Unpacking Ultra-Processed Foods: Exploring The Intersection Of Health, Environment, And Justice For Holistic And Equitable Policy

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Unpacking ultra-processed foods: Exploring the intersection of health, environment, and justice for holistic and equitable policy

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A Thesis Submitted in Fulfillment of the Degree of Master of Public Health
Abstract

This thesis highlights the interdependent mechanisms and impact of ultra-processed foods (UPFs) in relation to health, environment, and justice. It calls attention to the need for UPF policy that establishes synergistic interventions targeting issues across domains and proposes policy mechanisms as an illustrative example of how to achieve this. The intention of this thesis is not to motivate different consumer choices or to tell individuals to avoid UPFs. Rather than targeting consumers, UPF policy needs to hold food corporations responsible for the impact of the products that they’re creating and profiting from, and governments need to have more responsibility for effectively mitigating those impacts through equitable policy. To be both effective and equitable, UPF policy mechanisms must move beyond nutrition and consumer choice and consider frameworks that account for the multidimensional impact of UPFs across domains of health, environment, and justice. UPF policy is not sufficiently prioritized in food system dialogue, and current policy frameworks for UPFs are inadequate for systems-level change. There are opportunities to address this at the federal and state level across branches of government. This thesis is intended to be a resource for practitioners and policy makers to understand the consequences of UPFs across health, environment, and justice, and to be equipped with a conceptual framework and tangible policy mechanisms that address UPF impact across these domains. This thesis consists of (1) an introduction that provides essential background for later sections and summarizes the thesis purpose, (2) a review and synthesis of existing literature on the health, environmental, and justice-related impacts and mechanisms of UPFs, (3) a proposed conceptual framework for integrating these three domains across mechanisms and impacts, and (4) policy mechanism recommendations based on the findings and proposed conceptual framework, categorized by policy goal and by level and branch of government.
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1. Introduction

1.1 Definitions and Scale

*How we define ultra-processed food matters for research and policy.* Centering a clear and functional definition of ultra-processed foods (UPFs) has been a major challenge in the standardization of food classification systems. Globally, foods are most commonly defined using the four-category NOVA food classification framework. A recent systematic review found that 95% of the studies on UPFs and health outcomes published between 2015 and 2019 used the NOVA definition. The NOVA framework is based on degree of processing and defines “ultra-processed foods” (category 4) as foods that are “formulations of ingredients, mostly of exclusive industrial use, typically created by a series of industrial techniques and processes”. A main criticism of the NOVA definition of UPFs is primarily that the classification focuses too much on ingredients and processing types rather than food quality and nutritional value. There is also evidence that the use of the NOVA classification system can lack robustness and functionality, so that even food and nutrition specialists using the same NOVA system classify foods inconsistently. This is particularly true for foods that have conflicting qualities such as a low level of processing but a long ingredient list or a high level of processing but appreciable nutritional value. Alternative food classification systems include: (1) A classification system developed by the International Food Information Council Foundation (IFIC) attempting to establish the contribution of processed foods on nutrient intake in the US, (2) a similar system developed by the University of North Carolina (UNC) with modified categories for representing the American diet, and (3) a system by International Agency for Research on Cancer (IARC) in Europe that defines food categories based on methodology focused on the role of nutrients or phytochemicals on cancer risk. All of these classifications systems are similarly vulnerable to misclassifications of foods due to a lack of clearly defined categories and rigorous frameworks. When considering effective policy mechanisms, how we define ultra-processed foods matters, and inconsistent definitions present challenges for comparing evidence across studies and implementing policy that targets the highest impact foods. A recommended set of compatible definitions is detailed in Section 4 (Policy Recommendations).

*Due to the large scale of UPFs, talking about food systems also means talking about ultra-processed foods, and large food corporations both rely on and continue to drive UPF*
growth. UPFs lead the food supply of high-income countries and are becoming rapidly more prevalent in middle-income countries, with some research proposing that the primary force shaping global food systems is transnational food manufacturing, retailing, and fast food service corporations.\textsuperscript{10} UPFs account for over 50% of all calories eaten in the UK and US and about 20-40% of calories in other high- and middle-income countries.\textsuperscript{11} (See appendix Table A1 for scale of UPF consumption by country using data from Elizabeth et al., 2020). In a 2019 study investigating the domination of UPFs in US food supply through a cross-sectional assessment of all food and beverage products sold in the US in the last three years, 71% of products were classified as ultra-processed.\textsuperscript{12} This includes most store-bought breads, bakery products, snack foods, and ready-made meals. Three categories stand out in the literature for why UPFs dominate: (1) Producer-side low production cost, long shelf life, transportability, and high-profit margins (2) Consumer-side affordability, access, convenience, and hyper-palatability, and (3) Market-advantage through ownership, branding, and aggressive marketing by transnational corporations.\textsuperscript{10} Ultimately, the dietary dominance and continued rise of UPFs globally is driven by large corporations in pursuit of maximizing profits and short-term shareholder returns.\textsuperscript{13} Understanding the scale and dominance of UPFs and why they are continuing to grow is essential for shaping policy that targets more than just consumer choice.

1.2 Contextualizing UPFs Across Health, Environment, and Justice

The impacts of UPFs are most commonly examined through a health-focused, nutrition-based lens, leaving out necessary environmental and justice-based perspectives. While decades of research have documented the connection between UPFs and greater disease burden across proposed mechanisms and health outcomes, more recently attention has been brought to understanding the environmental consequences of UPFs (both detailed in Section 2). Similarly, both research and policy have historically tackled UPFs from a consumer-centered perspective of personal choice, often leaving out the justice-based social, political, and economic drivers of UPF consumption (also detailed in Section 2). Ultimately, talking about UPFs from solely nutrition-based health perspectives ignores other consequences and factors in effect. UPFs are a serious environmental and health issue that disproportionately impacts vulnerable populations. Dimensions of health, environment, and justice must all be considered synergistically for UPF policy that is both effective and equitable.
1.3 Thesis Purpose and Objectives

This thesis highlights the interdependent mechanisms and impact of ultra-processed foods in relation to health, environment, and justice. It calls attention to the need for UPF policy that establishes synergistic interventions targeting issues across domains and proposes policy mechanisms as an illustrative example of how to achieve this. The intention of this thesis is not to motivate “healthy” consumer choices or to tell individuals to avoid UPFs. Rather than targeting consumers, UPF policy needs to hold food corporations responsible for the impact of the products that they’re creating and profiting from, and governments need to have more responsibility for effectively mitigating those impacts through equitable policy. To be both effective and equitable, UPF policy mechanisms must move beyond nutrition and consumer choice and consider frameworks that account for the multidimensional impact of UPFs across domains of health, environment, and justice. UPF policy is not sufficiently prioritized in food system dialogue, and current policy frameworks for UPFs are inadequate for systems-level change. There are opportunities to address this at the federal and state level across branches of government. This thesis is intended to be a resource for practitioners and policy makers to understand the consequences of UPFs across health, environment, and justice, and to be equipped with a conceptual framework and tangible policy mechanisms that address UPF impact across these domains.

The main body of this thesis consists of (1) a review and synthesis of existing literature on the health, environmental, and justice-related impacts and mechanisms of UPFs, (2) a proposed conceptual framework for integrating these three domains across mechanisms and impacts, and (3) policy mechanism recommendations based on the findings and proposed conceptual framework, categorized by policy goal and by level and branch of government. The thesis closes with discussion and conclusions.

2. Review and Synthesis of Existing Literature
2.1 Health Impacts and Mechanisms

Health Impacts

UPFs are associated with increased risk for many non-communicable diseases, even when research methods vary significantly. A large number of epidemiological, nutritional, and dietary studies have called attention to a link between consumption of UPFs and increased risk of chronic illness and non-communicable diseases, including type 2 diabetes, hypertension, cardiovascular diseases, cancer, depression, and higher all-cause mortality. A review by Elizabeth and colleagues (2020) found that from 43 peer-reviewed studies published since the publication of the NOVA definition, 37 concluded that dietary exposure to UPFs is associated with at least one adverse health outcome. Using data from seven recent reviews and meta analyses and the individual studies included in these, particularly the 2020 summary review by Elizabeth et al., the associated risks for each condition are detailed below (all for adult populations). This is intended to provide an illustrative, quantitative overview of UPF risks for specific health outcomes, rather than a comprehensive inclusion of every available study. These significant and well documented impacts of UPFs across chronic disease categories and all-cause mortality indicate that UPFs should be central to food system policy.

Type 2 diabetes. When adjusting for known risk factors (e.g. sociodemographic, lifestyle, medical history) recent research by Srour et al. (2020) found that a 10% increase in dietary UPF intake was linked to a 15% increased type 2 diabetes risk. A meta-analysis of prospective cohort studies by Vitale et al. (2024) cites a 37% increased risk of developing diabetes associated with UPF consumption.

Hypertension. After adjusting for potential confounders, Mendonça et al. (2017) found a 21% increased risk of developing hypertension for those in the highest tertile of UPF intake when compared to the lowest tertile (with intake estimated using the sum of UPF items from completed food frequency questionnaires). A meta-analysis of prospective cohort studies by Vitale et al. (2024) cites a 32% increased risk of developing hypertension associated with UPF consumption.

Cardiovascular diseases. In a large 2019 observational prospective cohort study with a median follow-up of 5.2 years, Srour et al. found that those in the highest quartile of UPF intake had an 11% increased risk of cerebrovascular disease, a 12% increased risk of cardiovascular
disease, and a 13% increased risk of coronary heart disease.\textsuperscript{22} A 2021 analysis of prospective cohort studies by Pagliai et al. found higher associated risk, with a 29% increased risk of cerebrovascular disease incidence and/or mortality and a 34% increased risk of cerebrovascular disease.\textsuperscript{16}

**Cancer.** A case-control study by Quiroz et al. (2018) found that routine consumption of UPFs (greater than 5 days per week) was associated with a 2.35 times higher odds of developing breast cancer.\textsuperscript{14,23} Similarly, a 2018 longitudinal study by Fiolet et al. concluded that each 10% increase in proportion of UPF dietary consumption was associated with an 11% higher risk for developing breast cancer and a 12% higher risk for cancers overall.\textsuperscript{14,24}

**Depression.** An analysis of prospective cohort studies by Pagliai et al. (2021) found an associated 20% increase in the risk of depression with UPF consumption.\textsuperscript{16} A review of 43 observational studies by Lane et al. (2021) similarly found that high UPF consumption was associated with a 22% increased risk of depression.\textsuperscript{15}

**Higher all-cause mortality.** In a large study (>44k sample size), Schnabel et al. (2019) found that a 14% increased risk of all-cause mortality was statistically significantly associated with each 10% increment in UPF proportion consumed (measured by weight).\textsuperscript{25} In three separate studies, for those in the highest quartile of UPF consumption, Kim et al. (2019) found a 31% increased risk of all-cause mortality (intake measured by frequency/day)\textsuperscript{26}, Blanco-Rojo et al. (2019) found a 44% increased risk of all-cause mortality (intake measured by percent energy)\textsuperscript{27}, and Rico-Campà et al. (2019) found a 62% increased risk of all-cause mortality (intake measured by servings per day)\textsuperscript{28}.

As highlighted in a recent meta-analysis of prospective cohort studies by Vitale and colleagues (2024), existing studies investigating UPF impact on health differ significantly on methods, particularly the operational definition of UPFs used to categorize foods and the methodology used to assess UPF intake.\textsuperscript{18} Although the vast majority of studies use the NOVA classification system, the method sections of these studies typically do not establish the specific foods within the classification system that were investigated in the study (e.g. whether soft drinks were included along with foods), presenting difficulty in establishing which specific foods were studied. This heterogeneity in methods creates difficulties for accurate comparison of results across studies, as the value of health risks can fluctuate significantly based on cohort type and
level of total UPF intake.\textsuperscript{3,18} Despite this variability in methods of exposure assessment, systematic reviews and meta-analyses of epidemiological evidence consistently find a positive association between UPF intake and disease risk.\textsuperscript{3,18} These persistently differing methods and definitions still indicate a need to set standard approaches for estimation of UPF intake in epidemiological studies and for an expanded definition of UPFs that has more clear inclusion criteria for classification.

**Mechanisms: Nutrition and Food Matrices**

*Research doesn’t indicate a clear, single mechanism of harm for UPFs on health, but environmental impact and justice are typically left out.* In addition to the differing analytical methods detailed above, multiple mechanisms of action for UPF effects on health have been investigated. A significant portion of UPF studies highlight nutritional content and processing (destruction of food matrices) as primary modes of actions for UPF intake on health. Nutritional mechanisms include pathways of higher caloric intake and poorer average nutritional quality (e.g. higher saturated and trans fatty acids, salt, and added sugars with lower fiber, vitamin, and micronutrient content).\textsuperscript{18} For example, a 2020 study by Srour et al. on UPF intake and risk of type 2 diabetes found that higher intake of UPFs was associated with lower nutritional quality (using the FSAm-NPS DI diet index), higher consumption of sodium, sugar, and saturated fatty acids, lower intakes of fiber, higher consumption of red and processed meats, and lower intake of whole grains, fruits, and vegetables.\textsuperscript{20} Distinct but related, degree of processing defines the NOVA classification system and involves the disruption of food matrices as a mechanism of action on health. According to implications highlighted in a review by Aguilera in 2019, this includes disruptions of nutrient content, impact on bioavailability of nutrients, and effect on digestion and satiation.\textsuperscript{29} Despite the prevalence of both as proposed mechanisms, nutritional content and degree of processing can be at odds with each other, particularly when considering caloric intake.\textsuperscript{6} For example, diet soft drinks with artificial sweeteners are categorized as ultra-processed foods by NOVA, but have a lower caloric value than fruit juice with no added sugar, which are categorized as unprocessed or minimally processed foods by NOVA.\textsuperscript{17}

**Mechanisms: Additives and Chemical Contamination**

*When controlling for energy intake and nutritional quality of diet, UPFs are still associated with higher health risk, indicating that other mechanisms of action are involved.*\textsuperscript{17} Outlined in this 2022 meta-analysis of UPF mechanisms of impact on health by Srour and
colleagues, other important mechanistic considerations include contamination from packaging (e.g. phthalates, bisphenols, nanoparticles), contamination from processing (e.g. acrolein, acrylamide, industrial trans fatty acids), and use of additives (e.g. emulsifiers, colorants, artificial sweeteners, flavoring agents). Possible effects of these include impact on the gut microbiome and intestinal inflammation. Notably, discussion around nutrition-based mechanisms of action tends to focus significantly on individual personal choice as a driving factor for UPF health impacts, while discussion around other mechanisms, such as contamination from packaging, tend to put more responsibility on UPF manufacturers than consumers. It remains unclear which mechanism contributes most to the health impacts of UPFs, and greater understanding of how each mechanism contributes is needed. However, even if a single mechanism dominates UPF health impacts, these mechanisms of harm ultimately act synergistically, underscoring the need for policy frameworks that effectively address multiple domains of harm.

2.2 Environmental Impacts and Mechanisms

Environmental Impacts

Greenhouse gas emissions, pollution of water, and soil, loss of both natural and agricultural biodiversity, packaging waste, and high resource use (e.g. land, energy, water) have all been linked to the life-cycle of UPFs. For the purposes of narrowing scope and directing targeted policy recommendations, this thesis addresses the post-agricultural stages of UPFs (with the exception of agrobiodiversity loss). This includes the environmental impacts of UPF processing, packaging, distribution, and consumption (detailed in Anastasiou et al., 2022), which allow for greater isolation of the role of UPFs specifically, rather than general food system impacts. Specific mechanisms investigated are energy inputs, greenhouse gas emissions, packaging waste, pollution, and agrobiodiversity loss, due to the contributions of these categories to direct environmental degradation as well as health consequences. The environmental impact of UPF-related food waste and water use are intentionally not detailed due to the lack of clarity and consensus on whether UPFs contribute more to these areas than less processed foods.

Mechanisms: Energy Inputs and Greenhouse Gas Emissions

The high energy and greenhouse gas requirements of UPFs differ from other food categories particularly during the processing, packaging, and distribution stages, and the environmental impacts of this are avoidable, as UPFs are not essential for nutrition. Studies
included in a 2022 review by Anastasiou and colleagues reported that the whole life-cycle of UPFs accounted for between 17 and 39% of total diet-related energy use in Australia and Sweden and up to one-third of total diet-related greenhouse gas emissions in Australia and areas of Europe.\textsuperscript{31} Research in France by Kesse-Guyot and colleagues (2022) found that although UPFs represented 19% of the diet (far less than the US and UK), UPFs were responsible for 24% of dietary greenhouse gas emissions and 26% of energy demand.\textsuperscript{34} A time-series study by Silva et al. (2021) found that between 1987 and 2018 greenhouse gas emission from NOVA group 4 foods (ultra-processed foods) increased by 245%, while no change was found for group 1 foods (unprocessed and minimally processed foods) and greenhouse gas emissions decreased by 18% for group 2 foods (processed culinary ingredients).\textsuperscript{35} In the context of decreasing food system contributions of energy use and greenhouse gas emission to climate change, UPFs should be a central policy focus, as their contributions are largely unnecessary and avoidable.

**Mechanisms: Packaging Waste and Pollution**

Packaging waste remains one of the clearest contributions of ultra-processed foods when compared to less processed alternatives. There is a major research gap in studying the full impacts of specifically UPFs on packaging waste. However, studies on litter type frequently find that most debris comes from food packaging.\textsuperscript{36} A study in Brazil identified food-related packaging as the most frequent type of litter on beaches, with nearly all debris found across three beaches being primarily food-related items (e.g. plastic cups, soft drink bottle caps, lollipop sticks).\textsuperscript{37} Within the synthetic plastic market, food packaging is the largest and most rapidly growing sector. Nearly two thirds of global manufactured packaging materials (e.g. plastic, paper, glass, etc.) are used in the food sector alone, and food packaging is responsible for 50% of fossil-fuel-derived plastics in the packaging industry.\textsuperscript{38} While less processed foods can contribute to packaging waste, one of the defining features of the NOVA classification of UPFs is packaging, with nearly all UPFs involving packaging of some kind, most frequently plastic.\textsuperscript{39} The production of packaging is also one of the primary drivers of UPF-related energy use.\textsuperscript{32} Along with contributing to material waste pollution, UPF packaging contains a number of emerging contaminants and other chemicals that are harmful to the environment and human health, including per- and poly-fluorinated alkyl substances (PFAS), phthalates, perchlorate, benzophenone, and bisphenol A (BPA).\textsuperscript{40,41} When UPF packaging is broken down in landfills, these chemicals leach into soil and groundwater, presenting both environmental and health
risks. Microplastic pollution from breakdown of UPF packaging is also a significant consideration.

**Mechanism: Agrobiodiversity Loss**

*UPFs have a greater impact on agrobiodiversity than minimally-processed or unprocessed foods due to high inputs of monoculture crop species (e.g. wheat, soy, rice, corn) and land degradation due to intensive farming practices.* Defined as the variety and variability of species used for food and agriculture, global agrobiodiversity is declining, particularly in relation to species used for human consumption. Due to the high inputs of mass-produced, monoculture crops used in UPFs, as global diets become increasingly processed, they also become less diverse. Similarly, as demand for the industrial crops used in UPFs rises, the demand for diverse crop species decreases. For example, from 2008 and 2019 in Brazil, land area used for soy production, a crop primarily used for animal agriculture and UPF production, increased by 69.9% while land area for beans, a previously diverse food crop, decreased by about 30%. The agrobiodiversity-related consequences of UPFs is under-prioritized in global food policy dialogue, and there are significant research gaps in tangibly quantifying the impact of UPFs on agrobiodiversity. These UPF mechanisms of environmental harm also have significant implications for health and justice (detailed in Section 3), presenting policy potential for wide, systems-level impact.

### 2.3 Justice Impacts and Mechanisms

**Justice Impacts**

*Social justice can’t be left out of UPF policy when inequitable food access, targeted marketing, and other powerful socio-economic and political drivers underlie the health and environmental impacts that UPFs are increasingly associated with.* Both research and policy have historically tackled UPFs from a nutrient-based, consumer perspective of personal choice, leaving out the historic and systematic social, political, and economic drivers of UPF consumption. The justice-related mechanisms of UPFs result in vulnerable, low SES populations being impacted most by UPFs, resulting in diet-related health inequities and exacerbating existing risks for chronic health outcomes and environmental exposures.
Mechanisms: Access, Availability, and Affordability

Globally, research has demonstrated that lower SES households tend to purchase higher quantities of UPFs than higher SES households, and UPFs tend to be a higher proportion of total daily food purchased for lower SES households.\textsuperscript{48,49} Greater UPF consumption has also been associated with lower income, lower educational attainment, and higher rates of food insecurity.\textsuperscript{50–52} In the US, historic redlining of neighborhoods along with subsequent supermarket redlining practices have left many low-income areas with limited access to fresh, unprocessed foods.\textsuperscript{53–55} There is also evidence of higher availability of UPFs in supermarkets that are located in low-income areas. Despite their high processing requirements, UPFs are inexpensive to produce, in part due to factors of subsidized crop inputs, mass manufacturing, and corporate scale.\textsuperscript{10} This creates a foodscape in which UPFs are more affordable for consumers than less processed and fresh foods, and vulnerable populations are often forced to choose between health and costs.\textsuperscript{56}

Mechanisms: Marketing and Hyper-palatability

From the supply side, low SES areas are exposed to more UPF advertisements than higher SES areas\textsuperscript{57}, and some UPF advertising specifically targets children.\textsuperscript{58,59} Additionally, UPFs are formulated to be hyperpalatable and contain ingredients that have been demonstrated to be addictive in nature.\textsuperscript{60–62} The targeting marketing of vulnerable populations along with the presence of ingredients intended to promote continued consumption, highlight a need for justice-centered frameworks in UPF policy. Overall, there is a gap in research investigating the justice-related impacts of UPFs, particularly in relation to health and environmental outcomes.

3. A Conceptual Framework for Integrating Health, Environment, and Justice

3.1 Relationships Between Each Domain

The UPF impacts domains of health, environment, and justice cannot be siloed. The health impacts from increased environmental degradation and contamination due to UPFs is largely missing from the literature for UPF mechanisms of harm on health. Chemical exposures from packaging waste and breakdown, diminished dietary diversity from agrobiodiversity loss, and climate change-related exposures all associated with negative health impacts.\textsuperscript{63–65} Due to
these environmental consequences, UPFs have much wider health impacts that extend beyond the direct mechanisms detailed in Section 2.1, and the health impact of UPFs are under quantified by looking at direct impacts alone. Similarly, the highlighted justice mechanisms above indicate that the populations who are targeted most by UPF marketing and who have the least access to minimally processed foods also consume the highest amounts of UPFs. These populations then face diet-related health inequities and disproportionately increased risk of noncommunicable disease and mortality associated with UPF consumption. Vulnerable populations are also disproportionately impacted by the environmental consequences associated with UPFs (e.g. climate change, proximity to landfills, chemical pollution).66–68 These indirect justice impacts of the UPF health and environmental mechanisms of harm exacerbate the inequity associated with UPFs. We have to consider how health impacts, environmental consequences, and justice considerations are intertwined and leverage the influence of each for holistic and equitable UPF policy.

3.2 A Conceptual Framework for Integration Across Domains

This thesis proposes a conceptual framework that integrates the impact of UPF mechanisms of harm across the domains of health, environment, and justice (Figure 1). The health mechanisms use data from a meta-analysis conducted by Srour et al. (2020), the environmental mechanisms use data from a conceptual framework proposed by Anastasiou et al. (2022), and the justice mechanisms are adapted from various literature cited in Section 2.3.

*Figure 1. A conceptual framework for integrating health, environment, and justice perspectives for UPF policy*
**Figure 1.** Figure depicting the intersection of health, environment, and justice for UPF mechanisms of harm and impacts. Mechanisms are included in the outside circle of each domain and impacts are included in each overlapping section. The primary impact associated with each domain is directly below each domain title. This figure was made using draw.io.
4. Policy Recommendations

4.1 Current UPF Policies and Key Gaps

Current UPF policies fail to address the systems-level issues that contribute to the true cost of UPFs for health and the environment and fail to adequately center justice. Few countries have policies that directly regulate UPFs, and only 7 countries’ official dietary recommendations explicitly recommend consuming less UPFs. Out of 25 total US policy actions addressing processed food identified in a review by Pomeranz et al. (2023), the majority of policies were related to children’s nutrition (n=14) in the context of childcare facility meals and school food. A significant theme that emerged from Pomeranz and colleagues’ policy review was also food price, in recognition that (1) the farm share percentage for highly processed products is lower than for less processed foods and (2) there is an inverse association between higher levels of food processing and lower prices of food.69 Globally, taxation of UPFs has been a dominant policy for limiting consumption of UPFs, including sugar-based taxes, and over 45 countries and subregional entities have implemented taxes on ultra-processed drinks (e.g. sugar-sweetened beverages).70,71 Packaging labeling has also been a significant policy focus, with a few countries implementing warning labels on UPFs.70,71

While these policies of taxes and labeling can have some mitigating effect, they target consumers rather than UPF manufacturers. This presents significant justice issues when considering the affordability of UPFs when compared to less processed food as well as the social, political, and economic drivers of UPF consumption. Further, few policies target the environmental impacts of UPFs or the health impacts beyond nutrition, and there is a significant lack of policies that seek to drive systems-level and system-wide change across multiple domains, rather than focusing on singular, isolated regulatory approaches.72 Policy mechanisms that cross multiple system domains are needed to drive actionable change. As highlighted by Northcott and colleagues (2023), historic and current food policy frameworks primarily seek to address structural aspects of food systems (e.g. prices, labels, food composition). This approach does not address the deeper layers of influence that shape these systems (e.g. inequitable food access, food corporation marketing and influence, government subsidies, environmental impacts, barriers to effective research).72 In the case of UPFs, isolated policy actions can’t achieve the systems-level change that is needed.73 A combined, synergistic approach to regulation more
effectively propels systems transformation for UPFs and, when implemented across domains of health, environment, and justice, promotes policy that is both holistic and equitable.

4.2 Recommended Policy Mechanisms

**How UPF policy goals can cross domains of health, environment, and justice**

Using the conceptual framework developed in this thesis (Section 3), a given UPF policy goal can leverage mechanisms within each domain (Table 1). This allows for policies to work synergistically across areas of impact and aims to advance equity across UPF policy mechanisms, in order to mitigate potential for the furthering of inequities through isolated policy implementation. These policy mechanisms can then be categorized by level and branch of government (Table 2) in order to direct where these policy changes can occur. Government agencies responsible for each mechanism are also identified in Table 2 where possible. The color key for each domain is as follows: Health (blue), Environment (green), Justice (purple).

Given the evidence synthesized in this thesis and the proposed conceptual framework for integrating the health, environment, and justice impacts of UPFs, this thesis recommends the following policy mechanisms. These recommendations are intended to be illustrative rather than comprehensive. Selected examples are explored further following Table 2.

**Table 1. Leveraging mechanisms across domains for UPF policy goals**

<table>
<thead>
<tr>
<th>(Policy Mechanisms)</th>
<th>Domain</th>
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<tbody>
<tr>
<td></td>
<td><strong>Health</strong></td>
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<tr>
<td><strong>Goal</strong></td>
<td>Decrease UPF consumption</td>
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<tr>
<td></td>
<td>Taxes on UPF products</td>
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<tr>
<td></td>
<td>Health warning labels for high impact UPFs</td>
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<tr>
<td></td>
<td>Taxes on UPF companies (on the basis on market failure due to unaccounted for environmental impact)</td>
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<td></td>
<td>Educational campaigns about the environmental impacts of UPFs</td>
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<tr>
<td></td>
<td>Target subsidies for unprocessed or minimally processed foods</td>
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<tr>
<td><strong>Improve access to healthy food</strong></td>
<td><strong>Subsidize unprocessed or minimally processed foods for food banks</strong></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Limit influence of UPF industry</strong></td>
<td><strong>Restrict corporate marketing and media campaigns of UPFs through taxes on advertising (on the basis on health impacts)</strong></td>
</tr>
<tr>
<td><strong>Regulate harmful additives</strong></td>
<td><strong>Ban industrial food additives with documented health impact</strong></td>
</tr>
<tr>
<td><strong>Control packaging waste and pollution</strong></td>
<td><strong>Require labeling of packaging with harmful chemicals (focus on emerging contaminants - e.g. PFAS/PFOA)</strong></td>
</tr>
</tbody>
</table>
Improve definition of UPFs for more effective, unified research

Expand UPF definition to consider both the level of processing in food products and the product's nutritional components

Add UPF definitions that consider the largest environmental impacts

Add UPF definitions that consider the largest justice-related impacts

Table 1. Using the conceptual framework developed in this thesis (Section 3), six policy goals are matched with recommended policy mechanisms across domains for health, environment, and justice. These recommendations are intended to be illustrative rather than comprehensive.

Table 2. Categorizing UPF policy mechanisms by level and branch of government

<table>
<thead>
<tr>
<th>(Policy Mechanisms)</th>
<th>Level of Government</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Federal</td>
</tr>
</tbody>
</table>

Goal: Decrease UPF consumption (consumer side)

**Legislative:**
Federal taxes on UPF products (FDA)

Federal taxes on UPF companies (on the basis on market failure due to unaccounted for environmental impact)

Executive:
Federal subsidies for unprocessed or minimally

**Legislative:**
State taxes on UPF products

State taxes on UPF companies (on the basis on market failure due to unaccounted for environmental impact)

Executive:
State-level subsidies for unprocessed or

**Non-governmental:**
Educational campaigns about the environmental impacts of UPFs
<table>
<thead>
<tr>
<th>Processed foods (USDA)</th>
<th>Minimally processed foods</th>
<th>Improve healthy food access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health warning labels for high impact UPFs (FDA)</td>
<td><strong>Executive:</strong> Expand food assistance programs (e.g. SNAP) to include farmers markets (USDA - FNS; US Farm Bill)</td>
<td><strong>Executive:</strong> Reform agricultural subsidies (USDA) State-level support and administration of the expansion of food assistance programs (e.g. SNAP) to include farmers markets</td>
</tr>
<tr>
<td><strong>Legislative:</strong> Mitigate supermarket redlining (Local zoning authority)</td>
<td><strong>Executive:</strong> Expand access to grocery stores and supermarkets in areas with low food access through free transportation (Local transportation authority)</td>
<td></td>
</tr>
</tbody>
</table>

| Limit influence of UPF industry | **Legislative:** Restrict corporate marketing and media campaigns of UPFs through taxes on advertising (on the basis on health impacts) | **Legislative:** Restrict corporate marketing and media campaigns of UPFs through taxes on advertising (on the basis on environmental impacts) | **Legislative:** Ban targeted marketing of UPFs to disadvantaged populations at the state level |

<p>| Regulate harmful additives | <strong>Legislative:</strong> Ban industrial food | <strong>Legislative:</strong> Ban industrial | — |</p>
<table>
<thead>
<tr>
<th>Control packaging waste and pollution</th>
<th>Executive:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ban industrial food additives with documented health impact at the federal level</td>
<td>Redistribute profits from UPF corporations to fund health services</td>
</tr>
<tr>
<td>Ban industrial food additives with documented environmental impact (e.g. when released as waste materials or when broken down in landfills) at the federal level</td>
<td></td>
</tr>
</tbody>
</table>

**Executive:**

Redistribute profits from UPF corporations to fund health services

**Legislative:**

Require labeling of packaging with harmful chemicals (focus on emerging contaminants - e.g. PFAS/PFOA) (FDA)

**Executive:**

Regulate use and disposal of packaging through the Toxic Substances Control Act (EPA)

Redistribute profits
from UPF corporations to fund environmental cleanup initiatives

<table>
<thead>
<tr>
<th>Improve definition of UPFs for more effective, unified research</th>
<th>Non-Governmental:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standardize UPF definition that considers both the level of processing in food products and the product's nutritional components (Pokin et al., 2024)</td>
</tr>
<tr>
<td></td>
<td>Expand UPF definition to consider the largest environmental impacts</td>
</tr>
<tr>
<td></td>
<td>Expand UPF definition to consider the largest justice-related impacts</td>
</tr>
</tbody>
</table>

Table 2. The recommended policy mechanisms from Table 1 are organized by level and branch of government in order to direct where these policy changes can occur. These recommendations are intended to be illustrative rather than comprehensive.

Selected Examples for Deeper Exploration

The evidence base and feasibility of four of the above recommended policy mechanisms are explored further below. Previous exploration and support of these policy mechanisms in the literature are detailed. A list of other potential policy mechanisms is also included, with cited evidence that supports the potential of implementation.

I. Standardizing the definition of UPFs at the government level and integrating justice and environmental consequences

Of the 25 policies addressing processed food that were identified by Pomeranz et al. (2023), only 1 policy directly defined ultra-processed food. In 2015, when the National Academy of science recommended that the U.S. Department of Agriculture (USDA) limit highly processed meats in the Child and Adult Care Food Program (CACFP), the recommendation was rejected due to the anticipated challenges of defining UPFs as a category. In contrast, Brazil’s new requirement for food provided in schools defines and directly prohibits the sale of UPFs. The lack of consensus on how to define UPFs at the policy level, along with the research and
policy barriers that exist when a clear functional definition isn’t available, calls for a standardization of the definition of UPFs and an expansion to include more clear inclusion criteria. Popkin and colleagues (2024) call for a definition that considers both the level of processing in food products, but also the product's nutritional components.\textsuperscript{75} Their study results demonstrate that combining criteria for food high in saturated fat, salt, and sugar (HFSS) and criteria for UPFs (using the NOVA system) can be effectively used for consistent, simple identification and categorization of products.\textsuperscript{75}

However, to have a more effective, justice-centered conversation about the impacts of ultra-processed foods, we need to expand the definition of UPFs beyond solely the inputs of food manufacturing and towards including the outcomes of food manufacturing. The definition of UPFs should include elements of health, environmental, and justice outcomes. Using the evidence-based results of Popkin et al. (2024), an operational definition of UPFs at the policy level could combine existing HFSS and UPF criteria but include additional definitions that help to grade and target UPFS by lowest and highest impact. Questions that need to be asked are which UPFs, as categorized by this health-based criteria, also have the largest environmental consequences? (e.g. Is it those with the highest input of monoculture crops? The highest inputs of plastic packaging? The highest associated greenhouse gas emissions?), and which UPFs present the largest justice-related consequences? (e.g. Is it those marketed the most to children? Marketed the most as “health foods” when they are not? Used most often as substitutes for fresh, unprocessed foods?). These more holistic, additional definitions can then direct what needs to be addressed within effective UPF policy.

This thesis proposes definitions for low, medium, and high impact UPFs below, to direct research and policy that targets higher impact UPFs across domains of health, environment, and justice. Note, the beginning of each proposed definition below uses the exact language of the existing NOVA definition of UPFs and is then built on using original language. Future definitions should include exhaustive detail of what is included in each definition category, in order to provide adequate clarity and functionality.

\textit{Proposed definitions}

- \textbf{Low impact UPFs:} Foods made from formulations of ingredients, mostly of exclusive industrial use, typically created by a series of industrial techniques and processes that have \textit{low} quantities of industrial additives
(e.g. colorants, flavors, emulsifiers) and have moderate nutritional value (e.g. only moderately high in saturated fat, salt, and sugar). These foods typically have minimal packaging with low chemical contamination risk from packaging and are not typically disproportionately marketed to vulnerable populations. Foods in this category may also seek to mitigate environmental impact (e.g. plant-based meat alternatives) or have cultural or religious significance (e.g. gefilte fish, spam). Other examples: fruit yogurt, sweetened breakfast cereal, plant-based protein powders.

- **Medium impact UPFs:** Foods made from formulations of ingredients, mostly of exclusive industrial use, typically created by a series of industrial techniques and processes that have moderate quantities of industrial additives (e.g. colorants, flavors, emulsifiers) and low to moderate nutritional value (e.g. moderate to high in saturated fat, salt, and sugar). These foods typically have significant packaging with moderate chemical contamination risk and are sometimes disproportionately marketed to vulnerable populations. Examples: instant soups in plastic containers, mass-produced bread, pre-prepared frozen pizzas.

- **High impact UPFs:** Foods made from formulations of ingredients, mostly of exclusive industrial use, typically created by a series of industrial techniques and processes that have high quantities of industrial additives (e.g. colorants, flavors, emulsifiers) and very low nutritional value (e.g. very high in saturated fat, salt, and sugar). These foods typically have heavy packaging with high chemical contamination risk from packaging and are often disproportionately marketed to vulnerable populations. Examples: pre-prepared instant meals in microwave plastic packaging, mass-produced bakery products and candies, sodas and carbonated drinks, packaged snacks with high industrial additives and high HFSS.

II. Pairing subsidies with taxes to reduce cost disparities between ultra-processed and fresh foods
There is evidence that taxes on UPFs or HFSS foods do result in decreasing sales, with the most significant reduction of purchases seen in low-income groups. However, these taxes must be paired with subsidies for fresh, unprocessed or minimally processed foods to avoid regressive financial impacts and furthering of food access inequities. Recently demonstrated by Valizadeh & Ng (2024), national taxes on UPFs, when paired with targeted subsidies on minimally processed and fresh food, can be an effective mechanism for reducing the consumption of UPFs while improving access to alternatives that aren’t detrimental for health, with the largest impact on low-income households.

III. Banning targeted marketing of UPFs to disadvantaged populations

In the US policy review by Pomeranz et al. (2023), only 2 policies addressed food marketing, restricting the ability of highly processed food manufacturers to label food as natural and to market specifically to children. UPF industry marketing and media influence could be regulated through taxes on advertising or, as proposed by Wood et al. (2023), by leveraging competition law and enforcement. For example, the unsustainable practices of UPF corporations and the financially backed marketing of their products could be characterized as abuses of market dominance on the basis of unjust competitive advantage.

IV. Expanding food assistance programs to include farmers markets

Food assistance programs like USDA Supplemental Nutrition Assistance Program (SNAP) benefits are widely accepted at grocery stores, supermarkets, and other chain stores that also sell food such as Dollar Trees, Dollar General, and Five Below. These convenience store retailers often sell high quantities of UPFs and limited fresh food options. Farmers markets that are able to accept SNAP benefits are much more limited, and access varies significantly across US states. For example, in the USDA’s 2023 list of SNAP Authorized Farmers Markets, 39 farmers markets in CT are listed, compared to only 6 in Arkansas (states with comparable populations). Expanding farmers markets that accept food assistance could help expand access to fresh, health-promoting foods and mitigate the impacts of UPFs.

V. Other cited potential policy mechanisms

- Limit the influence of industry in food policy making
When considering regulations within the food industry, we have to center the reality that food and beverage companies regularly seek to prevent compulsory regulation, pushing for self-regulation instead (e.g. through corporate responsibility pledges), and often influence research through funding institutions to provide evidence that undermines the basis for compulsory regulations.  

- Redistribute profits from UPF corporations to fund health services and environmental initiatives.  
- Restrict supermarket redlining and expanding grocery store access.  
- Reform agricultural subsidies.

5. Discussion and Conclusions

Discussion

This thesis aimed to critically investigate the intersection of the health, environmental, and justice impacts of UPFs and the significance of implementing UPF policy that integrates solutions across domains. The findings address three key topic areas that can help direct effective policy mechanisms for regulating UPFs and mitigating their impacts: (1) There is significant, peer-reviewed evidence that UPFs have associated health, environment, and justice-related consequences that are quantifiable and measurable, (2) integrating these impact domains in policy is more effective and equitable than either separately—isolated policy mechanisms for UPFs are ineffective for the systems-level changes that are needed, and (3) justice must be a part of UPF policy to prevent regressive regulations and furthering of inequities. While the literature synthesis of this thesis has a global scope and the proposed conceptual framework can be applied globally, the recommended policy mechanisms are intended for US policymakers, with the possibility of adaptation for other national contexts.

This thesis has several strengths and limitations. Strengths include its flexible and practical scope, synthesis of diverse sets of literature and resources, and proposal of a novel framework for considering UPF impacts and policy. Additionally, this thesis goes beyond synthesizing existing issues and analyzing them in a unique framework, to providing concrete policy mechanisms for addressing these issues within the proposed framework. A primary limitation is the non-systematic narrative review approach, introducing risk for potential biases.
in the literature selection process due to no pre-defined or fully replicable methodology. Secondly, the literature synthesis of health, environment, and justice impacts in this thesis is intended to be illustrative rather than entirely comprehensive of all literature available in each domain. Additionally, in order to narrow scope, this thesis does not cover the role of fast food in UPF impact, but this is an important and significant dimension of ultra-processed foods. Third, the current body of work on UPFs is relatively new. While there is extensive literature available, there are many current research gaps. Future research should seek to address the highlighted gaps, including more thoroughly investigating the contributions of specifically UPFs to environmental degradation (e.g. packaging waste, contributions to climate change), and other potential environmental and health consequences such as the impacts of food processing wastewater. This sphere of study would also benefit from future research that investigates the feasibility of the additional listed policy mechanisms and furthers current understandings of applying systems thinking to UPF policy.

Conclusion

Ultra-processed foods are a critical health, environmental, and justice issue that disproportionately impacts vulnerable populations and results in increased disease burden for human health and heightened degradation for the environment. These impacts and mechanisms of harm are inextricably intertwined, and historic siloing of solutions in UPF policy inhibits meaningful progress. To enhance efficacy and center equity, policy action should seek to hold food corporations, rather than consumers, responsible for the products they profit from and should consider frameworks that integrate solutions across multiple systems of impact.

6. Methods

Due to the large and interdisciplinary scope of the investigated themes and the complex nature of using existing literature to inform specific policy mechanisms, a narrative review method was used to achieve these objectives. This thesis sought to address the following questions:

- What are the primary implications (impacts and mechanisms of action) of UPFs for health, environment, and food justice?
- How do the impacts of UPFs intersect across these three domains?
• What policy mechanisms can be leveraged to help holistically and actionably address the issues highlighted in the review?

The literature search used the ScienceDirect, Scopus, Google Scholar, and Lens databases as well as a manual snow-ball method search to identify additional relevant papers through the reference sections of other sources. The search was limited to the past 15 years (2009-2024), in English only, and included both peer-reviewed articles and gray literature. Particular focus was given to meta-analyses and systematic reviews. There were no limitations of country or academic field. The literature search used the following keywords, categorized into 3 concept areas, with AND used to combine each concept area with the key words Ultra-Processed Food” OR “UFP”:

1. Health: health OR nutrition OR “chronic disease” OR mortality OR exposure
2. Environment: “environmental impacts” OR “climate change” OR “greenhouse gas” OR “packaging waste” OR pollution OR plastic OR agrobiodiversity
3. Justice: “health equity” OR “food access” OR “food security” OR “food justice” OR “vulnerable population”

Additional keywords used include: definitions, “corporate growth”, and policy.

Results were categorized into four sections to direct the narrative review. Section 1 is an introduction that provides essential background for later sections and summarizes the thesis purpose. Section 2 is a synthesis of existing literature detailing the impacts and mechanisms of impact of UPFs across the three domains of health, environment, and justice. The health section provides understanding of the relationship between UPFs and health, detailed quantified impact across health outcomes as well as the history of differing research methods and investigated mechanisms. The environment section provides understanding of the relationship between UPFs and environmental impact, detailing mechanisms that are tied to health and justice in later sections. The justice section synthesizes issues of equity and disproportionate impact as they relate to UPFs. Section 3 argues for the importance of a synergistic conceptual framework and policy mechanisms that integrate domains of health, environment, and justice, using findings from the previous section. Section 4 is a call for policy change that (1) briefly summarizes existing policies and key gaps and (2) provides actionable holistic policy mechanisms, informed by previous sections, that can be combined to drive concrete, systems-level change.
7. References


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8. Appendix

Table A1. Proportion of total energy intake from UPFs by country (data from Elizabeth et al, 2020)

<table>
<thead>
<tr>
<th>Country</th>
<th>Proportion of total energy intake from UPFs (adults)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia</td>
<td>23%</td>
</tr>
<tr>
<td>Spain</td>
<td>24.4%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>27.1%</td>
</tr>
<tr>
<td>Brazil</td>
<td>20–29.6%</td>
</tr>
<tr>
<td>France</td>
<td>29.9–35.9%</td>
</tr>
<tr>
<td>Canada</td>
<td>45.1–51.9%</td>
</tr>
<tr>
<td>UK</td>
<td>53–54.3%</td>
</tr>
<tr>
<td>US</td>
<td>55.5–56.1%</td>
</tr>
</tbody>
</table>