.

What are the basic criteria for HIV transmission?

One partner has to be HIV-positive.

An HIV-positive person has to have enough virus in his or her body fluids (blood, semen, pre-cum, vaginal fluid, anal fluid or breast milk) to infect another person.

The virus has to be able to get into the blood of an uninfected person. This can happen through: unprotected vaginal or anal sex; vertical transmission (from a mother to her fetus or infant); sharing needles while injecting drugs; or blood transfusions. In Canada, blood transfusions are no longer a concern because all blood donations are screened for HIV. Blood transfusions may be a risk factor in countries that do not have consistent screening for HIV in blood.

HIV has to come into contact with CD4+ cells, which are the immune cells that HIV infects. HIV can get into the blood through breaks in the skin (for example, wounds or open sores) or by passing through a mucous membrane.

What are mucous membranes?

Mucous membranes are tissues that line the surfaces of body cavities, such as the nostrils, mouth, throat, vagina, urethra, anus and rectum.

Mucous membranes are moist and in some places secrete mucus that helps to keep out foreign invaders (such as viruses and bacteria).

Mucous membranes are lined by a thin protective layer of living cells called the epithelium.

Mucous membranes help protect against germs but, unlike the skin, which

is an excellent barrier against germs and many other things that should not be inside our bodies, mucous membranes allow some things to cross into and out of the body. For example, we absorb many nutrients through the mucous membrane in the intestines and colon.

Below the surface of mucous membranes there are many immune cells, which help to protect the body against possible infections.

However, because HIV targets and is able to infect immune cells, if HIV enters the body through a mucous membrane, there are lots of immune cells for HIV to infect.

Is it possible to know accurately the level of risk for HIV transmission?

It's possible to have a fairly good sense of the level of risk present in any situation. However, because there is still so much we do not know about HIV transmission, the immune system and the human body, it is not possible to assign an absolute level of risk to any particular act.

Worldwide, most HIV transmission happens through sex (almost 90%).

Many known and unknown factors contribute to the risk of someone becoming infected with HIV.

“Risk” should be seen as a continuum based on various social, cultural, and biological factors that could increase or decrease how vulnerable an HIV-negative person is to infection, as well as how infectious an HIV-positive person is.

Nevertheless, it is still useful and possible to talk about different levels of risk (high-risk and low-risk acts) based

on the information we do know. See the Canadian AIDS Society's *HIV Transmission: Guidelines for assessing risk for a review of different levels of risk*.

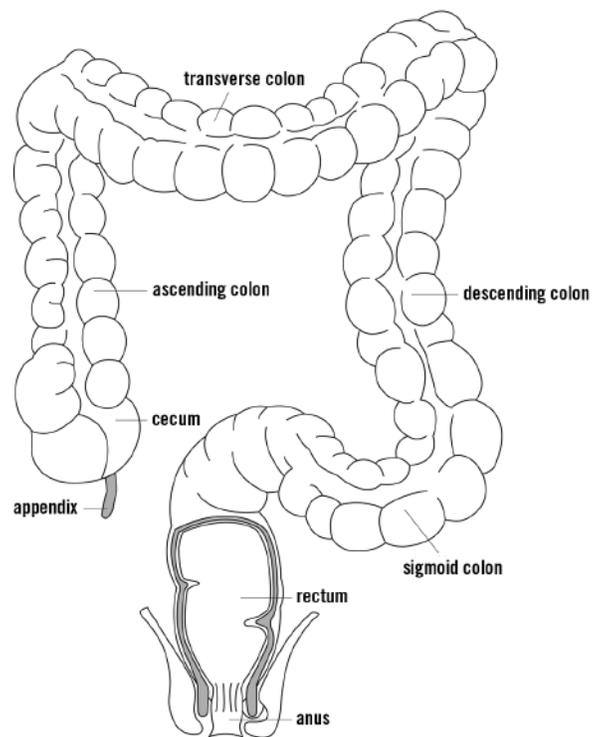
What are the most common routes for sexual transmission of HIV?

The anus and rectum

The mucous membrane lining the anus and rectum is very thin (only one cell layer thick). This makes it much easier for germs, including HIV, to find a way through these cells and enter the body.

This is one reason why unprotected receptive anal sex is considered to be higher risk than other kinds of sex.

The mucous membrane in the anus and rectum comes into contact with many potential invaders, such as bacteria from food. It therefore has a large number of immune cells (including CD4+ cells) to protect the body. These cells are easy targets for HIV.



The length of the rectum and colon also provides a large surface area with many immune cells that are potential targets for HIV.

The female reproductive or genital tract

The female reproductive tract is designed to protect a potential fetus from infection (see the fact sheet on Women and the Biology of HIV Transmission).

The vaginal mucous membrane is composed of ten to twelve overlapping layers of cells, which help prevent bacteria and viruses from getting into the body.

The vagina contains friendly bacterial species (for example, Lactobacilli) that help prevent the growth of “bad” bacterial species (for example, *Gardnerella vaginalis*) and also make it harder for HIV to survive.

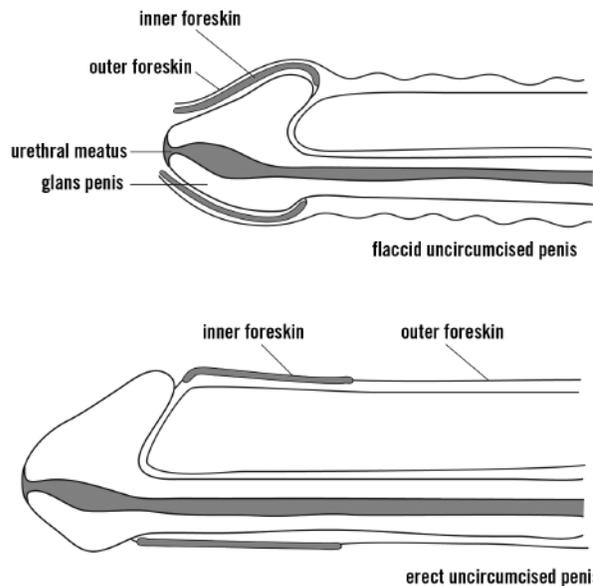
An increase in “bad” bacteria in the vagina makes the vagina less acidic, which makes it easier for HIV to survive. This increase in “bad” bacteria is called altered vaginal flora (AVF) or bacterial vaginosis (BV).

Further up the female genital tract, past the vagina, are the cervix and the uterus. The mucous membrane lining the cervix is only one cell layer thick, so it is much easier for HIV to cross.

The cervix has a very high number of immune cells below the mucous membrane. These cells are easy targets for HIV.

The foreskin of the penis

The penis has mucous membrane lining the urethra (the tube that pee and semen come out of) and the inner side of the foreskin in uncircumcised men.



The inner foreskin has many immune cells, called dendritic cells. HIV is able to bind to these cells. Dendritic cells can carry the virus to lymph nodes, which can be thought of as the headquarters of the immune system. At the lymph nodes, there are large numbers of CD4+ cells, which HIV can infect.

During sex, the foreskin is pulled back along the erect penis, revealing the inner foreskin. Dendritic cells present on the inner foreskin may come in contact with vaginal or anal fluids that might contain HIV. So even if a man only has penetrative sex, it is still possible for him to become infected with HIV.

Circumcision (removal of the foreskin) has been found to reduce the chance of acquiring HIV by almost 50%. However, this has been documented only in

low-income countries where HIV and sexually transmitted infections (STIs) are most commonly transmitted by heterosexual sex. It is unclear whether the same benefit would be seen in North America with its higher rate of male circumcision and where sexual transmission is most common among gay and bisexual men

In the studies, circumcision helped to protect the men but had no protective effect for their partners.

Oral sex

It is generally agreed that it is much harder to transmit HIV through oral sex; however, keep in mind that under certain circumstances HIV can be transmitted this way.

Researchers have found that saliva is inhospitable to HIV. Saliva also has a much lower viral load than blood or genital and anal fluids.

There is a very low risk of transmitting HIV during oral sex, unless the person giving it has open cuts, sores or lesions in their mouth. There is, however, a much higher risk of transmitting or acquiring other STIs when giving or receiving oral sex (see the fact sheet on Sexually Transmitted Infections and HIV).

Performing oral sex is more risky than receiving it because large amounts of semen, pre-cum or vaginal fluids may come into contact with the mucous membranes in the mouth or throat.

The person who is performing oral sex may be at higher risk if a female partner is menstruating or if a male partner ejaculates into the mouth.

Poor oral health (such as gum disease), inflammation, cuts/sores or oral infections (some of which may be symptom-free) can also increase the risk of becoming infected with HIV by performing oral sex. Smoking and other things that damage the mucous membrane in the mouth can also increase the risk.

Brushing or flossing teeth can cause minor cuts, abrasions and inflammation, which can increase the risk of HIV infection. It is advisable to avoid performing oral sex for up to two hours after brushing or flossing so the gums have a chance to heal.

Is it possible to get infected if an HIV-positive partner doesn't ejaculate during sex?

Even if the partner doesn't ejaculate, a small amount of fluid (pre-cum) may be released from the penis.

HIV has been detected in the pre-cum of HIV-positive men.

Little is known about levels of HIV in pre-cum and how it relates to HIV levels in blood or semen.

However, because HIV has been detected in pre-cum it means there is a possible risk for transmission.

What influences how infectious an HIV-positive person is?

Most doctors and scientists agree that if a person has a higher blood HIV viral load, they will be more infectious. This is because, in most cases, the higher the viral load in blood the higher the level of HIV in anal and genital fluids (see the fact sheet on HAART and HIV Transmission).

HIV in blood and genital fluids

The viral load in the blood does not always correspond with the viral load in genital and anal fluids. Someone with an undetectable blood viral load may still have virus in their semen, vaginal fluids and/or anal fluids and therefore pose a risk of transmitting HIV sexually.

Research has suggested that the risk of HIV transmission goes up with an increase in HIV viral load in the semen, vaginal fluids or anal fluids, even if the viral load does not increase in the blood.

The viral load could increase in the genital fluids without an increase in blood viral load if there is co-infection with another STI, reactivation of a latent STI, such as HSV-2, and/or CMV (see the fact sheet on Sexually Transmitted Infections and HIV) or if there is inflammation of the genital tract (see section on inflammation below).

Stage of HIV and infectiousness

The stage of HIV infection plays a big role in how likely someone is to transmit HIV sexually.

During early (acute) infection, which generally lasts around six months, the HIV viral load rises dramatically then falls to a level that remains stable during the later chronic stage of infection, which can last for several years. Without treatment the viral load will usually increase again as the infection progresses and develops into AIDS after up to 10 years.

Some studies suggest that because HIV levels in blood are almost 10-times higher during the acute phase of infection, as many as 50% of new infections may occur through sex or sharing needles with someone who has just recently been infected.

Someone who has been recently infected may not be aware that they are HIV-positive and so may not take the necessary precautions to avoid infecting their sexual partner(s).

What is the role of inflammation in transmission and susceptibility to HIV?

Inflammation is the body's natural response to infection and/or injury. During inflammation, immune cells are brought to the area to fight infection. These immune cells include dendritic cells, which may transport HIV to the lymph nodes, and CD4+ cells (the cells that HIV infects).

As immune cells arrive, the infected area becomes red and hot from increased blood flow.

The area swells as the walls of the capillaries (smallest blood vessels) expand and become thinner allowing blood to pass through more easily, so that more immune cells can pass through the mucous membrane to find invaders and HIV can more easily pass into the bloodstream.

Common causes of inflammation are: altered vaginal flora (bacterial vaginosis); allergic reactions; vaccination; trauma to an area (for example, from rough, dry, or prolonged sex); irritable bowel syndrome; sexually transmitted infections (for example, herpes, chlamydia, gonorrhea); cuts, sores or ulcers; irritation(s); yeast or other types of infections.

How does inflammation increase the risk of HIV transmission?

In an HIV-positive person, inflammation of the genital tract or rectum increases the viral load in the genital or anal fluids, even though it does not increase the blood viral load. This is because inflammation at a

site usually brings more infected immune cells to the area. When these cells become active to fight the infection they unwittingly make more copies of HIV.

If a person who is HIV-negative has inflammation, a larger number of immune cells will arrive at the site to fight off the cause of the inflammation. This means there is a greater chance that HIV, if present, will come into contact with these cells and infect them.

Other fact sheets in the series are:

- Women and the Biology of HIV Transmission;
- Sexually Transmitted Infections and HIV Transmission.
- HAART and HIV Transmission.

Credits

Authors: Prameet Sheth PhD, Brook Thornycraft

Illustrations: Sheena Gibson

2009

Key points

The risk of HIV transmission during sex is a continuum based on many factors.

For transmission to occur, HIV has to be able to get through the mucous membrane and then it has to find CD4+ cells to infect. The likelihood of this happening depends on the amount of virus, the possible routes through the mucous membrane and the number of immune cells in the area.

The viral load in sexual fluids is generally higher when the blood viral load is higher, inflammation is present or there is co-infection with another STI.

The vulnerability of the mucous membrane can be increased by inflammation, rough sex, the location and thickness of the mucous membrane and STIs.

While some of these factors are impossible to know, there are still ways to decrease the risk of transmission. For example, it is beneficial to maintain good genital, anal, and oral health to decrease inflammation and trauma to the mucous membranes.

For people who are at risk for HIV infection, it is also important to get tested and treated regularly for STIs.

Getting tested for HIV is important, not only for a person's treatment needs, but also because of the increased risk of transmission to partners when someone is newly infected.

Finally, being aware of some of the transmission risks enables people to make knowledgeable decisions about how to protect themselves, and how much risk they are willing to take.

Recommended reading

Sexual Transmission

Quinn TC, Wawer MJ, Sewankambo N, Serwadda D, Li C, Wabwire-Mangen F, et al. Viral load and heterosexual transmission of human immunodeficiency virus type 1. Rakai Project Study Group. *New England Journal of Medicine* 2000;342(13):921–929.

A large study done in Uganda looking at rates of HIV transmission between sero-discordant couples (one person in a couple is HIV-positive while the other is HIV-negative). One of the first studies to break down rates of transmission related to blood HIV levels.

Royce RA, Sena A, Cates W, Jr., Cohen MS. Sexual transmission of HIV. *New England Journal of Medicine* 1997;336:1072–1078.

An overview on sexual transmission of HIV and what factors increase or decrease the risk of transmitting HIV. A good reference to read for people interested in knowing more about correlates of transmission without a great deal of scientific jargon.

Body Defences Against HIV

Hladik F, McElrath J. Setting the stage: Host invasion by HIV. *Nature Reviews Immunology* 2008;8:447–457.

An overview of various protective mechanisms the body uses to thwart HIV entry. This review also highlights how the HIV virus gets around the various defences of the body to establish infection.

Circumcision

Bailey RC, Plummer FA, Moses S. Male circumcision and HIV prevention: current knowledge and future research directions. *Lancet Infectious Disease* 2001;1(4):223–231.

A review article that discusses information regarding the impact of male circumcision on HIV acquisition and its potential role as a preventive measure to reduce HIV acquisition.

Gray RH, Kigozi G, Serwadda D, Makumbi, F, Watya S, Nalugoda F, Kiwanuka N, et al. Male circumcision for HIV prevention in men in Rakai, Uganda: a randomised trial. *Lancet* 2007;369:657–666.

A large scale trial investigating the impact of male circumcision on HIV acquisition in the Rakai district of Uganda.

McCoombe SG, Short RV. Potential HIV-1 target cells in the human penis. *AIDS* 2006;20(11):1491–1495.

This study identifies cells in the inner foreskin of the penis that can serve as being potential targets for HIV.

Oral Sex

Robinson EK, Evans BG. Oral sex and HIV transmission. *AIDS* 1999;13(6):737–738.

This article examines the risk of transmitting HIV through oral sex.

HIV in Genital Fluids

Liuzzi G, Chirianni A, Clementi M, Bagnarelli P, Valenza A, Cataldo PT, Piazza M. Analysis of HIV-1 load in blood, semen and saliva: evidence for different viral compartments in a cross-sectional and longitudinal study. *AIDS* 1996;10(14):F51–F56.

This study measured HIV levels in blood, semen and saliva in 26 men and found detectable HIV levels in semen during all stages of HIV infection.

Putney J, Oneta M, Mayer K, Seage G, Anderson DJ. Pre-ejaculatory fluid as potential vector for sexual transmission of HIV-1. *Lancet* 1992;340:1470.

An early study investigating the presence of HIV in pre-ejaculatory fluid.

Sheth PM, Shahabi K, Rebbapragada A, Kovacs C, Dimayuga R, Chackalakal S, et al. HIV viral shedding in semen: lack of correlation with systemic virus-specific CD8 responses. *AIDS* 2004 Nov 5;18(16):2202–2205.

A study done on levels of HIV found in blood and semen in a cohort of men who have sex with men (MSM) in Toronto, Canada. The study found a strong correlation between HIV levels in blood and in the semen of HIV-infected men with virus levels being about 10-fold lower in semen than in blood.

Inflammation

Appay V, Sauce D. Immune activation and inflammation in HIV-1 infection: causes and consequences. *Journal of Pathology* 2008;214(2):231–241.

A recent review examining the impact of immune activation and inflammation on HIV infection. A good source for people wanting to know more about the close relationship between inflammation and HIV.

Wawer MJ, Gray RH, Sewankambo NK, et al. Rates of HIV-1 transmission per coital act, by stage of HIV-1 infection, in Rakai, Uganda. *Journal of Infectious Disease* 2005;191:1403–1409.

Another study done in Uganda, this study evaluates the impact HIV disease states have on sexual transmission of HIV transmission. The study authors break it down to look at the risk of transmission per sexual encounter.

Additional resource

The Canadian AIDS Society's *HIV Transmission—Guidelines for assessing risk: a resource for educators, counsellors and health care professionals* (2005) is available from the CATIE Ordering Centre (<http://orders.catie.ca>).

Disclaimer

Decisions about particular medical treatments should always be made in consultation with a qualified medical practitioner knowledgeable about HIV-related illness and the treatments in question.

The Canadian AIDS Treatment Information Exchange (CATIE) in good faith provides information resources to help people living with HIV/AIDS who wish to manage their own health care in partnership with their care providers. Information accessed through or published or provided by CATIE, however, is not to be considered medical advice. We do not recommend or advocate particular treatments and we urge users to consult as broad a range of sources as possible. We strongly urge users to consult with a qualified medical practitioner prior to undertaking any decision, use or action of a medical nature.

We do not guarantee the accuracy or completeness of any information accessed through or published or provided by CATIE. Users relying on this information do so entirely at their own risk. Neither CATIE nor the Public Health Agency Canada nor any of their employees, directors, officers or volunteers may be held liable for damages of any kind that may result from the use or misuse of any such information. The views expressed herein or in any article or publication accessed or published or provided by CATIE are solely those of the authors and do not reflect the policies or opinions of CATIE or the official policy of the Minister of Health Canada.

Permission to reproduce

This document is copyrighted. It may be reprinted and distributed in its entirety for non-commercial purposes without prior permission, but permission must be obtained to edit its content. The following credit must appear on any reprint: *This information was provided by the Canadian AIDS Treatment Information Exchange (CATIE). For more information, contact CATIE at 1.800.263.1638.*

Contact CATIE

by telephone
1.800.263.1638
416.203.7122

by fax
416.203.8284

by e-mail
info@catie.ca

on the Web
www.catie.ca

by mail
505-555 Richmond Street West
Toronto ON M5V 3B1 Canada



Funding has been provided by the Public Health Agency of Canada.