The Impact of Ultra-Processed Food Consumption on the Increase of Degenerative Diseases Incidence: A Scoping Review

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Abstract : Currently, degenerative diseases are not only experienced by elderly people, but also in teenagers and adults. The disease is triggered by an unhealthy lifestyle, such as lack of physical activity and poor diet. Poor diet, such as high consumption of ultra-processed food (UPF), can trigger various health problems. UPF has low nutritional quality but has high energy, fat, and salt content. UPF may therefore trigger an increase in the incidence of obesity, type 2 diabetes mellitus, cardiovascular disease (CVD), and cancer in society. **Objective:** This review aims to summarize and present the research evidence relating to the relationship between UPF consumption and the incidence of degenerative diseases in the community. **Methods:** The researchers used a scoping method by collecting and selecting relevant literature related to the consumption of UPFs associated with the incidence of obesity, diabetes mellitus, CVD, and cancer within the last 5 years (2018-2023) through Google Scholar, PubMed, and ScienceDirect. Respondents in this study were between the ages of 18 to 85 years. **Results:** From 7.937 articles within the last 5 years (2018-2023), nine articles were selected for further identification. The articles consisted of four cohort studies, a cross-sectional study, a multi-case-control study, a randomized control trial, and two reviews which were conducted among adolescents and adults in several countries. The results showed that there is a significant relationship between the consumption of UPFs and an increased risk of obesity, type 2 diabetes mellitus, CVD, cancer, and even death, with a greater proportion of female respondents experiencing these various problems.**Conclusion:** This review highlights the negative impacts of UPFs, where higher consumption of UPF has led to the increased incidence of non-communicable diseases in the community, such as type 2 diabetes mellitus, CVD, and cancer.

INTRODUCTION

Degenerative diseases are non-communic- able diseases that are caused by deterioration and decline in the function of cells and organs in the body. Degenerative diseases usually occur in older age groups. When people get older, the function of body cells will naturally decline. This is believed to be one of the trigger factors for the emergence of various degenerative diseases in the elderly (Abdel- Daim et al., 2019). However, degenerative diseases presently do not only occur in the elderly. It also increasingly occurs in children, teenagers, and adults. The degenerative diseases even rank among the current top ten diseases that exist globally. This can happen due to changes in bad lifestyle, such as lack of physical activity and unhealthy eating patterns (Kopp, 2019).

Nowadays, people tend to consume more ultra-processed food (UPF) because it can be found easily, is cheap, available in many forms, tastes good, can be stored for a long time, and can be cooked easily (Baker et al., 2020). The UPFs have therefore the potential to reduce or even replace the consumption of fresh food and minimally processed food (Monteiro et al., 2019). Several surveys conducted the UK, USA, Canada, New Zealand, and Brazil stated that UPF consumption contributes to 25-50% of total daily energy. Meanwhile, surveys conducted in Asian countries, such as Korea, Malaysia and Indonesia, reported an average consumption of 25.8%, 29% and 19.5% of total daily energy intake, respectively (Marino et al., 2021; Luiten et al., 2016; Moubarac et al., 2013).

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UPF is defined as food that is formulated and produced industrially by adding food additives, such as flavourings, colorings, sweeteners, and emulsifiers, as well as through various processes, such as hydrogenation, extrusion, and pre-frying, which altogether make the final food product ready to be eaten or cooked (Monteiro et al., 2019). Despite being packaged attractively, easy to obtain, cook and consume, and having delicious taste, the UPF products are classified as an unhealthy food due to the high content of total fat, saturated fat, sugar, and salt, as well as low content of protein, fiber, and vitamin (Fiolet et al., 2018). Therefore, without many people realizing it, the high consumption of UPF can cause obesity, which may subsequently trigger various non-communicable diseases, such as type 2 diabetes, cardiovascular disease (CVD), and cancer (Elizabeth et al., 2020).

This phenomenon has attracted the interest of many researchers to investigate the impacts of UPF consumption on health. Results from an experimental study show that UPF has low satiety capacity and stimulates a high glycemic response, thus affecting a person's daily energy intake (Forde et al., 2020). In addition, contamination occured during the processing and packaging of UPF may be carcinogenic that further causes endocrine disorders and inflammatory diseases (Friedman, 2015). Another study also states that the increasing global trend related to UPF consumption also increases the prevalence of obesity and non-communicable diseases, such as type 2 diabetes, CVD, and cancer, either in children, adolescents, or adults (Popkin & Ng, 2022). The aim of this review is to seek and explain the relationship between UPF consumption and its health impacts in the society, with particular emphasis on obesity and degenerative diseases.

METHOD

This study was compiled using the scoping review method. Various references from numerous journals and official websites were identified and synthesized in an in-depth manner that the relationship between UPF consumption and the health problems can eventually be elaborated. The steps carried out in the scoping review are as follows (Mak & Thomas, 2022):

1. Identifying the Research Question

This initial step is both important and useful to find relevant references. Dietary patterns associated with high consumption of UPFs can significantly increase the incidence of degenerative diseases in society. Dietary pattern characterized by high consumption of sodium, sugar, saturated fat, and trans-fat is believed to be a major contributor to the incidence of obesity, diabetes mellitus, CVD, and cancer. Based on these arguments, the research question in this review is "Can consumption of UPF cause various health problems, such as obesity, diabetes mellitus, CVD, and cancer?".

2. Identifying the Relevant Literature Sources Relevant literature sources were obtained from PubMed, ScienceDirect and Google Scholar databases by using the question formats of population, exposure, and outcome (PEO). These formats were used to determine keywords in conducting the literature search. The PEO format also facilitates the finding of relevant articles that use either qualitative or quantitative methods. The literature search from the three databases using the keywords of 'ultra-processed food', 'obesity', 'diabetes mellitus', 'cardiovascular disease', 'cancer', 'adolescents', and 'adults' resulted a total of 79,856 records that are relevant to the research topic. Of these numbers, 168 were retrieved from PubMed, 41,187 from ScienceDirect, and 38,501 from Google Scholar The records down by limiting search for publication within the last 5 years only (from 2018 to 2023). This process resulted in 7,937 articles for further screening. And then the remaining records after duplicates were removed became 4,381. After that, they were excluded according to the title or abstract and became 556 articles.

3. Selecting the Literature

At this step, the 556 articles obtained were screened by title and abstract, and their full-text version were sought to be scrutinized if they meet the eligibility criteria. Articles were included for further review if written in Bahasa Indonesian or English, and specifically discuss the main question of the review, namely the relationship between consumption of UPF and incidence of obesity, diabetes mellitus, CVD, and cancer in society. A total of 547 articles were excluded for not meeting the objective of this review, leaving nine articles only for further critical assessment and analysis.

In compiling articles for this scoping review the PRISMA flow diagram was used to show in detail the amount of literature obtained from the process of literature search, title and abstract screening, determining articles that met the eligibility criteria, and selection of articles for a comprehensive review (Figure 1).

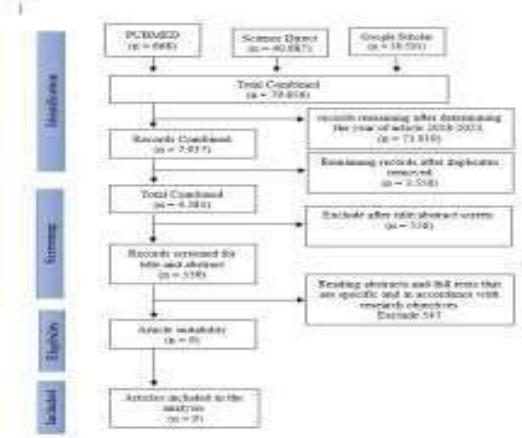

Figure 1. PRISMA Flow Diagram for Article Selection

4. Mapping and Collecting the Eligible Literature

Articles meeting the eligibility criteria were collected and grouped at this step. The researchers collected, analyzed and grouped the literatures found according to the research topic. The results of the literature grouping were then presented in the form of a matrix table.

5. Compiling and Reporting the Results of Literature Analysis

At this step, the selected articles were synthesized and ,compiled, the results of which were reported in the following sections.

RESULTS

The literature search from three databases returned a total of 79,856 articles. After eliminating duplication and performing screening by title and abstract, 556 articles were relevant to this review topic, but only 9 articles met the eligibility criteria to be further analyzed all selected Articles discuss the relationship between UPF and obesity, diabetes mellitus, CVD, and cancer. The articles consisted of 4 cohort studies, 1 cross-sectional study, 1 multiple case-control study, 1 randomized control trial, and 2 reviews. The were conducted in several countries, such as the US, Brazil, Spain and France, with the age range of respondents being 18 to 85 years. Population size of the studies varies from hundreds to thousands of respondents, consisting of several population layers, namely men, women, young adults (under 40 years), old adults (over 40 years), smokers and non-smokers, and other sociodemographic factors. A summary of the content analysis from the nine selected studies is presented in Table 1.

The results of the content analysis showed that three of the articles were obesity- related, and stated that high consumption of UPF had an effect on increasing daily energy consumption and was significantly related to increased BMI, enlarged waist circumference, body fat, and overweight, and this relationship was more often found in female respondents (Canhada et al., 2020; Juul et al., 2018; Hall et al., 2019). Two articles showed a positive relationship between high UPF intake and an increased incidence of type 2 diabetes mellitus in the community (Llavero-Valero et al., 2021; Delpino et al., 2022). One article on UPF and CVD explains that proportion of UPF in the diet is associated with an increased risk of CVD (Srour et al., 2019), while another article explains the various mechanisms underlying the influence of UPF consumption on cardiometabolic health (Juul et al., 2021). The last two articles documented that high UPF consumption has an impact on the incidence of cancer, especially breast and colorectal cancer (Fiolet et al., 2018; Romaguera et al., 2021). Both articles shared common characteristics, namely frequency of UPF consumption based on time of consumption and quartiles of UPF intake, which were shown to have a relationship with various health problems, especially in female respondents

Table 1. Summary Analysis of Selected Articles

No	Researcher, Year of Publication	Title	Research purposes	Research design	Results
1	Canhada et al., 2020	Ultra-processed foods, incident overweight and obesity, and longitudinal changes in weight and waist circumference: The Brazilian Longitudinal Study of Adult Health (ELSA-Brasil)	To examine the relationship between UPF consumption with increased body weight and waist circumference, and to estimate the incidence of overweight/obesity	*Longitudinal (cohort)*	Respondents' weight gain of 30.84–73.84% of total daily energy intake had a higher risk of increasing: body weight (RR 1.27; 95% CI 1.07-1.50) waist circumference (RR 1.33; 95% CI 1.12-1.58)
2	Juul et al., 2018	Ultra-processed food consumption and excess weight among US adults	To examine the relationships between UPFs and overweight in a nationally representative sample of US adults	*Cross-sectional*	Compared to respondents consuming small or moderate amounts of UPF, those with high UPF intake were more likely to:had a higher BMI be overweight (OR 1.48; 95% CI 1.25-1.76) be obese (OR 1.53; 95% CI 1.29-1.81) had abdominal obesity (OR 1.62, 95% CI 1.39-1.89)
3	Hall et al., 2019	Ultra-processed diets cause excess calorie intake and weight gain: An inpatient randomized controlled trial of ad libitum food Intake	To examine the effects of UPFs and non-UPFs on ad libitum energy intake and changes in body weight	*Randomized control trial*	Compared to respondents consuming a non-UPF diet, those who were exposed to UPF diet: consumed an average of 508 ± 106 kcal had an increased body weight of 0.9 ± 0.3 kg significantly ($p<0.001$) after two weeks had an increased body fat of 0.4 ± 0.1 kg significantly ($p<0.001$) after two weeks
4.	Delpino et al., 2022	*Ultra-processed food and risk of type 2 diabetes: a systematic review and meta-analysis of longitudinal Studies*	To review longitudinally the relationship between ultra-processed food consumption and the risk of type 2 diabetes and measure the resulting risk through meta-analysis.	*Systematic Review and Meta-Analysis*	Based on meta-analysis data, it is known that respondents who do not consume and consume ultra-processed foods moderately increase their risk of diabetes by 12% [relative risk (RR): 1.12, 95% CI: 1.06-1.17, I2 = 24 %], while respondents with high consumption of ultra-processed foods increased their risk of diabetes by 31% (RR: 1.31; 95% CI: 1.21-1.42, I2 = 60%)
5	Llavero-Valero et al., 2021	Ultra-processed foods and type-2 diabetes risk	To evaluate the relationship	*Prospective cohort*	Respondents with high intake of UPFs had:
		in the sun project: A prospective cohort Study	between consumption of UPFs and incidence of type 2 diabetes		53% the risk of developing type 2 diabetes mellitus ($p=0.024$) after 10 years, the results were still

			with a longer observation period than previous Studies		statistically significant (p=0.023)
6	Srour et al., 2019	Ultra-processed food intake and risk of cardiovascular disease: Prospective cohort study (NutriNet-Santé)	To determine the relationship Between consumption of UPFs and risk of CVD	*Prospective cohort*	Increasing UPF/drinks intake of 100 g/day increases the risk of: CVD events (RR 1.06, 95% CI 1.02-1.10, p<0.001)
7	Juul et al., 2021	Ultra-processed foods and cardiovascular diseases: Potential mechanisms of action	To summarize the latest evidence regarding the biological mechanisms underlying the association between UPFs and CVD	*Review*	Degradation of physical structure of UPFs affects: absorption kinetics satiety glycemic response gut microbiota in the body Additives & contaminants produced during the UPF production process play a role in increasing the risk of CVD through biological pathways, such as changes in:serum lipid concentrations inflammation oxidative stress dysglycemia insulin resistance hypertension
8	Fiolet et al., 2018	Consumption of ultra-processed foods and cancer risk: Results from NutriNet-Santé prospective cohort	To determine the relationship between consumption of ultra-processed foods and the risk of cancer	*Prospective cohort*	Intake of UPFs was associated with increased risk of: cancer (HR 1,12 95% CI 1.06-1.18, p<0.001) breast cancer (HR 1.11, 95% CI 1.02-1.22,p<0.02) Consumption of UPFs influences the incidence of breast cancer in: postmenopausal women (p<0.04) premenopausal women (p<0.02)
9	Romaguera et al., 2021	Consumption of ultra-processed foods and drinks and colorectal, breast, and prostate cancer	To evaluate the relationship between consumption of ultra-processed foods and colorectal, breast and prostate cancer	*Multi case-control*	High UPF consumption has the potential to increase the risk of: colorectal cancer by 44% (p<0.001)breast cancer by 24% (p=0.023) Consumption of UPFs has no relationship with the incidence of: prostate cancer (p=0.589)

Abbreviations: CVD, UPF, OR, RR, HR

DISCUSSION

The 9 articles reviewed suggest, consumption of UPFthe potential to cause obesity, which will subsequently trigger some non-communicable diseases. The articles have similarities and differences in their research protocols, which may be influenced by the objectives and research methods used. All reviewed articles have relatively similar objectives, where three articles sought to examine the relationship between UPF and incidence of obesity (Canhada et al., 2020; Juul et al., 2018; Hall et al., 2019) two articles assessed the relationship between UPF and type 2 diabetes mellitus (Llavero-Valero et al., 2021; Delpino et al., 2022) two other articles aimed to investigate a relationship between UPF and CVD (Srour et al., 2019; Juul et al., 2021), and the two remaining articles evaluated whether a relationship between UPF and cancer in adolescent to elderly group exists (Fiolet et al., 2018; Romaguera et al., 2021). The nine articles are however different in terms of complementary health outcomes. Regardless of the different study designall reviewed studies showed similar and consistent results in that UPFs having negative effects on health. This is in line with development of the NOVA classification for foods and beverages according to the level of processing, that many epidemiological studies have evaluated the relationship between consumption of ultra-processed foods and beverages and their adverse impacts on health.

The evidence presented in this review shows a significant relationship between consumption of UPFs and health problems, in populations aged 18 to 85 years from several countries. A study conducted in the US shows that consumption of UPF increases ad libitum energy intake by approximately 500 kcal/d and causes weight gain compared to consumption of minimally processed food (Hall et al., 2019). Other research also states that UPF intake in the highest quartile was significantly associated with an increased waist circumference ratio (RR, 85% CI) and risk of obesity (RR, 85% CI) as compared with the lowest quartile group (Canhada et al., 2020). Interestingly, the study documented that women tended to be obese. This is most likely influenced by differences in food choices between men and women. The study stated that on average, women had a higher percentage of daily intake that came from processed foods high in carbohydrate and sugar, such as biscuits, cakes, ice cream, ready-to-eat foods, sweet snacks and sweet drinks, when compared to men ($p<0.001$). This explains why women has higher average daily energy intake is believed to contribute to higher incidence of weight gain and abdominal obesity among women (Canhada et al., 2020; Juul et al., 2018).

Another mechanism believed to underlie the contribution of UPF consumption to weight gain and obesity is the nutritional profile of UPF which replaces low-calorie, nutritionally valuable foods and minimally processed foods (J.-C. Moubarac et al., 2014). UPF products are associated with a decrease in the nutritional quality of food as they have a high energy density, contain more sugar, sodium, saturated fat, and trans fat, but less fiber and protein as compared to non-UPFs (Louzada et al., 2015). Foods that are excessively processed tend to have an unfilling effect and stimulate a person to consume large portions. This is because the satiety mechanism in human is more sensitive to the amount of food consumed than the calorie content of food, meaning that foods with high energy density contribute to a person's excessive daily energy intake. This theory is in accordance with previous research stating that concentration of the appetite-suppressing hormone, namely peptide YY, was higher in the minimally processed diet group compared to the excessively processed diet group (Hall et al., 2019).

In addition to obesity, consumption of UPFs is also related to incidence of type 2 diabetes mellitus. Based on the two articles analyzed, it is known that respondents with high consumption of UPF were significantly associated with an increased risk for type 2 diabetes mellitus (Delpino et al., 2022). Analysis by gender showed that men who have moderate intake UPF has a 12% risk of developing diabetes, while in women the risk is 11%. Meanwhile, in the group with high UPF intake, men had a 37% risk and women had a 25% risk of developing diabetes. These are in line with the results of research published by the NutriNet-Sante Prospective Cohort which consistently shows that consumption of UPFs increased the risk of type 2 diabetes mellitus (Srour et al., 2020). Two mechanisms may be involved in this relationship, the first is that energy imbalance caused by high content of added sugars in UPFs results in increased body weight, and this is recognized as a risk factor for the development of type 2 diabetes. In addition, excessive addition of fructose is associated with increased inflammation and oxidative stress which ultimately results in the damage of β-cells so that insulin secretion in the body is reduced (Lustig, 2010). Another mechanism underlying the relationship between UPF consumption and type 2 diabetes is the low fiber content of UPF. As is known, a high fiber diet has an effect on reducing fasting blood glucose levels in people with type 2 diabetes (Silva et al., 2013).

Over the past few decades, it has been known that UPF consumption is significantly associated with an increase in cardiovascular, coronary heart, and cerebrovascular diseases. Based on the two articles reviewed, it is known that there are several factors in UPF processing, such as nutritional composition of the final product, the addition of additives, and the presence of contaminants during processing and packaging, which are believed to have a relationship

with the incidence of CVD (Srour et al., 2019).
The UPF processing causes significant

changes in the matrix, physical structure and nutrition of food. The physical structure of food that is excessively degraded during UPF production can cause cardiometabolic health problems by affecting absorption kinetics, satiety, glycemic response, as well as composition and function of the intestinal microbiota (Juul et al., 2021). An experimental study showed that most of the acellular nutrients in UPFs lead to increased nutrient availability in the small intestine, ultimately causing inflammation of the gut microbiota which is related to cardiometabolic conditions. In addition, excessive energy, fat, and sugar intake is associated with obesity, which is recognized as a major risk factor in the incidence of CVD (Zinöcker & Lindseth, 2018).

Other excessive intake such as sodium in UPF products are also believed to play a role in increasing the incidence of hypertension, which is an established risk factor for CVD and stroke. This is supported by an epidemiological study which states that the increased risk of death from CVD is caused by high sodium intake (He et al., 2020). In addition, heat treatment during the UPF cooking process will produce contaminants in the form of acrylamide as found in French fries, biscuits, and bread, as well as acrolein in grilled sausages. The results of the

NHANES study stated that acrylamide was associated with an increase in CVD cases, whereas according to the Louisville study, acrolein exposure was associated with platelet activation and suppression of angiogenic circulation at the cellular level, thereby increasing the risk of CVD (DeJarnett et al., 2014).

Based on the results of a prospective cohort study conducted by NutriNet-Sante in France in 2018 which was carried out in several population layers, namely men, women, young adults (under 40 years), old adults (over 40 years), smokers and non-smokers, as well as groups with low to moderate physical activity, it is known that the intake of ultra-processed foods and drinks is significantly associated with an increased risk of breast cancer and colorectal cancer. The content of food additives in UPFs is believed to be a driving factor in the incidence of colorectal cancer (Fiolet et al., 2018; Romaguera et al., 2021). Research conducted by the World Cancer Research Institute stated that the group consuming UPFs had significantly higher incidence of colorectal cancer compared to the group that consumed fruit and vegetables. It is thought that the high fiber content found in fruit and vegetables acts as a protector against the incidence of colorectal cancer (Latino- Martel et al., 2016). Another prospective cohort study also reported an association

between UPF intake and the incidence of breast cancer. This is supported by other research which states that there was a significant positive relationship between

glycemic index and glycemic load and the incidence of breast cancer (Rigi et al., 2022). This hypothesis is supported by results from another article being

analyzed which states that high intake of carbohydrate and sugar is associated with breast cancer risk, while low fat and high fiber intake significantly reduces the risk of breast cancer in premenopausal women (Romaguera et al., 2021).

CONCLUSION

UPFs do not only bring low-quality nutrients and ingredients, such as refined carbohydrates, sugar, sodium, fat, and other additives into the diet, but also have potential to replace healthy, minimally processed foods. Our review shows that high intake of UPFs is associated with a variety of adverse health effects, particularly the increased risk of several degenerative diseases. Although it is not yet firmly established, certain processes, compounds, or subtypes of UPFs may be accountable for the affected health outcomes. Therefore, it is important to provide information to consumers regarding the health impacts of UPFs. It is necessary for the stakeholders to develop strategies as well as to enact and implement regulations for food industry regarding the reformulation of UPF products. The importance and benefit of improving the quality of nutritional content and reducing the use of unnecessary food additives should be emphasized at all times. Promoting consumption of food that is not processed or undergoes minimal processing in order to limit UPF consumption is also equally important to improve health in society.

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