Editorial

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# Cancers Caused by Viral, Bacterial, and Parasitic Infections

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Some cancers are caused by viral, bacterial, and parasitic infections, the following are a few recognized cancers caused by various infections [1–7].

Cervical cancer, oropharyngeal cancer, anal cancer, penile cancer, vaginal cancer, vulvar cancer and human papillomaviruses (HPVs).

Liver cancer and hepatitis B virus (HBV), hepatitis D virus (HDV), and hepatitis C virus (HCV).

Nasopharyngeal cancer, several lymphomas and Epstein-Barr virus (EBV).

Kaposi sarcoma and human herpesvirus 8 (HHV-8), also known as Kaposi sarcoma–associated herpes virus (KSHV).

Leukemia and human T-cell leukemia/lymphoma virus type 1 (HTLV-1).

Merkel cell carcinoma and Merkel cell polyomavirus.

Gastric cancer and bacterium *Helicobacter pylori*.

Bladder cancer and parasite *Schistosoma haematobium*.

Cholangiocarcinoma (bile duct cancer) and two parasites: *Opisthorchis viverrini* and *Clonorchis sinensis*.

The first human cancer–causing virus-the Epstein-Barr virus (EBV) was first discovered by Michael Anthony Epstein (1921–2024), and two of his laboratory assistants Yvonne Barr and Bert Achong in 1964.

EBV infection not only can cause nasopharyngeal cancer, but also can cause other cancers like Burkitt's lymphoma, post-transplant and HIV-associated lymphomas, Hodgkin's lymphoma, diffuse large B-cell lymphoma, T-cell lymphoma, extranodal NK/T-cell lymphoma (nasal type), gastric carcinoma. It is estimated that cancers caused by EBV can kill about 137,900–208,700 people worldwide every year [3,4,8].

The causal linkage between HPV and cervical cancer was discovered by Harald zur Hausen (1936–2023) [5]. HPV can cause cervical cancer, oropharyngeal cancer, anal cancer, penile cancer, vaginal cancer, and vulvar cancer [5,6]. HPV types 16 and 18 are two major pathogenic types of HPV, which account for about 72% of cancers caused by HPV infections [1,6].

Hepatitis A virus (HAV) and hepatitis E Virus (HEV) infections are usually acute and self-limited.

But chronic HBV and HCV infections, and HBV and HDV co-infections all can lead to liver cancer. There were about 257 million chronic hepatitis B patients, and 130–170 million chronic hepatitis C patients in the world. These patients are at high risk to have liver cancer in their entire lives [7].

*Helicobacter pylori* bacterium is the most common etiologic agent of infection-related cancers. About 810,000 cases of gastric cancer were caused by *Helicobacter pylori* infection in the world in 2018 [1].

Cancers were clinically defined and diagnosed by the organ names where they were first formed, for example lung cancer, bladder cancer, pancreatic cancer, prostate cancer, colon cancer… But we know almost every cancer will eventually spread to several organs of the body through the blood or lymph system, and form new tumors in these organs. Similarly, a viral or bacterial infection would spread from one organ to many organs of our body through the blood and lymph system if our immune system fails to protect us from the infection. As above mentioned, some cancers can be caused by more than one virus, for example liver cancer can be caused by HBV/HDV, and HCV; and some viruses like EBV and HPV can cause more than one cancer.

The normal function of immune system is very important for preventing both viral infections and cancers. People with unhealthy behaviors and habits like drinking alcohol can reduce functions of their immune systems, thereby these people are more vulnerable to infections and cancers. Most of cancers are very rare among young and healthy populations, whereas immunocompromised persons are more likely to be the victims of various cancers. Likewise, healthy people usually can survive from viral, bacterial, and parasitic infections, however, immunocompromised people are more susceptible to these infections, and are at high risk of death from these infections.

Some infectious diseases like tuberculosis, leprosy, syphilis, and hepatitis B, can frequently occur in several members of different generations of a family, these diseases can be transmitted among family members through direct person-to-person contact or sexual contact, air, blood, and mother-to-child. It is clear that these diseases are not ge-

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netic diseases. Therefore, we cannot claim a disease is a genetic disease just because there are several cases of a same disease in different generations of a family.

Nowadays, a large number of susceptibility loci were reported to have possible linkages to many diseases, for example, at least 652 breast cancer-associated loci were reported up to 2021, ironically, 198 of these loci were negative correlations (odds ratio <1) [9]. Unfortunately, a real genetic linkage is very hard to be found and confirmed [10].

We critically analysed the published family pedigree charts [11–13] according to the Mendel's laws of inheritance, and we could not find any solid evidence to support that breast cancer is either a dominant or a recessive genetic disease [14].

Presently, the real etiology of breast cancer is unknown. Mouse mammary tumor virus, human papillomavirus, Epstein Barr virus, bovine leukemia virus, human cytomegalovirus [8,15], and other unidentified viruses might be the etiologic agents of breast cancer.

The tendency is that more and more viruses, bacteria, and parasites were found to be the causal agents of various cancers. On the other hand, we should strictly and cautiously verify whether a cancer is a genetic disease or not based on the same Mendel's laws of genetics, just like what we have done for the past many years when we have confirmed a non-cancer genetic disease such as haemophilia, Down syndrome, sickle cell anemia, Fanconi anemia, and deuteranopia (red-green color blindness).

Some cancers are preventable and controllable by screening and vaccination. Currently, HBV and HPV Vaccines are available to be used to prevent liver cancer, and cervical cancer, oropharyngeal cancer, anal cancer, penile cancer, vaginal cancer, and vulvar cancer separately [1–3]. We need to develop effective EBV vaccines [3], HCV vaccines, HTLV-1 vaccines, and *Helicobacter pylori* vaccines [1] to prevent nasopharyngeal cancer, Burkitt's lymphoma, post-transplant and HIV-associated lymphomas, Hodgkin's lymphoma, diffuse large B-cell lymphoma, T-cell lymphoma, extranodal NK/T-cell lymphoma (nasal type), liver cancer, leukemia, and gastric cancer respectively. Last but not least, effective antiviral drugs are urgently needed to save lives of millions of patients of cancers caused by various viral infections in the future.

## Author Contributions

LS designed the research study. The author drafted the manuscript. The author contributed to important editorial changes in the manuscript. The author read and approved the final manuscript. The author has participated sufficiently in the work and agreed to be accountable for all aspects of the work.

## Ethics Approval and Consent to Participate

Not applicable.

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