Evidence for Plant-based Dietary Changes that may influence certain Causative Factors Leading to Cancer Incidence and Progression

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ABSTRACT: Strong evidence suggests that vegetarians, more notably vegans, have lower chances of suffering from multiple forms of cancer and lower body mass index (BMI) and cholesterol levels than omnivores. Several mechanisms have been proposed to explain these links, the most established being associations with dietary influences on obesity, the microbiome, and the immune system. This study provides an updated summarization of the data present regarding these relationships and, more broadly, between diet and cancer.

KEYWORDS: Biomedical and Health Sciences; Cancer; diet; plant-based; vegan; vegetarian; microbiome; obesity.

Introduction

Impact:
Cancer has been a significant threat to society for decades, taking 10 million lives worldwide in 2020 alone, according to data published by the World Health Organisation (WHO). The mortality rate of cancer has increased drastically from 1955 to 2015, as can be observed in the following graph:¹

As humans develop over time, i.e., gain access to previously unavailable resources like processed foods, the cancer rates collectively increase.

The graph depicts cancer incidence against human development for both males and females in 2020, and cancer rates steadily increase.

ASR(W) - Age-standardised incidence rates
Cancer is a disease caused by genetic mutations in cells, resulting in these cells no longer adhering to their functions once they have undergone mutations. These mutations alter the body cells, making them immortal and highly replicative. Uncontrolled proliferation gives rise to tumors – swellings of the body caused due to the abnormal growth of tissues. Blood vessels - tumor vasculature – can form within these tumors, nourishing the evolving tumor.²

Cancer cells can travel to different parts of the body through these blood vessels surrounding the tumor, as the tumor vasculature connects with the blood vessels in the rest of the body. Tumor cells can enter the pulmonary and systemic circulation of the body, get lodged in narrow capillaries, and begin to grow there. This commences the spread of cancer cells throughout the body in a process known as metastasis.³

Locally invasive cancer is different from metastatic cancer and is when a tumor can invade the normal tissues surrounding it by sending tendrils or ‘fingers’ of cancer cells into them.⁴

Tumors formed in the body can differ based on their nature: (a) benign tumors are proliferative dormant. They grow slowly and do not spread, and (b) malignant tumors are cancerous tumors that tend to proliferate, invade and destroy nearby tissues, and spread throughout the body.⁴

Factors such as red and processed meats, cholesterol, and obesity contribute to increased cancer incidence in modern times. They can cause damage to the microbiome and the immune system, which elevates the risk of cancer development. Dietary changes, therefore, can play a significant role in reducing cancer, as obesity and hypercholesterolemia can be controlled by consuming a diet focusing more on veganism and less on red and processed meats.

Red and processed meats:
Red and processed meat can indirectly cause cancer through obesity, but there is strong evidence for direct causality.

Table 1: Definitions of Red and processed meat

<table>
<thead>
<tr>
<th>Red meat</th>
<th>Processed meat</th>
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<tbody>
<tr>
<td>Red meat is any meat that is red in color when raw - beef, pork, and lamb are red meat. White chicken and fish are white meats.⁵</td>
<td>Processed meat is any meat that has been preserved or previously changed - cooking, salting, and adding preservatives are ways in which meat is processed.⁶ A few examples of processed meat are ham, bacon, salami, sausages, and white meat like chicken nuggets.</td>
</tr>
</tbody>
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⁵ White meat does not have any correlation to cancer.
Chemicals used to preserve the meat as well as those naturally occurring within, pose an increased risk:

**Haem:**
Haem iron is found naturally in red meat - high intakes of it promote colorectal tumorigenesis and stimulate the formation of carcinogenic N-nitroso compounds when it is broken down in the gut.⁶

**N-nitroso compounds, nitrates, and nitrates:**
N-nitroso compounds (NOCs), aside from being produced when red and processed meat is digested, are formed when preservatives, mainly nitrates, are introduced into the body.

There are two major routes by which NOCs can enter the body: exogenous or endogenous routes.

Exogenously, nitrate is added to processed meat as an antibacterial agent against Clostridium botulinum.⁷ It is also added to red meat for cosmetic purposes - nitrite reacts with the myoglobin in red meat to preserve the characteristic red-pink color. Nitrites promote the formation of NOCs in the body, as mentioned above. Endogenously, NOCs are formed when haem iron is broken down in the gut when red meat is digested.⁸

**Heterocyclic amines:**
HCAs are carcinogens produced when meat is cooked at high temperatures - for example, grilling, and barbecuing. The precursors of these compounds are creatinine, amino acids, and sugars.⁶

A study⁹,¹⁰ linked red meat to cancer using a theory that implicated heterocyclic amines produced when meat is cooked at high temperatures. However, since HCAs are found in red meat and white meat (which has reduced associations with cancer⁶), they were unlikely to be the whole explanation. Another hypothesis was that the preservatives used in processed meat, nitrates, gave rise to carcinogenic nitrosamines. Although, since fresh red meat is also linked to colon cancer, this finding was incomplete.

Scientists from England experimented wherein healthy volunteers agreed to stay in a metabolic research unit where their diet could be carefully controlled and their fecal waste analyzed. The volunteers ate one each of three test diets for 15-21 days. The first diet consisted of 14 ounces of red meat daily, ensuring minimized HCA formation. The second diet was strictly vegetarian, and the third contained large amounts of red meat and dietary fiber.

Upon analyzing the stool specimens, the 21 volunteers who ate the high-meat diet showed high levels of carcinogenic N-nitroso compounds (NOCs) compared to the low levels of NOCs observed in the 12 volunteers who ate the vegetarian diet. In the remaining 13 volunteers who ate the diet with red meat and dietary fiber, intermediate levels of NOCs were excreted.

With every bowel movement, cells from the colon lining are shed into the stool. Upon the scientists’ analysis, it was noticed that many of the cells shed into the stool of the volunteers who consumed the high-meat diet had experienced NOC-induced DNA changes. A few vegetarian volunteers were genetically damaged, and an intermediate number of cells of those who ate the high-meat, high-fiber diet were damaged.

Given the importance of DNA damage in carcinogenesis, this investigation provides strong evidence for the claim that a diet high in red meat increases the risk of developing cancer.

**Cholesterol and diet:**
The cholesterol levels in our body increase when we consume foods high in saturated fat, trans fat, and cholesterol, such as milk, meat, and eggs. Saturated fat is especially harmful as it triggers the body to produce cholesterol. Plant-based products like oatmeal, barley, and soy products are high in soluble fiber, which reduces the production of cholesterol by the liver by slowing down its absorption.¹¹ Several studies have shown that adhering to a plant-based diet lowers the total cholesterol in the body - the LDL levels in the body are reduced by almost 30%, double the percentage dropped when following an omnivorous diet.¹²

**Obesity and diet:**
High meat consumption, over-nutrition or over-eating, and foods high in fat - such as dairy and meat products - and sugar are drivers of obesity, and obesity, in turn, is a driver of diseases like diabetes, certain cancers, and heart disease.

Red and processed meat bring cholesterol, saturated fat, trans fat, and animal protein into the body, all of which contribute to the build-up of excess tissue, leading to obesity. The Nurses’ Health Study reported that the relative risk for diabetes for every 1-serving increase in intake increased by 26% for red meat, and 38% for total processed meats.¹⁵

On the other hand, fruits, vegetables, and grains bring increased amounts of carbohydrates, fiber, magnesium, potassium, folate, and antioxidants into the system, reducing the risk of developing diseases.¹⁶ Studies have shown that vegetarians, and more notably, vegans, have lower chances of suffering from hypertension, type 2 diabetes, and colorectal cancer and have lower body mass index (BMI) and blood pressure.¹⁷

**The microbiome and diet:**
The microbiome refers to the collection of microorganisms in the human body.¹⁸

One’s diet influences what type of microbiota reside in the colon/gut/digestive tract. When we consume indigestible dietary fiber, the enzymes of the microbiota in the colon break it down into short-chain fatty acids (SCFA), which lower the pH of the colon. This acidic environment of the colon will determine the types of microbes residing there, encouraging the colonization of different species depending on their suitability to the environment. The lowered pH will additionally prevent the growth of a harmful bacteria, Clostridium difficile.¹⁹ When we consume fermented foods, our gut flora is replenished and can help the body against irritable bowel syndrome (IBS), diarrhea, constipation, diabetes, mental health, skin conditions, and cardiovascular health.¹⁹

The microbiome also influences immune cells and alters cholesterol levels and obesity as discussed in the next section.

**Prebiotics:**
Prebiotics are indigestible macromolecules that promote the growth of beneficial bacteria in the intestines. Some prebiotics present naturally in the form of fruits, vegetables, or grains are garlic, onions, leeks, asparagus, Jerusalem artichokes, endives, salsify, bananas, and seaweed. Resistant starches²⁰ are naturally
occurring prebiotics formed when starch-rich foods such as potatoes, rice, and legumes are boiled and then left to cool. This allows the starch to crystallize, making it more resistant to digestion. This starch is left untouched as it travels through the body until it reaches the gut and intestines, where the enzymes from the various microbes break it down into SCFA. Resistant starches are one of the best sources of SCFA, which is why they are an essential prebiotic (SCFA is very beneficial for stimulating immune cell activity and maintaining normal blood glucose levels and cholesterol).

Two forms of dietary fiber are found in food: 21

Insoluble fiber consists of complex carbohydrates, also known as polysaccharides, such as cellulose found in the cell wall of plants. It is insoluble in the gastrointestinal fluid and passes through undigested, does not get broken down by gut microorganisms and gets excreted from the body along with feces to add bulk to the stool. Insoluble fiber also reduces constipation by allowing the smooth bowel movement of feces through the intestine. It is not a prebiotic – all prebiotics are dietary fibers, but not all dietary fibers are prebiotics. The only soluble dietary fiber is a prebiotic.

Soluble fiber is soluble in the gastrointestinal fluid. Gut microorganisms can break it down into small molecules of short-chain fatty acids, or SCFA, which serve as around 60-70% of the energy content of the cells lining the colon (colonic cells). Resistant starch is a form of soluble fiber.

Pure prebiotics can be found in common pharmacies or drugstores and include inulin, a prebiotic extracted from the endive plant’s roots, and galactooligosaccharides (GOS), isolated from milk ~90% of breast milk contains GOS. In comparison, the other 10% is another indigestible fiber. On the other hand, only 10% of cow’s milk is made up of GOS. 18

Generally, all prebiotic-rich foods are plant-based, and any animal-based prebiotics are poor sources.

Probiotics:

Probiotics are live bacteria that are beneficial to the body when consumed. They increase the number of beneficial bacteria in the digestive tract, preventing harmful pathogens from invading and taking control. Probiotics are contained naturally in foods like kombucha, German sauerkraut, yogurt, Indian lassi, kefir, and Korean kimchi, which are all fermented foods. Supplement pills that contain live-action bacteria are also available, which promote digestive health.

Three main types of probiotics, which have been described in the adjoining Figure 2 below, are:

- Lactobacillus is a type of bacteria that produces lactic acid when digested in the gut. The resultant lowered pH of the gut will prevent the growth of harmful pathogens like Helicobacter pylori (H. pylori) and Clostridium difficile (C. diff).

As many promising studies suggest, bifidobacterium is effective at treating IBS, killing the infections caused by H. pylori, and restoring the gut flora post-chemotherapy, which is a process resulting in a significant drain in the body’s healthy bacteria. Replenishing the microbiome after taking a course of antibiotics is another one of the benefits of bifidobacterium.

Saccharomyces is a yeast, of which its strain Saccharomyces boulardii (S. boulardii) is a strong probiotic that helps manage various diseases.

The above evidence provides that probiotics and prebiotics are strong influencers of our microbiome and can be introduced to the body solely via our diet, by taking supplements, or by eating foods rich in them. We can use our diet to strengthen and diversify our microbiome, improving our health and protecting the body from diseases like cancer.

Figure 2: The factors which strengthen and diversify the microbiome.
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The immune system and diet:

Certain nutrients such as vitamin C, vitamin D, zinc, selenium, iron, and the amino acid glutamine have been identified as critical for the growth and function of immune cells. 21 Animal studies have found that deficiencies in zinc, selenium, iron, copper, folic acid, and vitamins A, B6, C, D, and E can alter immune responses. 24 These nutrients help the immune system in several ways: working as an antioxidant to protect healthy cells, supporting the growth and activity of immune cells, and producing antibodies. Epidemiological studies find that those who are poorly nourished are at greater risk of bacterial, viral, and other infections. Probiotic and prebiotic foods are beneficial in strengthening the immune system as well. 25 Some herbal supplements have been suggested to boost immune function:
- Echinacea is a flower that has been shown to be able to destroy influenza viruses. However, limited research in humans has led to inconclusive evidence of echinacea’s active components. Taking echinacea after catching a cold has not been shown to shorten its duration; taking it before catching a cold, on the other hand, has shown to mitigate the effects and offer some protection. 26, 27
- Garlic contains an active ingredient allinic sativum which displays antiviral and antimicrobial properties, but high-quality clinical trials comparing garlic supplements to placebo are lacking. A Cochrane review identified only one trial of reasonable quality following 146 participants. Those taking the garlic supplement for 3 months had fewer occurrences of the common cold than those taking a placebo, but after contracting the cold virus, both groups had a similar duration of illness. 28 These findings are from a single trial, which needs to be replicated.
Tea catechins such as those found in green tea can prevent flu and some cold viruses from replicating and can increase immune activity. Human trials, however, are still limited. Two randomized controlled trials found that green tea capsules produced less cold/flu symptoms or incidence of flu than a placebo; however, both studies were funded or had author affiliations with tea industries.²⁹

Discussion

Cholesterol and cancer:
Cancer cells often experience stress when metastasizing, which they cannot withstand, resulting in their death. But some cells can overcome this stress-induced cell death and migrate to other body parts. A study showed that the reason for some cells having this ability to evade death and damage during metastasis was due to hypercholesterolemia.

In estrogen-positive breast cancers, it was observed that cancer cells used cholesterol metabolites, similar to estrogen, to avoid stress-induced death when metastasizing. Long-term exposure to this same cholesterol metabolite makes tumor cells more resistant to stress-induced death when metastasizing.³⁰ This mechanism is illustrated in Figure 4. Another study³¹ carried out by scientists at the Breast Cancer Now Toby Roberts Research Centre at The Institute of Cancer Research had a similar observation - they identified that estrogen receptor (ER)- positive breast cancers produced a molecule made from cholesterol, called 25-hydroxycholesterol (25-HC). This molecule mimics estrogen and encourages cancer cells to grow without it.³² These theories are valid for those types of cancer which utilize estrogen to metastasize, such as breast cancer, as well as those which do not require estrogen.

Although the same study stated that an increase in metastasis of other kinds of cancer cells which do not use estrogen was observed with an increase in the cholesterol level, other studies oppose this claim, stating that those types of cancer which do not use estrogen to metastasize such as colon cancer, lung cancer, and bowel cancer are not dependent on cholesterol for metastasis at all.³³ If the study mentioned above holds, cholesterol-controlling treatments such as statins could be a potential prophylactic treatment for cancer.³⁴ This study has limitations; however, further research must be done to achieve conclusive results.

In estrogen-positive breast cancers, cholesterol components similar to estrogen were shown to reduce stress-induced death of cancer cells while metastasizing. 25-hydroxycholesterol is a molecule that mimics estrogen and encourages estrogen receptor (ER) positive cancer cells to grow with it. Adipose tissue produces excess estrogen, which promotes cancer cell metastasis in ER-positive breast cancers. Likewise, leptin production increases with body fat, stimulating cell proliferation. "Estrogen receptor (ER) positive breast cancer is the subtype of breast cancer that requires estrogens for growth and metastasis. Created using BioRender: BioRender.com

Obesity and cancer:
The following mechanisms help to explain the link between obesity and cancer.³⁵, ³⁶ Adipose tissue produces excess amounts of estrogen, which is used in some types of cancer - breast cancer and ovarian cancer - to metastasize.

People with obesity have high amounts of insulin and insulin growth factor-1 (IGF-1), which is a factor in the progression of kidney, prostate, and endometrial cancer (cancer of the uterus).³⁷

People suffering from obesity usually develop chronic inflammatory conditions like gallstones or non-alcoholic fatty liver disease. These conditions can cause oxidative stress, leading to DNA damage³⁸, causing certain types of cancer like biliary tract cancer.³⁹

Adipose cells secrete hormones - adipokines - that can stimulate or inhibit cell growth.⁴⁰ In obese people with excess adipose tissue, the level of adipokine in the blood, leptin, increases with an increase in body fat and can cause uncontrolled cell proliferation, as shown in Figure 3. On the other hand, another adipokine called adiponectin, more common in people having a healthy weight than in obese people, has anti-proliferation properties.⁴¹

Obesity leads to a weak immune system driven through various mechanisms⁴², which poses a significant problem as the immune system is essential in eliminating mutated cells in the body or cells with DNA damage that will eventually replicate, increasing the risk of cancer emergence.

A nationwide study using BMI and cancer incidence from the US Cancer Statistics database estimated that each year from 2011 to 2015, among people of the age of 45 and older, around 37,670 new cancer cases in men (4.7%) and 74,690 new cancer cases in women (9.6%) were due to excess body weight.⁴³ Evidence suggests that consuming a predominantly vegetarian or vegan diet will lead to losing weight, decreasing one’s chances of developing cancer.
The microbiome and cancer:
The microbiome and obesity:
Obesity is a factor in the causation of cancer. This leads to the microbiome being an indirect cause of cancer regarding obesity. Two ways in which the bacteria in our body can be a driver of obesity are:⁴³

1. The gut’s flora includes bacteria that are competent at breaking down indigestible carbohydrates into fatty acids; there are two types of these bacteria: (a) vegetable-loving ones, which break down the carbohydrates coming from plant-based sources, or vegetable sources, into SCFA for the colonic cells and the liver, and (b) other bacteria which break down non-plant-based carbohydrates, such as lactose, and feed the SCFA produced from this breakdown to the somatic cells of the body. We are less likely to gain weight when consuming plant-based products as plant carbohydrates are more likely broken down by bacteria that produce fatty acids for the liver. When we eat a piece of chocolate, the bacteria which get attracted are the ones that break it down into fatty acids to feed the rest of the body, which leads to weight gain and potential obesity.²⁵ This mechanism is depicted in Figure 5 below.

2. Our gut bacteria produce certain transmitters responsible for satiety when we eat. To induce the feeling of satiety is a two-way process; this feeling comes from the brain and the rest of the body, as the bacteria communicate with the brain in the form of signals. However, the transmitters that induce satiety can be defective, and people with such transmitters will not be satiated after eating, leading to obesity.²⁵

The microbiome and cholesterol:
Cholesterol is a factor of cancer, just like obesity, and the microbiome can influence the amounts of cholesterol in our body, thus affecting our risk of cancer:

An experiment²⁵ in 2011 was conducted in which 114 Canadians consumed specially produced yogurt - a probiotic - twice daily (yogurt formation requires milk to be curdled with specific bacteria from the genus lactobacillus). The bacteria added to the yogurt in the experiment was lactobacillus reuteri. Within six weeks, their LDL cholesterol levels sank by 8.91%, almost half the improvement from taking a mild anti-cholesterol drug.

Other studies show that using different types of bacteria lowered cholesterol levels by as much as 11% to 30%.²⁵ However, follow-up research needs to be carried out to verify the above.

The immune system and cancer:
Cancer immunotherapy revolves around the idea that a person’s immune system can be harnessed to recognize and destroy cancer cells. Scientists are working diligently to improve current immunotherapy approaches and promising chances for future cures.

Most available immunotherapies focus on immune cells called cytotoxic T cells, which are part of the adaptive immune system. Cytotoxic T cells specialize in recognizing and killing cancer cells that display specific antigens on their surfaces. The innate immune system also drives immunotherapy - the body’s first line of defense. However, this defense does not involve the recognition of antigens.

Once an innate immune response has been initiated, an adaptive immune response is stimulated, and both work together to eliminate infections or other cells from the body. NCI-funded researchers have recently discovered new ways to manipulate the innate immune system to improve cancer immunotherapy. Some examples are:

Harnessing dendritic cells:⁴⁵
A group of NCI-funded researchers at the University of Pennsylvania has found a way to exploit dendritic cells, innate immune cells that process antigens and present them to T-cells by releasing a protein, CD40, that triggers a wave of biochemical reactions that prime T cells to attack cancer cells. In a mouse model of pancreatic cancer, activating the production of CD40 in dendritic cells altered the tumor’s microenvironment, caused an expansion of T cells within, and ultimately led to the destruction of the tumor. Based on this study, clinical trials are underway in patients with pancreatic cancer, a disease that thus far has been unresponsive to immunotherapy approaches.

Helping macrophages engulf cancer cells:⁴⁶
Macrophages are innate immune cells that engulf and digest cancer cells, cell debris, bacteria, and other foreign substances through phagocytosis. Normal body cells are protected from being engulfed by displaying a protein called CD47 on their surfaces, which relays a signal to macrophages to stay away; in effect, a ‘don’t eat me’ signal. Many cancer cells, however, also display CD47 on their surfaces, protecting them from macrophages. NCI-funded researchers at Stanford University and their collaborators have developed an antibody that blocks or deactivates CD47, rendering the individual cancer cells susceptible to attack and engulfment by macrophages.

Another study done by a different group of researchers at the University of Pennsylvania demonstrated that the metabolism of macrophages could be ‘rewired’ so that they could detect and eat cancer cells, regardless of their expressing the protein CD47.

Engineering natural killer cells to target cancer:⁴⁵
Natural killer (NK) cells are another type of innate immune cells used to treat cancer. The engineering of CAR (chimeric antigen receptor) NK cells is underway to improve their ability to kill cancer cells. This is because CAR NK cells overcome a specific limitation of CAR T cells: personalized CAR T cells can only be developed from a patient’s cells. CAR NK cells, however, can be made using another person’s blood cells and cause fewer side effects than CAR T cells thus far.

Figure 5: The impact of the microbiome on cholesterol and obesity and their resultant role in cancer incidence and progression.
A trial testing the effects of CAR NK cells in patients with B-cell lymphoma has recently begun at the University of Texas MD Anderson Cancer Centre.

**Removing microbes that suppress immunity in liver cancer:**⁴⁷

As we know, the microbiome is crucial in shaping the development of innate and adaptive immunity. It can either promote it or hinder it, as in the following case:

A recent study conducted in NCT's intramural research program showed that, in mice, the bile acids were being modified by a specific type of gut bacteria - Clostridium, to be exact. These modified bile acids suppress innate immune cells called natural killer T (NKT) cells and inhibit their function from controlling cancerous tumors' growth in the liver. Furthermore, when antibiotics were used to kill the strain of bacteria selectively, it was found that NKT cells accumulated in the liver at the sight of tumor growth and could inhibit its development effectively.

Based on this research, a clinical trial by NIH Clinical Centre tests a combination of the antibiotic vancomycin, which kills the Clostridium species, with other drugs that enhance antitumor immune responses.

**Disrupting microbes to prevent and treat colon cancer:**⁴⁸

It has been discovered that certain microbes are associated with the progression of cancer. For instance, the bacterium *Fusobacterium nucleatum* is strongly causal to colorectal cancer. Furthermore, it has been found to affect the innate and adaptive immune system, creating an immunosuppressive tumor microenvironment that promotes colorectal cancer progression. Using this knowledge, scientists are developing cancer treatment and prevention strategies by disrupting the effects on the aforementioned bacterium.

The last two methods explaining the use of the microbiome to protect against cancer show that it can be directly correlated to cancer apart from being indirectly linked to it through the immune system.

Researchers have only just begun to understand the complexity of the immune system and microbiomes in the context of cancer. With continued investment in these areas, scientists will discover new strategies to prevent cancer and improve the lives of people who develop it. The organization of immune cells in the body has been explained using Figure 6 below.

**Figure 6:** The organization of the immune cells in the body. Created on BioRender: Biorender.com.

### Conclusion

A plant-based diet results in a reduction in the LDL cholesterol levels in the body, lower obesity rates, a more diverse and healthy microbiome through the intake of plant-based prebiotics, and as a result of a healthy microbiome and a well-equipped immune system. All these, in turn, are factors in triggering and supporting the cancer state in the body.

Scientists have recently discovered that the immune system can oppose cancer development in the body. It is shown that the microbiome is influential in conditioning the immune system. In addition, strong evidence shows that what a person consumes in their diets, such as probiotics and prebiotics, make up their microbiome.

Diet is essential in deciding one's susceptibility to cancer, cardiovascular disease, poor bone health, diabetes, hypertension, and several other conditions.

And though there are studies stating that a plant-based diet results in nutritional deficiencies, these can easily be avoided by taking dietary supplements, some of which are vitamin B-12, vitamin D, calcium, n-3 fatty acids, and zinc. Calcium, n-3 fatty acids, and zinc can be found in green leafy vegetables, flax seeds, whole grains, and legumes, respectively.⁴⁹ Vitamin B-12 and vitamin D, on the other hand, as sufficient amounts are not present in plants, can be ingested via supplements.⁵⁰

The correlation between diet and cancer is an emerging field in medical research. Though there are limitations regarding dietary studies, including differing metabolisms and nutritional patterns, improved mechanistic models are encouraging further research into this topic.

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