

Dietary Factors Contributing to Pancreatic Cancer Risk

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Abstract: Throughout recent years, pancreatic cancer has been recorded as having one of the lowest survival rates among major cancers. As incidence rates continue to rise globally, identifying risk factors has become increasingly important. This review examines the relationship between dietary factors, particularly ultra-processed foods and added sugars, and the risk of pancreatic cancer development. It synthesizes evidence from many epidemiological and clinical studies to evaluate the potential role of diet in the development of this malignant disease. Current literature suggests that a higher consumption of ultra-processed foods is associated with pancreatic cancer; however, findings vary across populations and study designs. Overall, an analysis of these studies indicates that the consumption of ultra-processed foods may increase the chances of developing pancreatic cancer, mostly via the induction or enhancement of chronic inflammation. Despite the conclusions of this review, further longitudinal and mechanistic studies are needed to determine the relationship between diet and the development of pancreatic cancer.

Author keywords: Ultra-processed foods; pancreatic cancer; sugar; dietary factors; nutritional oncology

Introduction

The pancreas is a gland located behind the stomach and is responsible for releasing hormones that regulate blood sugar and producing enzymes that help with digestion. Pancreatic cancer occurs when abnormal cells in the pancreas grow uncontrollably and form a tumor. It is known as one of the most aggressive cancers with a very low survival rate and a 5-year survival rate of 13%.¹ Pancreatic cancer incidence rates are expected to increase, as they have from 1988 to 2012. The ASR (age-standardized rates) increased from 5.89 in 1988 to 6.78 in 2012, which means that there was an average annual percentage change of 8.45%.² The value 5.89 indicates that 5.89 people were diagnosed with pancreatic cancer for every 100,000 people. Pancreatic Cancer is most common in older people, especially men over the age of 65, and in people who smoke. Some symptoms include weight loss, abdominal pain, fatigue, nausea, anorexia, and back pain.³ Pancreatic cancer is separated into two larger categories: exocrine and neuroendocrine. Exocrine pancreatic cancer develops from the exocrine cells, while pancreatic neuroendocrine tumors develop from cells in the endocrine gland of the pancreas. Exocrine pancreatic cancer is more common, and more than 90% of all diagnoses are adenocarcinoma, which is a type of exocrine pancreatic cancer. Some treatment methods include surgery if the cancer is detected early, chemotherapy, and radiation therapy.

What sets pancreatic cancer apart from other cancers is the lack of early detection methods, causing the cancer to

be identified at later stages when the treatment options are more limited and the cancer becomes more deadly. Some key issues include the lack of specific biomarkers for diagnosing pancreatic cancer early, the high recurrence rate, and resistance to treatment. Pancreatic tumors are often resistant to chemotherapy and radiation since the dense tissues around the tumor, or a thick and desmoplastic stroma, can make it harder for the treatment to reach the cancer cells. By understanding the causes of this deadly disease, we can potentially reduce its incidence.

Though the exact cause of pancreatic cancer has not been determined yet, some risk factors have been identified. Genetic mutations, lifestyle factors, and chronic conditions are all risk factors for pancreatic cancer. Diet is a major factor in determining the health of an individual. Knowing how diet can affect a person's health would be beneficial in understanding and finding a connection between diet and pancreatic cancer development. Sugar is a big part of the diet and is present in a lot of foods, such as cereals, desserts, and even condiments. It is important to understand the results of a high sugar intake. On average, US adults consume 17 teaspoons of added sugar a day,⁴ even though the recommended daily intake is significantly lower (9 teaspoons for men and 6 teaspoons for women). Additionally, processed foods, especially ultra-processed foods, are also very common, as they account for more than half of the calories consumed by a person.⁵

There is growing evidence that diet plays a significant role in regulating inflammation within the body, a factor that is linked to the development of many chronic diseases, including cancer.⁶ UPF-rich diets, which contain high amounts of sugars, salt, and saturated fats directly promote the development of chronic inflammation.⁷

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This review will focus on the role of sugar intake and processed foods in the development of pancreatic cancer, potentially via the induction of chronic inflammation. If processed foods are linked to pancreatic cancer development, it could prompt greater emphasis on dietary habits to increase cancer prevention. Public health campaigns could focus on educating people about the dangers of ultra-processed foods and the importance of a nutrient-rich diet.

Methodology

The goal of this review article was to analyze the effects of ultra-processed foods and other dietary components on the development of pancreatic cancer. The research for this paper was conducted in the form of a literature review, in which various research studies and clinical trials were analyzed. Papers from PubMed, the National Library of Medicine, and other reputable sources were analyzed. During the process of finding literature, the following terms were used to filter for relevant papers: pancreatic cancer, ultra-processed foods, diet, and inflammation. Most of the literature chosen focused on inflammation and diet and their association with pancreatic cancer. As a result, 37 papers were chosen. The main themes explored were chronic inflammation, obesity, sugar/ultra-processed food consumption, and their links to pancreatic cancer. The review begins by discussing the incidence rates for pancreatic cancer and the association between cancer and chronic inflammation, a known factor that contributes to the development of pancreatic cancer. Additionally, this study was heavily dependent on the quality of secondary sources, and potential bias or variability in definitions of ultra-processed foods could have been encountered.

Pancreatic Cancer Incidences

Table 1, which is based on the data from the World Cancer Research Fund, provides data on the ASR/100,000, number of cases, and total population of 10 different countries. Age-standardized rates (ASR) are a summary measure of the rate

of disease that a population would have if it had a standard age structure. In addition to the data, this table provides context on the rising issue of increasing pancreatic cancer incidences. It is observed from this table that the highest incidence of pancreatic cancer was in the Czech Republic, followed by Japan, Italy, and the USA. By knowing the incidence rates in various countries, examining dietary trends in each of these countries would help identify the trend between diet and the development of pancreatic cancer. In addition to this, these high incidence rates emphasize the importance of preventing this malignant disease.

Association between Chronic Inflammation and Cancer

Inflammation is the body’s response to an illness or injury. Although inflammation is a normal process that helps the body heal, it can harm the body if it occurs in healthy tissues or continues for too long. There are two types of inflammation: acute inflammation and chronic inflammation. Acute inflammation is the immune system’s response to a sudden or immediate injury. During this process, inflammatory cells travel to the site of injury and start the healing process. Some examples of acute inflammation include infections such as strep throat and a bee sting, which could induce an acute inflammation. On the other hand, chronic inflammation is a long-lasting state of inflammation in which the body is constantly fighting something, even when there is no immediate threat. During this process, the body continuously sends inflammatory cells, even when there is no danger. Chronic inflammation can lead to a variety of diseases, including cancer, autoimmune diseases, and cardiovascular disorders.⁸ Many of these diseases can increase the risk of developing cancer. For example, a 2023 study⁹ studies the risk of developing cancer after diagnosis of cardiovascular disease. They did this by selecting 27 million cancer-free individuals, who were then divided into two groups based on the presence or absence of cardiovascular disease (CVD). The cumulative risk of cancer was calculated after an analysis of cardiovascular risk factors was performed. The results showed that

Table 1. Incidence of pancreatic cancer in various countries^{10,11}

Rank	Country	ASR/100,000 (2012)	Number of Cases (2022)	Total Population (2022)
1	Japan	8.89	47,627	124,214,766
2	Czech Republic	9.36	15,895	68,305,148
3	Germany	7.72	21,869	84,316,622
4	USA	7.53	60,127	337,341,954
5	Italy	7.91	15,710	61,095,551
6	Turkey	5.06	21,842	142,021,981
7	UK	6.6	11,351	67,791,400
8	Brazil	3.46	14,670	217,240,060
9	China	5.09	118,672	1,410,539,758
10	India	1.30	13,661	1,389,637,446

among 27,195,088 individuals, those with CVD were 13% more likely to develop cancer than those who did not have CVD.⁹

Chronic inflammation could be caused by many environmental factors, including toxins. Simple daily choices like not getting a good amount of sleep, not exercising enough, and not brushing your teeth regularly are also factors that can increase the risk of chronic inflammation.¹² Lack of sleep increases inflammatory substances in the blood and contributes to obesity, which is linked to chronic inflammation. Aerobic exercise—the kind that gets your heart rate up—is an important way to fight chronic inflammation. A large population-based study on pancreatic cancer revealed that obesity, itself, increases the risk of developing pancreatic cancer by 50%–60%.¹³ Aerobic exercise—the kind that gets your heart rate up—is an important way to fight chronic inflammation. Such exercise helps reduce body fat, which contains inflammation-promoting substances. In addition, exercise increases the production of hormones that keep inflammation in check. A lack of physical activity can increase the risk of chronic inflammation. Not brushing your teeth regularly, or even properly, can increase the risk of chronic inflammation. It is necessary to brush away all the bacteria that can inflame the gums, lead to inflammation, and even cause inflammation or infection in other parts of the body. Red meats, processed foods, deep-fried items, and foods that are high in sugar are some examples of foods that can cause inflammation.¹⁴

The association between chronic inflammation and pancreatic cancer has been shown through two case-control studies, with one conducted in the United States and the other in Italy. During the study that was conducted in Italy, subjects were asked to indicate the weekly frequency of the consumption of each dietary item. It was found that the cases of pancreatic cancer had a higher Dietary Inflammation Index (DII) with a value of 0.26 compared to controls, which had a value of 2.013. This indicates that individuals with pancreatic cancer were consuming a diet that consisted of pro-inflammatory foods. Additionally, an association between the DII and the risk of pancreatic cancer among women and normal-weight subjects was observed. The odds ratio comparing women in the highest quintile of DII to the lowest was 1.371, which indicates that a higher risk of pancreatic cancer is associated with a pro-inflammatory diet.¹⁵ The link between inflammation and other types of cancers has also been investigated. For example, a 2016 study that collected data on Colorectal Cancer (CRC) diagnoses from 1997 to 2008 investigated how Non-Steroidal Anti-inflammatory drugs (NSAIDs) affected the survival rates in patients who were diagnosed with CRC. This study found that patients who used NSAIDs after their CRC diagnosis had significantly better survival rates. The risk of death was 31% lower compared to patients who did not use NSAIDs after diagnosis, with a hazard ratio of 0.69.

Understanding Ultra-Processed Foods and Sugar

Ultra-processed foods may contain many added ingredients such as salt, sugar, fat, and artificial colors. Frozen meals, soft drinks, fast food, and packaged cookies are all common ultra-processed foods. A recent study included 10 female and 10 male weight-stable adults who were admitted and randomly assigned to either an ultra-processed or an unprocessed food diet for two weeks.¹⁶ During each diet phase, subjects were presented with three daily meals, with 60 minutes to consume each meal. One significant observation was that participants gained an average of two pounds in the ultra-processed foods phase and lost approximately two pounds during the unprocessed foods phase. Therefore, ultra-processed food consumption and obesity are correlated. With this, it was concluded that limiting ultra-processed food consumption could be an effective strategy to prevent obesity.¹⁶ Similarly, through another study, food consumption data were collected through 24-h food records. Food items were classified according to characteristics of food processing. Regression models were made to evaluate the association between the consumption of ultra-processed foods and body mass index. It was found that those in the highest quintile of consumption of ultra-processed foods had a significantly higher body mass index (0.94 kg/m^2 ; 95% CI: 0.42, 1.47) compared to those in the lowest quintile of consumption.¹⁷

Additionally, an association between ultra-processed food consumption and all-cause mortality has been established. In Nilsson et al.'s¹⁸ study, the authors performed a dose-response meta-analysis of observational cohort studies that assessed the association between UPF dietary share and all-cause mortality. Then, researchers estimated how much of the premature deaths from all causes could be linked to eating ultra-processed foods in different countries. Eight countries were chosen based on their levels of ultra-processed food consumption. Columbia and Brazil were chosen for the low-consumption category, and Chile and Mexico were chosen for the medium category. Australia, Canada, the United Kingdom, and the United States were chosen for their high consumption of ultra-processed foods. This review article found that for every 10% increase in UPF contribution to total energy intake, there was a 2.7% increase in the risk of all-cause mortality.¹⁸ Additionally, the authors estimated that the proportion of deaths caused by UPF consumption in 8 selected countries ranges from approximately 4% in Colombia to 14% in both the United States and the United Kingdom.¹⁸

In a study published in September 2005,¹⁹ the relationship between sugar and the development of pancreatic cancer was studied. Through this study, the relation between consumption of sugar-sweetened soft drinks and the development of pancreatic cancer in the Nurses' Health Study and the Health Professionals Follow-up Study was examined. Among 49,364 men and 88,794 women without cancer at baseline, this study documented 379 cases of pancreatic cancer during and up to 20 years of follow-up. Sugar-sweetened

Table 2. Consumption of different food groups in four countries

Country	Pancreatic cancer incidence rank	Processed food consumption	Seafood consumption	Alcohol consumption in liters (data from 2019 est.)
Japan	1		~60 kg per day	~8.36 liters
USA	4	~58%	~23 kg per day	~8.93 liters
UK (Europe)	7	~56%	~25 kg per day	~9.8 liters
India	10		~28 kg per day	~3.09 liters

soft drink consumption was assessed at baseline in 1980 for women and in 1986 for men. It was updated periodically. Through this study, it was determined that participants who consumed more than three sugar-sweetened soft drinks weekly compared to participants who restrained themselves from sugar-sweetened soft drinks experienced overall a multivariate relative risk (RR) of pancreatic cancer of 1.13 [95% confidence interval (95% CI), 0.81–1.58; *P* for trend = 0.47]. Women in the highest category of sugar-sweetened soft drink consumption experienced a significant increase in risk, while there was no association between soft drink intake and pancreatic cancer among men. Among women, the risk associated with higher sugar soft drinks was limited to those with low physical activity (RR, 2.02; 95% CI, 1.06–3.85) or higher body mass index (>25 kg/m²; RR, 1.89; 95% CI, 0.96–3.72). This shows that, among women, sugar consumption increased the risk of developing pancreatic cancer.

Another study examined the associations between sweetened and unsweetened beverages, sweets, and sugars and pancreatic cancer risk. They conducted a population-based case–control study (532 cases, 1701 controls) and used multivariate logistic regression models to estimate 95% confidence intervals (CI) and odds ratios (OR). Results for men and women were presented combined and separately since associations were often different by gender. The results show that greater intakes of sweets were associated with a higher pancreatic cancer risk for men (total sweets: OR = 1.9, 95% CI: 1.0, 3.6). On the other hand, sweets were not consistently associated with risk among women. Similarly, sweetened beverages were not associated with increased pancreatic cancer risk.²⁰ In contrast, low-calorie soft drinks were associated with an increased risk in men, while other low-/non-caloric beverages were not associated with the risk. This study provides limited evidence that sweets and sugars are positively associated with the risk of pancreatic cancer. Results varied by gender and the types of sweets/candy.

Association between Dietary Pattern and Pancreatic Cancer

Many studies have shown a link between the incidence rate of pancreatic cancer and the consumption of ultra-processed foods. A study published in 2023²¹ included a prospective cohort of UK Biobank participants aged 40–69 years who completed 24-h dietary recalls between 2009 and 2012 and were followed up until January 31, 2021. These food items

that were consumed were categorized into their degree of food processing using the NOVA food classification system. Individuals’ UPF consumption was expressed as a percentage of food intake. This study found that every 10% increment in UPF content was associated with a 2% increase in the incidence of overall cancer.²¹

Table 2 shows the consumption of different food groups in Japan, the USA, the UK, and India.^{22–24}

The age-standardized incidence rates (ASR) per 10⁵ of the Indian population are approximately 0.88 for females and 0.81 for males, while they are significantly higher in the United States, reaching a 6.6 for females and 9.0 for males.²⁵ The Indian diet consists of many diverse foods, but mainly consists of rice, lentil-based dishes, various curries, or flatbread. A study observing the diets of various Indian households in different regions, including North, West, East, South, North-East, and Central, recorded the percentages of each food group in a diet. This study found that the most consumed food group was whole grains, accounting for over 50% of the average total caloric intake, the highest being 68% for the North-East region and the lowest being 46% for the West region.²⁶ It has been demonstrated that whole-grain consumption is associated with lower risks of being diagnosed with many cancers. The consumption of whole grains lowers the risk of pancreatic cancer by approximately 24% to 30%.²⁷ Meanwhile, in the United States, people are consuming whole grains at levels far below the recommendation, with only ~15% of grain intake deriving from whole grain sources, and the majority derived from refined grains.²⁸ The Dietary Guidelines for Americans recommended that >50% of total grain intake derive from whole grains. Processed foods make up around 8%–13% of the daily caloric intake in India.²⁶ The lowest is 8% in the North/North-East region, and the highest is 13% in the South region. Meanwhile, in the United States, ultra-processed foods have increased to more than 50% of the current diet.⁵ India’s low UPF consumption, combined with its rich whole-grain diet, likely contributes to a healthier lifestyle and lower risk of pancreatic cancer development. Additionally, alcohol consumption is also a factor that increases the risk of pancreatic cancer, since countries with higher alcohol consumption tend to have higher incidence rates for pancreatic cancer. Based on Table 2, India had a relatively low alcohol consumption rate compared to Japan, the UK, and the USA. Similarly, India had a lower pancreatic cancer incidence rate than these countries. Even though alcohol consumption may not be the biggest cause of pancreatic cancer, it is one of the main factors. Similarly,

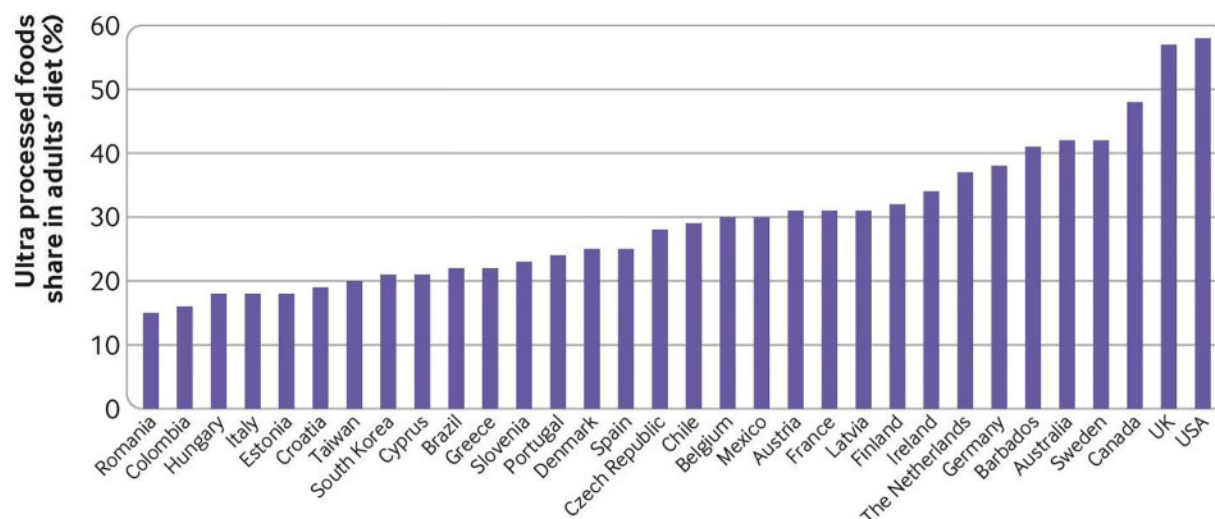


Figure 1. Mean proportion of ultra-processed foods in adults' diets across countries. This figure shows consumption of ultra-processed food (% of energy intake) in various countries. (Source: Touvier et al.,²³ under the Creative Commons CC-BY-NC 4.0 license)

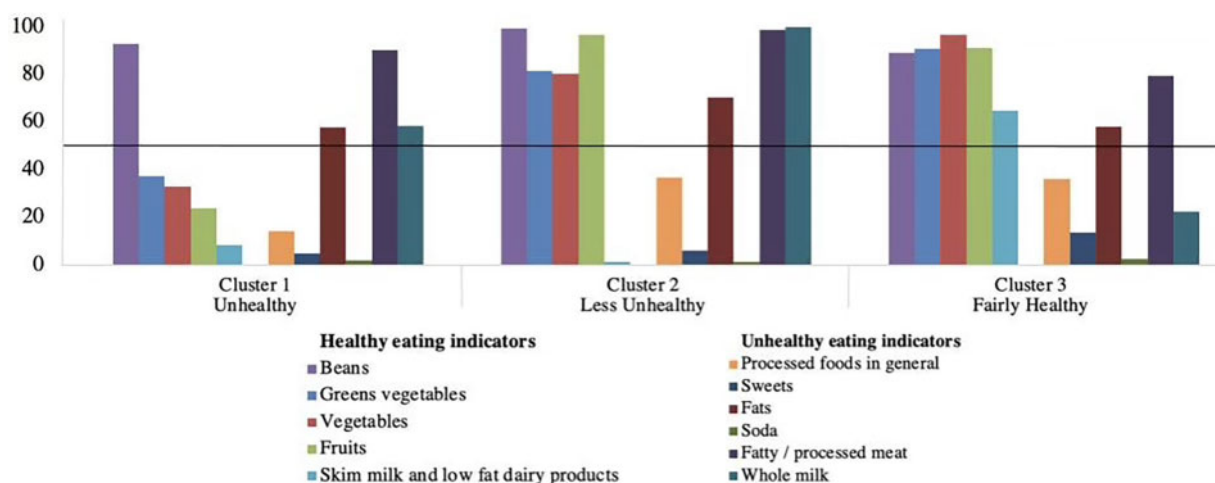


Figure 2. Consumption of different categories of foods in three different groups

seafood is another food that may play an important role in the development of pancreatic cancer. Japan, a country with one of the highest pancreatic cancer incidence rates, has a seafood consumption rate of ~60 kg per day. Compared to other countries, Japan consumes a lot more seafood and also has a higher incidence rate for pancreatic cancer. Although a correlation is shown, more investigation is required.

Fig. 1 provides a visual comparison of ultra-processed food intake in 32 different countries.²³ It shows that almost 60% of the USA's food intake is ultra-processed, the highest compared to 31 other countries. Similarly, Graph 1 states that the USA reported 60,127 new pancreatic cancer cases with an age-standardized rate (ASR)/100,000 of 8.6. Although it does not rank the highest in pancreatic cancer incidence in terms of ASR, it has one of the top numbers in terms of incidence rate.

Brazil's diet, depicted in Fig. 2²⁹ across three dietary clusters, primarily consists of beans. Additionally, fruits, vegetables, and fats are more likely to be consumed in the "less

healthy" and "fairly healthy" groups, becoming less common in the 'unhealthy' group. Processed food consumption stayed relatively the same between clusters 2 and 3, but decreased in cluster 1. Even though their diet also consists of processed meats and processed foods in general, it is consumed less than the USA's consumption of processed foods. Brazil has an ASR/100,000 of 4.7, which is far below the USA's ASR. To sum up, Brazil's processed food consumption and pancreatic cancer incidence rate were lower than the USA's. This shows a correlation between the consumption of ultra-processed foods and pancreatic cancer development.

These graphs show the consumption of different categories of foods in three different groups. The variables associated with the clusters "unhealthy" and "less unhealthy" were education level, individual income, number of doctor appointments, history of diabetes, history of dyslipidemia, polypharmacy, consumption of alcoholic beverages, smoking habit, reduction in food ingestion, and waist circumference (graph from Loureiro et al., "Food

Table 3. Current clinical studies

Title	Study ID#	Preventive measure	Results
Physical Activity and Nutrition to Halt Elevated Risk in the Pancreas Interception Center (PANTHER-PIC)	NCT06712797	Self-monitored physical activity and physical diet	No results yet—study is active, but not recruiting participants
Lifestyles and Breast Cancer	NCT04174391	Mediterranean diet supplemented with extra-virgin olive oil and low-fat diet	No results have been posted—study is active, but not recruiting participants. Study is expected to be completed in December of 2026

consumption and characteristics associated in a Brazilian older adult population: a cluster analysis”. *Frontiers in Nutrition*, 8. <https://doi.org/10.3389/fnut.2021.641263>).

Ongoing Clinical Studies

Table 3 shows two clinical studies that focus on the prevention of cancer and lifestyle. They are both ongoing studies between nutrition and cancer; one being on pancreatic cancer and the other being on breast cancer.

The study “Physical Activity and Nutrition to Halt Elevated Risk in the Pancreas Interception Center (PANTHER-PIC)” (NCT06712797)³⁰ is focused on assisting in implementing a practical lifestyle intervention that optimizes patient outcomes and minimizes the pancreatic ductal adenocarcinoma (PDAC) risk. A single-arm trial that evaluates the feasibility and acceptability of a 6-month Physical Activity and Nutrition Intervention for Intraductal Papillary Mucinous Neoplasm (IPMN) patients who are overweight and/or have elevated SOC incretin, cytokine, and adipokine biomarkers will be held. Patients with IPMNs >15 who will or have received care in Moffitt Cancer Center’s Pancreas Intervention Center will be recruited. This study is currently recruiting participants.

The clinical study “Lifestyles and Breast Cancer” (NCT04174391)³¹ is focused on assessing the efficiency of nutritional intervention with MedDiet+EVOO (Mediterranean diet with extra-virgin olive oil) for the prevention of relapses among women with early-stage breast cancer. In this study, 766 women who were diagnosed with early breast cancer were randomized in a 1:1 ratio to either MedDiet+EVOO or a low-fat diet. Changes in circulating tumor cells, oxidative stress, inflammatory biomarkers, and quality of life are being evaluated. This intervention will be delivered by phone calls, face-to-face interviews with study dietitians, and online tools. The study is ongoing, and participants are receiving an intervention or being examined, but potential participants are not currently being recruited or enrolled.

Conclusion

The objective of this review article was to identify the association between diet and the development of pancreatic cancer. The results show that diet plays a significant role in the development of pancreatic cancer. More specifically, it is concluded that ultra-processed foods play a significant role in increasing the risk due to their many components including added sugars and salts. The results clearly show that ultra-processed foods negatively impact the body by promoting inflammation, which contributes to a range of other health risks, including autoimmune disorders and diabetes. Additionally, it was also identified that a low consumption of whole grains can contribute to the risk of pancreatic cancer. This was shown through the comparison of India’s and the United States’ whole-grain consumption. Alcohol and seafood consumption were also major factors in the development of pancreatic cancer. These findings suggest that ultra-processed foods may increase the risk of developing pancreatic cancer due to the many components they contain.

In conclusion, this research provides compelling evidence that ultra-processed foods contribute to pancreatic cancer development but also highlights the need for further investigation in this area. Therefore, diet plays an important role in cancer development, and limiting the consumption of ultra-processed foods may lead to lower chances of developing pancreatic cancer. Based on these findings from many studies, it is advised that people should limit the consumption of ultra-processed foods high in added sugars and salts.

Limitations

Despite these promising results, this study has several limitations. The dataset for the overall incidence rate of pancreatic cancer was not limited to ultra-processed food, but included all factors, including family history,³² smoking, and other foods. Additionally, there is a limited number of clinical studies investigating ultra-processed foods’ effects on pancreatic cancer development. There is also a limited availability of long-term studies that focus specifically on pancreatic cancer and diet.

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About the Author



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