

Episode 53 – Role of Vaccines in Cancer Prevention & Treatment

January 28, 2022

Overview of vaccines[1]

Vaccines are complex biologic products designed to induce immune responses to protect against infection and disease on subsequent exposure to a pathogen. To generate an immune response, vaccines contain antigens that are either derived from the pathogen or produced synthetically to represent components of the pathogen. [1] [2]

Administering a vaccine antigen generates an inflammatory response that is initially mediated by the innate immune system and subsequently involves the adaptive immune system through the activation of T and B cells.[2] Most vaccines provide protection through antibody-mediated immunity (humoral immunity), mainly via B cells. However, some vaccines (e.g., bacillus Calmette-Guérin [BCG][3] and live herpes zoster vaccines) primarily induce cell-mediated immunity, mainly via T cells. [3]

Research has led to the development of numerous types of vaccines that safely and effectively elicit immune responses to protect against infection, illness, disability, and death. [1] [2]

Evidence of vaccine effectiveness was demonstrated in research by Schneider et al. (2021). The authors estimated COVID-19 vaccination prevented more than 1 million deaths and over 10.3 million hospitalizations in the US as of November 30, 2021. [4]

Vaccine types

There are several different types of vaccines, such as:

- Inactivated vaccines
- Live-attenuated vaccines
- Messenger RNA (mRNA) vaccines
- Subunit: recombinant, polysaccharide, and conjugate vaccines
- Toxoid vaccines
- Viral vector vaccines [5]

[1] Refer to Episode 15 for additional information on vaccines.
[2] Refer to Episodes 44 & 45 for addition information on the immune system.
[3] BCG vaccination is administered to protect against tuberculosis (TB), a disease caused by *Mycobacterium tuberculosis*.

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Types of vaccines [5] [6] [7] [8]

Vaccine type	Components & Mode of action	Disease(s)
Inactivated	Uses killed version of the disease-causing pathogen. May require booster doses as induced immunity is weaker than live vaccines.	Hepatitis A Influenza Polio Rabies
Live-attenuated	Contains a weakened form of the live pathogen. Most confer life-long immunity after only 1 or 2 doses.	Measles, mumps, rubella (MMR vaccine) Rotavirus Smallpox Chickenpox Yellow fever
Messenger ribonucleic acid (mRNA)	Contains piece of mRNA that instructs cells to produce some of the antigenic proteins of the disease-causing virus.	COVID-19[4]
Subunit: recombinant, polysaccharide, and conjugate	Contains the antigenic parts of the pathogen, e.g., protein, polysaccharide, capsid. Contains adjuvants[5] to create stronger immune response. Requires multiple doses for long-term immunity.	*Haemophilus influenzae* type b (Hib) Hepatitis B Human papillomavirus (HPV) Whooping cough (part of DTaP vaccine) Pneumococcal disease Meningococcal disease Shingles
Toxoid	Uses inactivated toxin (toxoid) secreted by disease-causing bacteria. May require boosters to maintain immunity.	Diphtheria Tetanus
Viral vector	Uses a harmless virus to carry genetic material of pathogen into cells. Requires high dose to confer immunity.	COVID-19

Cancer vaccines

Cancer vaccines work on the same principle as vaccines used to prevent infectious disease by programming the immune system to recognize cancer antigens as 'foreign'. Cancer vaccines can be administered prophylactically to prevent tumour occurrence, or therapeutically to treat individuals who have developed cancer. [9]

[4] Refer to Episodes 15, 28, 34, 39, 40, 48, & 52 for more information on COVID-19 vaccines.

[5] Adjuvants are added to certain vaccines to enhance immune response and extend duration of B and T cell activation. Adjuvants permit the antigen amount per dose or the number of required doses to achieve immunity to be reduced, and improve immune response in individuals with immune suppression (e.g., elderly). [67]

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Tumour viruses

Viral infections contribute to approximately 15-20% of all human cancers globally. Both DNA and RNA viruses have been shown capable of causing cancer in humans. [10] [11]

Virally infected cells are either eliminated through cell-mediated apoptosis[6] or persist causing chronic infection. Chronic persistence of infection by tumour viruses can lead to oncogenesis. [11]

Viruses linked to oncogenesis are human papillomavirus (HPV), hepatitis B virus (HBV), Epstein-Barr virus (EBV), human herpesvirus 8 (HHV-8) [also called Kaposi sarcoma herpesvirus (KSHV)], human T-cell lymphotropic virus (HTLV-1), hepatitis C virus (HCV), and Merkel cell polyomavirus (MCV). [12]

Oncogenesis is a multistage process in which viruses employ different mechanisms throughout cancer development. For example, HPV promotes chromosomal instability, which may directly contribute to cellular genetic changes. However, HBV has a more indirect role in cancer development by causing chronic inflammation that continually damage local tissue and taking many decades for gene mutations to accumulate. [12]

Nonetheless, virus infection alone is usually insufficient for oncogenesis and additional factors may also play a role, such as immunosuppression, somatic mutations,[7] genetic predisposition, and carcinogen exposure. [13]

Tumour viruses [12] [13] [14] [15]

Virus	Type	Family	Cancer(s)
Human papilloma virus (HPV)	Non-enveloped DNA virus	Papillomavirus	Cervical cancer Oropharyngeal cancer Anogenital cancer
Hepatitis B virus (HBV)	Enveloped DNA virus	Hepadnavirus	Hepatocellular carcinoma[8]
Epstein-Barr virus (EBV)	Enveloped DNA virus	Herpesvirus	B cell lymphomas (e.g., Burkitt's lymphoma) T cell lymphomas (e.g., angioimmunoblastic T-cell lymphoma) Hodgkin's disease Post-transplant lymphoproliferative disease Leiomyosarcoma Nasopharyngeal carcinoma
Human herpesvirus 8 (HHV-8)	Enveloped DNA virus	Herpesvirus	Kaposi sarcoma

[6] Apoptosis, also called cellular suicide, is a programmed cell death where a cell actively destroys itself to maintain the health of the body by eliminating old, unneeded, and abnormal cells.
[7] Somatic mutation is an alteration in DNA that occurs after fertilization. Somatic mutations can occur in any cell of the body except germ cells (sperm and egg) and therefore are not passed on to offspring. Somatic mutations may cause cancer or other diseases.
[8] Hepatocellular carcinoma (HCC) is the most common primary tumour of the liver. [68]

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Virus	Type	Family	Cancer(s)
(Kaposi sarcoma herpesvirus [KSHV])			Primary effusion lymphoma Multicentric Castleman disease
Human T-cell lymphotropic virus (HTLV-1)	Enveloped RNA virus	Retrovirus	Adult T-cell leukemia/lymphoma
Hepatitis C virus (HCV)	Enveloped RNA virus	Flavivirus	Hepatocellular carcinoma
Merkel cell polyomavirus (MCV)	Non-enveloped DNA virus	Polyomavirus	Merkel cell carcinoma

Vaccines prevent cancer by inhibiting certain viral infections that can cause cancer or contribute to cancer development. They stimulate the immune system to eliminate the viruses prior to causing infection and are administered before cancer develops. Currently, there are 2 types of vaccines that prevent cancer, HPV vaccine and HBV vaccine. [16]

Human papillomavirus (HPV)[9]

- HPV is a group of viruses common globally.
- There are 200 types of HPV, with at least 14 being oncogenic (high-risk type), including HPV types 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, and 68. HPV16 and HPV18, are responsible for most HPV-related cancers. [17]
- HPV-related cancers include: cervical, oropharyngeal, anal, penile, vaginal, and vulvar cancers. [17]
- Low-risk HPV types, especially 6 and 11, can cause skin warts (e.g., on hands, feet, genitals, anus) and may also cause respiratory papillomatosis.[10] Low-risk HPV infections do not cause cancer, and many resolve without treatment. [18]
- Both males and females can become infected with HPV and develop HPV-caused cancers. [17]
- All types of HPV are spread by skin-to-skin contact. Over 40 types are transmitted through sexual contact and most individuals are infected with HPV shortly after onset of sexual activity. [14]
- HPV infection can also be transmitted to the fetus before and during birth. Consequently, newborns can develop recurrent respiratory papillomatosis, which is associated with a high degree of morbidity and mortality. [19]
- Most HPV infections are asymptomatic and usually resolve without treatment within a few months after acquiring. Approximately 90% are cleared by the immune system within 2 years. [20]
- Approximately 10% of individuals with cervical HPV infection will develop long-lasting HPV infections increasing risk for cervical cancer. Similarly, long-term high-risk HPV infection of the vulva, vagina, penis, or anus can cause precancerous cell changes, which may develop into cancer if not detected and removed early. [21]

[9] Refer to Episode 7 for information on HPV and oral cancer.
[10] Respiratory papillomatosis is a condition where benign papillomas (warts) form on the larynx or other areas of the respiratory tract and can lead to vocal cord damage and airway obstruction.

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- HPV-associated oncological disease of the cervix, vagina, vulva, penis, anus, and oropharynx are primarily squamous cell carcinomas. HPV-associated adenocarcinomas of the cervix represent 85-90% of all adenocarcinomas. [22]
- Cervical cancer is the most common HPV-related disease.
- HPV types, 16 and 18, cause 70% of cervical cancers and pre-cancerous cervical lesions. Almost all cases of cervical cancer can be attributed to HPV infection. [20]
- HPV is responsible for approximately:
    - >90% of anal and cervical cancers,
    - 70% of vaginal and vulvar cancers,
    - 60-70% of oropharyngeal cancers, and
    - 60% of penile cancers. [23]
- Many oropharyngeal cancers may be caused by a combination of tobacco, alcohol, and HPV.
- HPV-related oropharyngeal cancers are seen more often in males and are becoming more common in younger individuals who have a history of multiple sex partners (including oral sex) and no history of alcohol abuse or tobacco use. [24]
- HPV-related oropharyngeal cancers tend to have better prognoses than non-HPV tumours because chemotherapy and radiation treatments work better for these cancers. However, this improvement in outcome is not seen in individuals with HPV-related oropharyngeal cancers who also smoke. [24]

Risk factors for HPV infection

In females, risk factors may include:

- Number of sexual partners and number of lifetime sex partners
- Previous sexually transmitted infection
- Early age of first sexual intercourse
- Tobacco or marijuana use
- History of sexual abuse
- Immune suppression
- HIV infection [19]

In males, risk factors may include:

- Lifetime number of sex partners
- Inconsistent condom use
- Men who have sex with men (MSM) [19]

Risk factors for oral HPV infection

Risk factors for acquiring oral HPV may include:

- Oral sexual activity, with males being more at risk, especially if they smoke.
- Multiple sexual partners increase risk of being exposed to HPV.
- Smoking is associated with HPV prevalence, incidence, and persistence.
- High alcohol intake. Chronic alcohol abuse and acute and moderate alcohol consumption can adversely affect the immune system. Alcohol may also impact sexual behaviour. Smoking combined with high alcohol intake elevates risk.
- Male sex. Prevalence for HPV is higher among males than among females.

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- Immunosuppression increases risk of acquiring an oral HPV infection. [25] [26] [27] [28] [29] [30]

Risk factors for HPV persistence and cervical cancer development

Risk factors may include:

- Oncogenicity of the type of HPV
- Immunocompromised (e.g., living with HIV increases risk of persistent HPV infections and a more rapid progression to pre-cancer and cancer)
- Coinfection with other sexually transmitted infections (e.g., herpes simplex, chlamydia, gonorrhoea)
- Parity (number of times giving birth) and young age at first birth
- Tobacco smoking [20]

Symptoms of oropharyngeal cancer

Symptoms may include:

- Constant and/or long-lasting sore throats
- Persistent earaches, maybe unilateral
- Hoarseness, change in voice, difficulty speaking
- Constant cough
- Enlarged and/or hard lymph nodes
- Inability to open mouth fully
- Trouble moving the tongue
- Coughing up blood
- Difficult or painful swallowing; feeling something is ‘stuck’ in the throat
- Swollen, painless tonsil
- Pain when chewing
- Unexplained weight loss
- Lump or swelling in mouth or neck
- Numbness in the orofacial region
- Lip or mouth sores that do not heal within 14 days
- Indurations
- Red, white, or red and white patches on the mucosa, gingiva, tongue, tonsils, palate, floor of mouth
- Teeth that suddenly become loose
- Dentures that stop fitting

Note: Some individuals do not experience symptoms. [25] [31] [32]

Early-stage symptoms of cervical cancer

Early-stage symptoms may include:

- Irregular blood spotting or light bleeding between menstrual cycles in women of reproductive age
- Postmenopausal spotting or bleeding
- Bleeding after sexual intercourse
- Increased vaginal discharge, sometimes foul smelling [20]

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Later-stage symptoms of cervical cancer
As cervical cancer advances, symptoms may include:
- Persistent back, leg and/or pelvic pain
- Weight loss, fatigue, loss of appetite
- Foul-smelling discharge and vaginal discomfort
- Leg swelling, one leg or both
- Other symptoms may arise depending on organs affected by metastasis [20]

Preventing HPV-associated cancers
The following protective factors may decrease the risk of HPV-associated cancers:
- HPV vaccination can prevent over 90% of cancers caused by HPV, as well as anal, vaginal, cervical, and vulvar precancers. [33]
- Cervical cancer also can be prevented or found early through regular screening and follow-up treatment.
- Early detection by regular oral cancer screenings by an oral health professional and oral self-examination.
- Consistently and correctly using condoms and dental dams can lower risk of transmitting/contracting HPV.
- Limiting number of sexual partners.
- Avoiding smoking and second-hand smoke, and using smokeless tobacco products.
- Limiting alcohol consumption. [31] [33]

HPV vaccination
- HPV vaccines protect against certain types of HPV.
- If not immunized, approximately 75% of sexually active Canadians will acquire an HPV infection at some point.
- Cervarix® (HPV2), Gardasil® (HPV4), and Gardasil® 9 (HPV9) vaccines are authorized for use in Canada. These vaccines protect against anogenital cancers. HPV4 and HPV9 vaccines also protect against anogenital warts (AGWs).
- In Canada, immunization against:
    - HPV types 16 and 18 can prevent approximately 70% of cervical cancers and 60% of high-risk precancerous cervical lesions.
    - HPV types 31, 33, 45, 52, and 58 could further prevent up to 17% of cervical cancers and 30% of high-risk precancerous cervical lesions.
    - HPV types 6 and 11 can prevent approximately 90% of genital warts. [19]
- For maximum protection, individuals should get vaccinated before becoming sexually active and, ideally, around age 11 or 12 (grade 7). [34]

HPV vaccines [19] [35] [36]

	Cervarix® (HPV2)	**Gardasil® (HPV4)**	**Gardasil® 9 (HPV9)**
Vaccine type	Bivalent HPV recombinant vaccine	Quadrivalent HPV recombinant vaccine	Nine-valent HPV recombinant vaccine
Types of HPV	16, 18	6, 11, 16, 18	6, 11, 16, 18, 31, 33, 45, 52, 58
Route of administration	Intramuscular	Intramuscular	Intramuscular

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

	Cervarix® (HPV2)	Gardasil® (HPV4)	Gardasil® 9 (HPV9)
Indications for use[11]	Females aged 9 - 45 years to prevent cervical cancer & pre-cancerous lesions associated with HPV 16 & 18	Females aged 9 - 45 years to prevent cervical, vulvar, vaginal cancers & pre-cancerous lesions and AGWs associated with HPV types contained in vaccine Females aged 9 - 26 years to prevent anal cancer & pre-cancerous lesions associated with HPV types contained in vaccine	Females aged 9 - 45 years to prevent cervical, vulvar, vaginal cancers & pre-cancerous lesions and AGWs associated with HPV types contained in vaccine Females aged 9 - 26 years to prevent anal cancer & pre-cancerous lesions associated with HPV types contained in vaccine
	Not approved for use in males in Canada at this time	Males aged 9 - 26 years to prevent anal cancers, pre-cancerous lesions & AGWs associated with HPV types contained in vaccine	Males aged 9 - 26 years to prevent anal cancers, pre-cancerous lesions & AGWs associated with HPV types contained in vaccine
Dose	0.5 mL	0.5 mL	0.5 mL
Dose schedule	Healthy females aged 9 to <15 years: 2 doses (months 0 & 6), or 3 doses (months 0, 1, & 6) Females aged ≥15 years, immunocompromised females, & immunocompetent HIV infected females: 3 doses (months 0, 1, & 6)	Healthy individuals aged 9 to <15 years: 2 doses (months 0 & 6), or 3 doses (months 0, 2, & 6) Individuals aged ≥15 years, immunocompromised individuals, & immunocompetent HIV infected individuals: 3 (months 0, 2, & 6).	Healthy individuals aged 9 to <15 years: 2 doses (months 0 & 6), or 3 doses (months 0, 2, & 6) Individuals aged ≥15 years, immunocompromised individuals, & immunocompetent HIV infected individuals: 3 doses (months 0, 2, & 6).
Company	GlaxoSmithKline Inc.	Merck Canada Inc.	Merck Canada Inc.
Authorized for use in Canada	2010	2006	2015

Note: Eligibility for HPV-9 vaccination through the Ontario publicly funded vaccine program includes all Ontario students in grade 7; students grade 7 to 12 who have not already completed their vaccine series; and high-risk males (i.e., men who have sex with men) aged 9 to 26 years. [34] [37]

[11] HPV2, HPV4, or HPV9 vaccine is recommended to prevent cervical cancer and precursors in females aged 9 to <27 years, including those who have had previous Pap test abnormalities, cervical cancer, or genital warts since recipients will benefit from receiving HPV vaccine for the HPV types to which they have not been exposed. [19]

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Hepatitis B virus (HBV)

- Hepatitis B is a potentially life-threatening liver infection caused by HBV and is a major global health problem.
- In 2019, global estimates showed:
    - 296 million people were living with chronic hepatitis B infection, with 1.5 million new infections each year, and
    - 820,000 deaths resulted from hepatitis B, mostly from cirrhosis and hepatocellular carcinoma. [38]
- Hepatitis B remains highly or moderately endemic in the Far East, the Middle East, Africa, South America, Eastern Europe, and Central Asia, with rates of 2-20% in the general population. [39]
- In Ontario, hepatitis B is a reportable communicable disease.
- HBV can be transmitted by contact with infected blood, blood products, and bodily fluids, including saliva.
- In Canada, HBV is most commonly transmitted horizontally via:
    - Unprotected sexual contact,
    - Percutaneous exposure (e.g., sharing needles, needlestick injury), or
    - Close household contact.

  Vertical transmission (i.e., perinatally to the infant) still remains a risk. Most acute cases of HBV are reported in unimmunized adults aged ≥25 years or older. [40]
- HBV can also be transmitted through blood transfusions, but is rare in Canada because donated blood is tested for HBV. [39] [41]
- Acute HBV infection may be asymptomatic in up to 50% of adults and 90% of children. [42]
- Most adults (95%) recover completely from HBV infection within a few months and develop lifelong immunity. Only a very small portion of adults develop chronic HBV infections and most remain contagious for the rest of their lives.
- Immunocompromised adults are at risk of developing chronic infection. [14]
- Infants and children are more likely to develop a chronic infection. Risk varies inversely with age of infection:
    - 90-95% risk in infants
    - 25-50% risk aged >1 to <5 years
    - 3-10% risk in adolescents and adults. [42]
- Chronic HBV infections increase risk of developing cirrhosis and hepatocellular carcinoma (HCC), which cause high morbidity and mortality. [14] [38] [40] [43]

Risk factors for HBV infection

Risk factors for HBV infection may include:

- High-risk sexual activities (e.g., unprotected sexual contact, multiple sex partners)
- Injection drug use (past and/or present) and intranasal drug use (snorting) when sharing contaminated equipment (e.g., needles, straws, pipes, spoons, cookers)
- Unsafe tattooing, piercing, and acupuncture practices
- Use of contaminated medical or dental devices
- Men who have sex with men (MSM)
- Household contact with someone with chronic HBV infection

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- Sharing personal care articles (e.g., razors, scissors, nail clippers, toothbrushes) with an HBsAg-positive[12] person
- Infants born to HBsAg-positive individuals
- Occupational exposure to human blood and body fluids
- Being born or living in a region where HBV is endemic.
- Travelling to or staying in endemic regions for extended period of time.
- Exposure to blood and blood products (e.g., medical or dental care, tattooing, etc.) in endemic regions without routine infection control measures
- Exposure to blood, blood products, or organ transplantation in Canada prior to 1970 [43] [44] [45]

Symptoms of HBV infection

Many individuals with HBV infection may be asymptomatic or experience only mild symptoms. Most people with chronic hepatitis B are unaware of their infection. Symptoms can take 2 to 6 months to appear and may include:

- Abdominal pain
- Fever
- Dark urine
- Joint pain
- Nausea and vomiting
- Loss of appetite
- Weakness and fatigue
- Rash
- Jaundice (yellowing of sclera and skin) [14] [43] [46] [47]

Risk factors for hepatocellular carcinoma (HCC)

Risk factors for developing HCC include:

- Chronic HBV or HCV infection is the main risk factor for developing HCC
- Cirrhosis
- Heavy alcohol use
- Consuming foods contaminated with aflatoxin B1, a poisonous mold made by *Aspergillus flavus* and *Aspergillus parasiticus*, is often found on poorly stored grains, peanuts, corn, and nuts. It is most common in sub-Saharan Africa, Southeast Asia, and China
- Nonalcoholic steatohepatitis (NASH), the most severe form of nonalcoholic fatty liver disease
- Tobacco smoking [48]

Symptoms of hepatocellular carcinoma (HCC)

Most individuals do not experience symptoms in early stages HCC. When symptoms appear, they may include:

- Unexplained weight loss
- Loss of appetite, feeling full (early satiety)
- Upper abdominal pain or feeling of heaviness

[12] A positive or reactive HBsAg (Hepatitis B surface antigen) test result indicates hepatitis B infection.

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- Palpable mass in upper abdomen
- Nausea and vomiting
- General weakness and fatigue
- Ascites, abdominal swelling due to fluid buildup
- Jaundice
- White, chalky stools
- Dark urine
- Hepatic encephalopathy[13] [43] [49]

Preventing hepatocellular carcinoma (HCC),
The following protective factors may decrease the risk of HCC:
- Hepatitis B vaccination
- Treatment for chronic hepatitis B infection
- Avoid risk factors for HBV infection
- Reduce exposure to aflatoxin B1
- Avoid smoking
- Limit alcohol consumption [48]

Preventing HBV infection
The following protective factors may decrease the risk of HBV infection:
- Hepatitis B vaccination is the best way to protect against infection.
- In Canada, it is recommended infants born to HBsAg-positive individuals receive hepatitis B immune globulin (HBIg) and the initial dose of HBV vaccine within 12 hours of birth, followed by a second and third dose of the vaccine at 1 and 6 months of age to help prevent infection. [46]
- Avoid sharing drug related equipment (e.g., needles, syringes, spoons, drug solutions or water, etc.)
- Consistently and correctly using condoms and dental dams to reduce the risk of acquiring sexually transmitted and blood borne infections (STBBIs) including HBV.
- Avoid procedures that penetrate the skin (e.g., acupuncture, piercing, tattooing) unless infection prevention and control measures are followed.
- Avoid sharing personal items (e.g., glucometers, razors, scissors, nail clippers, toothbrushes).
- Being cautious when travelling to countries where HBV is endemic. [44]

HBV vaccination
- HBV vaccine is 95-100% effective in preventing chronic infection for at least 30 years following immunization.
- Hepatitis B vaccines authorized for use in Canada are:
    - Engerix®-B and Engerix®-B-Pediatric
    - Infanrix hexa™

[13] Hepatic encephalopathy is a condition in which toxins (normally cleared by the liver) are not cleared and travel to the brain via the bloodstream and may cause symptoms, such as personality changes, intellectual and memory impairment, or loss of consciousness (coma). [69] [68]

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- Recombivax HB®, Recombivax HB®-Pediatric, and Recombivax HB®-Adult dialysis
- Twinrix® and Twinrix®Junior [39]

HBV vaccines [37] [39] [40] [50] [51] [52] [53] [54] [55]

	Engerix®-B **Engerix®-B-Pediatric**	**Infanrix hexa™**	**Recombivax HB®** **Recombivax HB®-Pediatric** **Recombivax HB®-Adult dialysis**	**Twinrix®** **Twinrix®Junior**
Vaccine type	Recombinant hepatitis B vaccine	Adsorbed vaccine containing diphtheria & tetanus toxoids, acellular pertussis, hepatitis B (recombinant), inactivated poliomyelitis & conjugated *Haemophilus influenzae* type b vaccine (DTaP-HB-IPV-Hib)	Recombinant hepatitis B vaccine	Combined inactivated hepatitis A & recombinant hepatitis B vaccine
Route of administration	Intramuscular	Intramuscular	Intramuscular	Intramuscular
Indications for use	Active immunization against infection caused by all known subtypes of hepatitis B virus	Active primary immunization against diphtheria, tetanus, pertussis, hepatitis B, poliomyelitis, & disease caused by *Haemophilis influenzae* type b in infants & children 6 weeks to 2 years	Active immunization against infection caused by all known subtypes of hepatitis B virus	Active immunization against hepatitis A & hepatitis B virus infection.
Ontario publicly funded vaccine program	Engerix®-B administered in grade 7 & 8 (2 doses) High risk individuals[14] ≥0 years of age (2-4 doses & boosters if required)	Not publicly funded	Recombivax HB® administered in grade 7 & 8 (2 doses) High risk individuals ≥0 years of age (2-4 doses & boosters if required)	Combination hepatitis A & B vaccine is not publicly funded.
Company	GlaxoSmithKline Inc.	GlaxoSmithKline Inc.	Merck Canada Inc.	GlaxoSmithKline Inc.
Authorized for use in Canada	1987	2008	1987	1997 Twinrix 1998 Twinrix Junior

[14] High-risk eligibility criteria: Children <7 years whose families have immigrated HBV endemic countries & may be exposed to HBV carriers through their extended families; household & sexual contacts of chronic & acute cases; history of a sexually transmitted disease; infants born to HBsAg-positive individuals; intravenous drug use; liver disease (chronic), including hepatitis C; awaiting liver transplants; men who have sex with men; multiple sex partners; needle stick injuries in non-health care setting; on renal dialysis or those with diseases requiring frequent receipt of blood products. [37]

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Vaccines to treat cancer
Vaccines to treat cancer, also called therapeutic vaccines or treatment vaccines, are a type of immunotherapy to trigger or enhance immune system response to cancer cells. They are administered to individuals already diagnosed with cancer.

Depending on the vaccine type, treatment vaccines are designed to help:
- Prevent the cancer from returning,
- Destroy any cancer cells remaining after cancer treatment, or
- Prevent metastasis. [56]

Classes of treatment vaccines
There are 2 main classes of treatment vaccines: autologous vaccines and allogeneic vaccines.

Autologous cancer vaccines are personalized vaccines made from an individual's own cancer cells or immune system cells.

To create a vaccine using a person's cancer cells, the tumour cells are extracted and treated to make them a target for the immune system. When the vaccine is administered, the immune system recognizes and destroys the treated tumour cells, and then proceeds to destroy other cancer cells in the body. Ideally, memory B cells would persist and respond if the cancer cells returned.

The goal of therapy is to treat the cancer or to prevent tumours from recurring after more conventional cancer treatments (e.g., surgery, radiation, chemotherapy) have eliminated most or all of the cancer.

Several autologous cancer cell vaccine trials are in progress or have been completed, although none has been licensed as of yet.

The other approach is to use an individual's own immune cells to make the vaccine. Sipuleucel-t (Provenge®) is an autologous immune cell prostate cancer vaccine, recently licensed by the US FDA. Clinical trials have shown it to extend life for individuals with treatment-resistant metastatic prostate cancer.

Several trials of other autologous cancer cell vaccines are in progress or have been completed. However, Provenge is the only autologous licensed treatment vaccine in the US.

Allogeneic cancer vaccines are made from non-self cancer cells grown in a lab. Several of these vaccines are being studied, including vaccines to treat pancreatic cancer, melanoma (skin cancer), leukemia, non-small cell lung cancer, and prostate cancer. Allogeneic cancer vaccines are less costly to develop and produce than autologous vaccines. Currently, none have shown sufficient effectiveness to be licensed. [57]

Challenges of using treatment vaccines
Creating successful treatment vaccines is challenging because:

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- Cancer cells suppress the immune system, which allow the cancer to develop and grow. To combat this, adjuvants are used in vaccines to improve the body's immune response.
- Cancer cells develop from healthy cells. As a result, cancer cells may not appear harmful and consequently be ignored by the immune system.
- Larger or more advanced tumours are hard to treat using only a vaccine. Thus, cancer therapy may involve a cancer vaccine along with other treatment.
- Immune systems of individuals who are ill or elderly may not be able to produce a strong immune response after receipt of a treatment vaccine. Also, some cancer treatments may weaken a person's immune system. These factors limit how well a treatment vaccine works and how well a person's immune system can respond to a treatment vaccine.

For these reasons, cancer treatment vaccines may work better for smaller tumours or early-stage cancer. [56]

Types of treatment vaccines

Research is being conducted globally on different types of treatment vaccines. Cancer treatment vaccines most commonly studied include:

- Whole tumour vaccines use the whole cancer cell, not just a specific antigen, to create the vaccine. The cancer cells are treated in the lab to make them easier for the immune system to find. These vaccines can be autologous or allogeneic.

- Protein or peptide-based vaccines are made from a sequence of amino acids derived from tumour-specific or tumour-associated antigens. They aim to stimulate the immune system to attack the cancer. As with most treatment cancer vaccines, these vaccines are still in clinical trials. [9]

- Antigen vaccines are made from antigens in cancer cells. The goal of antigen vaccines is to stimulate the immune system to attack the cancer.

- Dendritic cell vaccines are made from dendritic cells that are grown in a lab together with cancer cells. Dendritic cells are a type of antigen-presenting cell, derived from leukocytes, that help T cells recognize foreign antigens. The vaccine stimulates the immune system to attack the cancer. For example, Sipuleucel-T is an autologous dendritic cell vaccine developed for advanced prostate cancer. [58]

- DNA and RNA vaccines are made with pieces of DNA or RNA from cancer cells. The vaccine makes immune system cells better at responding to and destroying cancer cells. Human trials for these vaccines are underway, including for breast cancer, HPV-related cancers, prostate cancer, and melanoma. [57]

- Anti-idiotype vaccines stimulate the immune system to produce antibodies against cancer cells almost in the same way as antigen vaccines. An idiotype is the part of an antibody that determines the specific antigen the antibody will act against.

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- Oncolytic adenovirus vaccines use a viral vector to deliver cancer antigens into the body. The immune system responds to the viral vector, which then helps the immune system to recognize and respond to the cancer antigen.

- Oncolytic virus vaccines appear to selectively kill cancer cells, stimulate the immune system to target cancer cells, or both. For example, talimogene laherparepvec (T-VEC) is approved in the US to treat advanced melanoma. It uses a genetically modified herpesvirus and is injected directly into the tumour. The virus is engineered to stimulate an immune-mediated anticancer response and to directly destroy the cancer cells without harming normal cells. [59] [58] [16] [60]

- Bacillus Calmette-Guérin (BCG) is a vaccine that uses a live attenuated strain of *Mycobacterium bovis* to stimulate the immune system. It is approved in Canada for individuals with early-stage bladder cancer. The drug is delivered via intravesical immunotherapy (i.e., the drug is placed directly into the bladder through a catheter). Treatment often includes a maintenance phase for up to 3 years. Drugs approved in Canada are OncoTICE® by Merck Canada Inc. and VERITY-BCG™ by Verity Pharmaceuticals Inc.[15] [60] [61] [62] [63] [64]

Clinical trials for treatment vaccines[16]
Research is underway to test treatment vaccines for many types of cancer, including:

- Bladder cancer. Studies are investigating a vaccine made from a virus altered with the human epidermal growth factor receptor 2 (HER2) antigen. These antigens are expressed on the surface of some bladder cancer tumours and promote the growth of cancer cells. The virus may help teach the immune system to find and destroy these tumour cells. Research is also comparing standard bladder cancer treatment to treatment with a vaccine.

- Brain tumours. Many studies are testing treatment vaccines aimed at certain molecules on the surface of brain tumour cells for early stage and recurring cancer. Many studies include children and teens.

- Breast cancer. Many studies are testing treatment vaccines for breast cancer, given alone or with other treatments. Some researchers are working to get breast cancer prevention vaccines into clinical trials.

- Cervical cancer. As noted earlier, there are HPV vaccines to prevent cervical cancer. Research continues on vaccines to treat the various stages of cervical cancer.

- Colorectal cancer. Development is underway for treatment vaccines that target antigens thought to cause colorectal cancer, including carcinoembryonic antigen (CEA), MUC1, guanylyl cyclase C, and NY-ESO-1.

[15] OncoTICE® and VERITY-BCG™ are not vaccines to prevent cancer or tuberculosis.
[16] To find a cancer trial in Canada visit https://www.canadiancancertrials.ca/

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

- Kidney cancer. Many treatment vaccines are being tested to treat kidney cancer and to prevent kidney cancer in its later stages from recurring.

- Leukemia. Studies are investigating treatment vaccines for various types of leukemia (e.g., acute myeloid leukemia [AML] and chronic lymphocytic leukemia [CLL]). Some are to improve other treatments, such as hematopoietic stem cell transplant (bone marrow transplant). Some autologous vaccines are to help the immune system destroy the cancer.

- Lung cancer. Lung cancer treatment vaccines in clinical trials target antigens.

- Melanoma. Many melanoma vaccines, administered alone or with other treatments are being tested (e.g., allogeneic cancer vaccines).

- Myeloma. Many clinical trials are investigating vaccines for individuals with multiple myeloma who are near remission. Clinical trials also include testing vaccines in individuals with asymptomatic myeloma or who need to have an autologous stem cell transplant.

- Pancreatic cancer. Many treatment vaccines are being designed to boost immune response to pancreatic cancer cells, administered alone or with another treatment.

- Prostate cancer. As noted above, sipuleucel-T is a vaccine used to treat advanced prostate cancer. Studies are investigating its use in early-stage prostate cancer. [56]

Take home messages

- Oral health professionals should routinely conduct oral cancer screenings for all clients and refer any suspicious finding to the appropriate medical/dental provider.
- Encourage and teach clients to perform monthly oral cancer self-examinations and to report anything unusual or suspicious to a dental or medical professional.
- Advise smoking cessation.
- The pandemic has resulted a disruption of many immunization programs. [65] [66] Advise clients to speak with their medical providers to ensure routine immunizations are completed (e.g., HBV, HPV) to prevent vaccine-preventable diseases and their associated sequelae.
- Cancer treatment vaccines hold great promise for the prevention and treatment of cancer.

References

[1] National Institute of Allergy and Infectious Diseases, "Vaccines," 13 August 2020. [Online]. Available: https://www.niaid.nih.gov/research/vaccines. [Accessed 17 January 2022].

[2] A. Pollard and E. Bijker, "A guide to vaccinology: From basic principles to new developments," *Nature Reviews Immunology,* vol. 21, pp. 83-100, 5 January 2021.

[3] Government of Canada, "Basic immunology and vaccinology: Canadian Immunization Guide for Health Professionals," 23 December 2021. [Online].

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Available: https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-1-key-immunization-information/page-14-basic-immunology-vaccinology.html. [Accessed 17 January 2022].

[4] E. Schneider, A. Shah, P. Sah, S. Moghadas, T. Vilches and A. Galvani, "The U.S. COVID-19 Vaccination Program at One Year: How Many Deaths and Hospitalizations Were Averted?," Commonwealth Fund, 14 December 2021. [Online]. Available: https://www.commonwealthfund.org/publications/issue-briefs/2021/dec/us-covid-19-vaccination-program-one-year-how-many-deaths-and. [Accessed 20 January 2022].

[5] U.S. Department of Health & Human Services, "Vaccine Types," 29 April 2021. [Online]. Available: https://www.hhs.gov/immunization/basics/types/index.html. [Accessed 17 January 2022].

[6] National Institute of Allergy and Infectious Diseases, "Vaccine Types," 1 July 2019. [Online]. Available: Vaccine Types. [Accessed 24 January 2022].

[7] World Health Organization, "Module 2 Types of vaccine and adverse reactions," World Health Organization, Geneva.

[8] N. Ramesh, "Types of Vaccines Infographics," Boston University, [Online]. Available: https://sites.bu.edu/covid-corps/projects/science-communication/types-of-vaccines-infographics/. [Accessed 18 January 2022].

[9] A. Stephens, N. Burgess-Brown and S. Jiang, "Beyond just peptide antigens: The complex world of peptide-based cancer vaccines," *Frontiers in Immunlogy,* vol. 12, no. Article 696791, pp. 1-14, 30 June 2021.

[10] D. Esau, "Viral Causes of Lymphoma: The History of Epstein-Barr Virus and Human T-Lymphotropic Virus 1," *Virology: Research and Treatment,* vol. 8, pp. 1-5, 1 November 2017.

[11] P. Purushothaman, T. Uppal and S. Verma, "Human DNA tumor viruses and oncogenesis," *Animal Biotechnology,* pp. 131-151, 2020.

[12] M. White, J. Pagano and K. Khalili, "Viruses and human cancers: A long road of discovery of molecular paradigms," *Clinical Microbiology Reviews,* vol. 27, no. 3, pp. 463-481, July 2014.

[13] J. Liao, "Viruses and human cancer," *Yale journal of biology and medicine, 79(3-4),,* vol. 79, no. 3-4, pp. 115-122, October 2006.

[14] American Cancer Society, "Viruses that Can Lead to Cancer," 21 June 2021. [Online]. Available: https://www.cancer.org/cancer/cancer-causes/infectious-agents/infections-that-can-lead-to-cancer/viruses.html. [Accessed 20 January 2022].

[15] American Society for Microbiology, "The 7 Viruses That Cause Human Cancers," 2 January 2019. [Online]. Available: https://asm.org/Articles/2019/January/The-Seven-Viruses-that-Cause-Human-Cancers. [Accessed 19 January 2022].

[16] Canadian Cancer Society, "Cancer vaccines," 2022. [Online]. Available: https://cancer.ca/en/treatments/treatment-types/cancer-vaccines. [Accessed 20 January 2022].

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

[17] National Cancer Institute, "HPV and Cancer," 25 October 2021. [Online]. Available: https://www.cancer.gov/about-cancer/causes-prevention/risk/infectious-agents/hpv-and-cancer. [Accessed 20 January 2022].

[18] National Cancer Institute, "Low-risk HPV," [Online]. Available: https://www.cancer.gov/publications/dictionaries/cancer-terms/def/low-risk-hpv. [Accessed 20 January 2022].

[19] Government of Canada, "Human papillomavirus vaccine: Canadian Immunization Guide for health professionals," 23 September 2021. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-4-active-vaccines/page-9-human-papillomavirus-vaccine.html. [Accessed 20 January 2022].

[20] World Health Organization, "Cervical cancer," 21 January 2022. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/human-papillomavirus-(hpv)-and-cervical-cancer. [Accessed 21 January 2022].

[21] Centers for Disease Control and Prevention, "HPV and Cancer," 13 December 2021. [Online]. Available: https://www.cdc.gov/cancer/hpv/basic_info/index.htm. [Accessed 20 January 2022].

[22] C. Parra-Herran, "Cervix Adenocarcinoma HPV related adenocarcinoma (usual type and variants)," PathologyOutlines.com, 2 November 2021. [Online]. Available: https://www.pathologyoutlines.com/topic/cervixhpvadenocarcinoma.html. [Accessed 20 January 2022].

[23] Centers for Disease Control and Prevention, "Cancers Associated with HPV," 13 December 2021. [Online]. Available: https://www.cdc.gov/cancer/hpv/basic_info/cancers.htm. [Accessed 20 January 2022].

[24] American Cancer Society, "Risk Factors for Oral Cavity and Oropharyngeal Cancers," 23 March 2021. [Online]. Available: https://www.cancer.org/cancer/oral-cavity-and-oropharyngeal-cancer/causes-risks-prevention/risk-factors.html. [Accessed 20 January 2022].

[25] The Oral Cancer Foundation, "HPV / Oral Cancer Facts," 2022. [Online]. Available: https://oralcancerfoundation.org/understanding/hpv/hpv-oral-cancer-facts/. [Accessed 21 January 2022].

[26] H. Shigeishi and M. Sugiyama, "Risk factors for oral human papillomavirus infection in healthy individuals: A systematic review and meta-analysis," *Journal of Clinical Medicine Research,* vol. 8, no. 10, pp. 721-729, October 2016.

[27] M. Schabath, Z. Thompson, K. Egan, B. Torres, A. Nguyen, et al., "Alcohol consumption and prevalence of human papillomavirus (HPV) infection among US men in the HIM (HPV in Men) Study," *Sexually Transmitted Infections,* vol. 91, no. 1, pp. 61-67, 26 February 2015.

[28] K. Dahlstrom, A. Burchell, A. Ramanakumar, A. Rodrigues, P. Tellier, et al., "Sexual Transmission of Oral Human Papillomavirus Infection among Men," *Cancer Epidemiology, Biomarkers & Prevention,* vol. 23, no. 12, pp. 2959-2964, December 2014.

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

[29] M. Gillison, T. Broutian, R. Pickard, Z. Tong, W. Xiao, et al., "Prevalence of oral HPV infection in the United States, 2009-2010," *JAMA,* vol. 307, no. 7, pp. 693-703, 15 February 2012.

[30] J. Purdie, "Human Papillomavirus (HPV) of the Mouth: What You Should Know," Healthline, 12 February 2021. [Online]. Available: https://www.healthline.com/health/hpv-in-the-mouth. [Accessed 20 January 2022].

[31] Centers for Disease Control and Prevention, "HPV and Oropharyngeal Cancer," 13 December 2021. [Online]. Available: https://www.cdc.gov/cancer/hpv/basic_info/hpv_oropharyngeal.htm. [Accessed 22 January 2022].

[32] National Cancer Institute, "Oropharyngeal Cancer Treatment (Adult) (PDQ®)–Patient Version," 14 October 202. [Online]. Available: https://www.cancer.gov/types/head-and-neck/patient/adult/oropharyngeal-treatment-pdq. [Accessed 20 January 2022].

[33] Centers for Disease Control and Prevention, "HPV Cancers," 23 July 2021. [Online]. Available: https://www.cdc.gov/hpv/parents/cancer.html. [Accessed 20 January 2022].

[34] Government of Ontario, "Getting the HPV vaccine," 21 October 2021. [Online]. Available: https://www.ontario.ca/page/getting-hpv-vaccine. [Accessed 20 January 2022].

[35] Government of Canada, "Updated Recommendations on Human Papillomavirus Vaccines: 9-valent HPV vaccine and clarification of minimum intervals between doses in the HPV immunization schedule," 28 July 2016. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/healthy-living/9-valent-hpv-vaccine-clarification-minimum-intervals-between-doses-in-hpv-immunization-schedule.html. [Accessed 20 January 2022].

[36] Government of Canada, "Human Papillomavirus (HPV) Prevention and HPV Vaccines: Questions and Answers," 4 October 2017. [Online]. Available: https://www.canada.ca/en/public-health/services/infectious-diseases/sexual-health-sexually-transmitted-infections/hpv-prevention-vaccines-questions-answers.html. [Accessed 20 January 2022].

[37] Government of Ontario, "Publicly Funded Immunization Schedules for Ontario," Government of Ontario, Toronto, 2021.

[38] World Health Organization, "Hepatitis B," 27 July 2021. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/hepatitis-b. [Accessed 20 January 2022].

[39] Government of Canada, "Hepatitis B vaccine: Canadian Immunization Guide for health professionals," 23 September 2021. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-4-active-vaccines/page-7-hepatitis-b-vaccine.html. [Accessed 20 January 2022].

[40] Public Health Ontario, "Hepatitis B immunization," Public Health Ontario, Toronto, 2017.

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

[41] Canadian Blood Services, "Getting donors back into the system – Canadian Blood Services' donor re-entry program," 2022. [Online]. Available: https://www.blood.ca/en/node/999220. [Accessed 20 January 2022].

[42] Government of Canada, "Update on the recommended use of Hepatitis B vaccine," 5 July 2021. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/healthy-living/update-recommended-use-hepatitis-b-vaccine.html. [Accessed 24 January 2022].

[43] Tripathi, N; Mousa, O, "Hepatitis B," StatPearls [Internet], 18 18 2021. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK555945/. [Accessed 20 January 2022].

[44] Government of Canada, "Hepatitis B - Get the Facts," 22 September 2014. [Online]. Available: https://www.canada.ca/en/public-health/services/surveillance/blood-safety-contribution-program/bloodborne-pathogens-section/hepatitis/hepatitis-b-facts.html. [Accessed 20 January 2022].

[45] Mayo Clinic, "Hepatitis B," 4 September 2020. [Online]. Available: https://www.mayoclinic.org/diseases-conditions/hepatitis-b/symptoms-causes/syc-20366802. [Accessed 22 January 2022].

[46] Government of Canada, "Primary Care Management of Hepatitis B – Quick Reference (HBV-QR)," 26 February 2014. [Online]. Available: https://www.canada.ca/en/public-health/services/reports-publications/primary-care-management-hepatitis-b-quick-reference.html. [Accessed 22 January 2022].

[47] Government of Canada, "Hepatitis B," 27 July 2021. [Online]. Available: https://www.canada.ca/en/public-health/services/diseases/hepatitis-b.html. [Accessed 22 January 2022].

[48] National Cancer Institute, "Liver (Hepatocellular) Cancer Prevention (PDQ®)–Patient Version," 30 July 2021. [Online]. Available: https://www.cancer.gov/types/liver/patient/liver-prevention-pdq. [Accessed 22 January 2022].

[49] Mayo Clinic, "Liver cancer," 18 May 2021. [Online]. Available: https://www.mayoclinic.org/diseases-conditions/liver-cancer/symptoms-causes/syc-20353659. [Accessed 22 January 2022].

[50] GlaxoSmithKline Inc, "ENGERIX-B Product Monograph," GlaxoSmithKline Inc, Mississauga, 2020.

[51] GlaxoSmithKline Inc, "INFANRIX hexa Product Monograph," GlaxoSmithKline Inc, Mississauga, 2021.

[52] Merck Canada Inc., "RECOMBIVAX HB® Product Monograph," Merck Canada Inc., Kirkland, 2012.

[53] GlaxoSmithKline Inc., "TWINRIX Product Monograph," GlaxoSmithKline Inc., Mississauga, 2018.

[54] City of Toronto, "Get Vaccinated – Adults," 12 November 2020. [Online]. Available: https://www.toronto.ca/community-people/health-wellness-care/health-programs-advice/immunization/immunization-for-adults/. [Accessed 21 January 2022].

[55] City of Toronto, "Hepatitis B Vaccine Fact Sheet," October 2018. [Online]. Available: https://www.toronto.ca/community-people/health-wellness-

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

care/diseases-medications-vaccines/hepatitis-b-vaccine-fact-sheet/. [Accessed 21 January 2022].

[56] Cancer.Net, "What are Cancer Vaccines?," August 2020. [Online]. Available: https://www.cancer.net/navigating-cancer-care/how-cancer-treated/immunotherapy-and-vaccines/what-are-cancer-vaccines. [Accessed 22 January 2022].

[57] The College of Physicians of Philadelphia, "Cancer Vaccines and Immunotherapy," 2022. [Online]. Available: https://www.historyofvaccines.org/content/articles/cancer-vaccines-and-immunotherapy. [Accessed 22 January 2022].

[58] R. Gale, "Systemic Cancer Therapy," September 2020. [Online]. Available: https://www.merckmanuals.com/professional/hematology-and-oncology/principles-of-cancer-therapy/systemic-cancer-therapy. [Accessed 22 January 2022].

[59] American Cancer Society, "Cancer Vaccines and Their Side Effects," 8 January 2020. [Online]. Available: https://www.cancer.org/treatment/treatments-and-side-effects/treatment-types/immunotherapy/cancer-vaccines.html. [Accessed 22 January 2022].

[60] Cancer Research UK, "Vaccines to treat cancer," 11 February 2021. [Online]. Available: https://www.cancerresearchuk.org/about-cancer/cancer-in-general/treatment/immunotherapy/types/vaccines-to-treat-cancer. [Accessed 22 January 2022].

[61] Cancer Research Institute, "Cancer Vaccines: Preventive, Therapeutic, Personalized," January 2020. [Online]. Available: https://www.cancerresearch.org/en-us/immunotherapy/treatment-types/cancer-vaccines. [Accessed 22 January 2022].

[62] Canadian Cancer Society, "Immunotherapy for bladder cancer," 2022. [Online]. Available: https://cancer.ca/en/cancer-information/cancer-types/bladder/treatment/immunotherapy. [Accessed 22 January 2022].

[63] Merck Canada Inc., "OncoTICE® Product Monograph," Merck Canada Inc., Kirkland, 2019.

[64] Verity Pharmaceuticals Inc., "VERITY-BCG™ Product Monograph," Verity Pharmaceuticals Inc., Mississauga, 2021.

[65] P. Piché-Renaud, C. Ji, D. Farrar, J. Friedman, M. Science, et al., "Impact of the COVID-19 pandemic on the provision of routine childhood immunizations in Ontario, Canada," *Vaccine,* vol. 39, no. 13, pp. 4373-4382, 13 July 2021.

[66] H. Sell, A. Assi, S. Driedger, E. Dubé, A. Gagneur, et al., "Continuity of routine immunization programs in Canada during the COVID-19 pandemic," *Vaccine,* vol. 39, no. 39, pp. 5532-5537, 15 September 2021.

[67] Government of Canada, "Contents of immunizing agents available for use in Canada: Canadian Immunization Guide for Health Professionals," 23 December 2021. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-1-key-immunization-information/page-15-contents-immunizing-agents-available-use-canada.html. [Accessed 18 January 2022].

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

[68] National Organization for Rare Disorders, Inc. , "Hepatocellular Carcinoma," 2017. [Online]. Available: https://rarediseases.org/rare-diseases/hepatocellular-carcinoma/. [Accessed 22 January 2022].

[69] WebMD, "Hepatocellular Carcinoma," 14 June 2020. [Online]. Available: https://www.webmd.com/cancer/hepatocellular-carcinoma. [Accessed 22 January 2022].

Client resources

Human Papillomavirus (HPV) Prevention and HPV Vaccines: Questions and Answers, Government of Canada (available in pdf format)
https://www.canada.ca/en/public-health/services/infectious-diseases/sexual-health-sexually-transmitted-infections/hpv-prevention-vaccines-questions-answers.html

Human Papillomavirus (HPV) & Oral Care, ODHA Factsheet
https://odha.on.ca/wp-content/uploads/2016/08/ODHA-Facts-HPV-copyright.pdf

Oral Cancer Screening, ODHA Factsheet
https://odha.on.ca/wp-content/uploads/2016/08/Oral-Cancer-Screening.14.1-copyright.pdf

Oral Cancer Self-Examination, ODHA Factsheet
https://odha.on.ca/wp-content/uploads/2016/08/Oral-Cancer-Self-Exam14.1-copyright.pdf

7-Step DIY Oral Cancer Screening, CDHO Factsheet
https://cdho.org/docs/default-source/pdfs/oral-health-rpt/article-7-step-oral-cancer-screening.pdf

How Your Sexual History and Oral Health Are Connected, CDHO Factsheet
https://cdho.org/docs/default-source/pdfs/oral-health-rpt/article-sexual-history-and-oral-health.pdf

Smoking and Smokeless Tobacco, ODHA Factsheet
https://odha.on.ca/wp-content/uploads/2016/08/ODHA-Facts-Smoking.VFS19.1-copyright.pdf

CDHO Oral Cancer Awareness Campaign videos (available in English and French)
https://www.youtube.com/playlist?list=PLkr7BW04kHljG4KMZ8-AfnxBVyLZAO4gM

Additional Resources

Cancer Treatment and Oral Care, ODHA Dental Hygiene Resource Sheet
https://odha.on.ca/member-benefits/dental-hygiene-resource-sheets/

A guide to vaccinology: From basic principles to new developments, Pollard, A; Bijker, E. *Nature Reviews Immunology*, Volume 21, December 22, 2020, p 83-100
https://www.nature.com/articles/s41577-020-00479-7

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Basic immunology and vaccinology: Canadian Immunization Guide for Health Professionals, Government of Canada, December 23, 2021
https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-1-key-immunization-information/page-14-basic-immunology-vaccinology.html

The U.S. COVID-19 vaccination program at one year: How many deaths and hospitalizations were averted? Schneider, E; Shah, A; Sah, P; Moghadas, S; Vilches, T; Galvani, A. Commonwealth Fund, December 14, 2021
https://www.commonwealthfund.org/publications/issue-briefs/2021/dec/us-covid-19-vaccination-program-one-year-how-many-deaths-and

Human Papillomavirus and Warts, CDHO Factsheet, May 10, 2015
https://www.cdho.org/Advisories/CDHO_Factsheet_Human_Papillomavirus.pdf

Human papillomavirus vaccine: Canadian Immunization Guide for Health Professionals, Government of Canada, September 23, 2021
https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-4-active-vaccines/page-9-human-papillomavirus-vaccine.html

The efficacy of vaccination to prevent human papilloma viruses infection at anal and oral: A systematic review and meta-analysis, Zhang, J; Qin, Z; Lou, C; Huang, J; Xiong, Y. *Public Health*, Volume 196, July 2021, p 165-171
https://www.sciencedirect.com/science/article/pii/S003335062100192X

Risk factors for oral human papillomavirus infection in healthy individuals: A systematic review and meta-analysis, Shigeishi, H; Sugiyama, M. *Journal of Clinical Medicine Research*, Volume 8, Issue 10, October 2016, p 721-729
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5012241/

Hepatitis B, CDHO Factsheet, May 19, 2015
https://www.cdho.org/Advisories/CDHO_Factsheet_Hepatitis_B.pdf

Hepatitis B vaccine: Canadian Immunization Guide for Health Professionals, Government of Canada, September 23, 2021
https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-4-active-vaccines/page-7-hepatitis-b-vaccine.html

Hepatitis B Immunization, Public Health Ontario, July 2017, p 1-48
https://www.publichealthontario.ca/-/media/documents/H/2017/hepb-technical-report.pdf

Update on the recommended use of Hepatitis B vaccine, An Advisory Committee Statement (ACS) National Advisory Committee on Immunization (NACI), Public Health Agency of Canada, Government of Canada, February 2017, p 1-55
https://www.canada.ca/en/public-health/services/publications/healthy-living/update-recommended-use-hepatitis-b-vaccine.html

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA

Primary Care Management of Hepatitis B – Quick Reference (HBV-QR), Public Health Agency of Canada, Government of Canada, February 26, 2014 https://www.canada.ca/en/public-health/services/reports-publications/primary-care-management-hepatitis-b-quick-reference.html

The changing landscape of therapeutic cancer vaccines – Novel platforms and neoantigen identification, Jou, J; Harrington, K; Zocca, M; Ehrnrooth, E; Cohen, E. *Clinical Cancer Research*, Volume 27, Issue 3, February 1, 2021, p 689-703 https://clincancerres.aacrjournals.org/content/27/3/689.long

Beyond just peptide antigens: The complex world of peptide-based cancer vaccines, Stephens, A; Burgess-Brown, N; Jiang, S. *Frontiers in Immunology*, Volume 12, Article 696791, June 30, 2021, p 1-14 https://www.frontiersin.org/articles/10.3389/fimmu.2021.696791/full

Targeting head and neck cancer by vaccination, Wang, C; Dickie, J; Sutavani, R; Pointer, C; Thomas, G; Savelyeva, N. *Frontiers in Immunology*, Volume 9, Article 830, p 1-12 https://www.frontiersin.org/articles/10.3389/fimmu.2018.00830/full

Continuity of routine immunization programs in Canada during the COVID-19 pandemic, Sell, H; Assi, A; Driedger, M; Dubé, E; Gagneur, A; et al. *Vaccine*, Volume 39, Issue 39, September 15, 2021, p 5532-5537 https://www.sciencedirect.com/science/article/pii/S0264410X2101077X

Impact of the COVID-19 pandemic on the provision of routine childhood immunizations in Ontario, Canada, Piché-Renaud, P; Ji, C; Farrar, D; Friedman, J; Science, M; et al. *Vaccine*, Volume 39, Issue 31, July 13, 2021, p 4373-4382 https://www.sciencedirect.com/science/article/pii/S0264410X21007027

Pediatric vaccination during the COVID-19 pandemic, Ackerson, B; Sy, L; Glenn, S; Qian, L; Park, C; et al. *Pediatrics*, Volume 148, Issue 1, July 1, 2021, p 1-11 https://publications.aap.org/pediatrics/article/148/1/e2020047092/179954/Pediatric-Vaccination-During-the-COVID-19-Pandemic

Delay in childhood vaccinations during the COVID-19 pandemic, Lee, D; Vanderhout, S; Aglipay, M; Birken, C; Morris, S; et al. *Canadian Journal of Public Health*, January 20, 2022, p 1-9 https://link.springer.com/article/10.17269/s41997-021-00601-9

Disclaimer: This document is educational and not intended to provide clinical advice nor should it be used as a replacement for professional dental or medical advice. Dental hygienists are encouraged to consult with CDHO practice advisors and refer to CDHO guidelines. Dental hygienists are responsible for the decisions they make and for the consequences associated with those decisions. © ODHA