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Food Environment as a Moderator in the Relationship Between Ultra-Processed Food Intake and Mortality in the United States

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Abstract

Food Environment as a Moderator in the Relationship Between Ultra-Processed Food

Intake and Mortality in the United States

by

Brandon Jerod Grandy

MPH, Liberty University, 2017

BS, East Carolina University, 2009

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

According to recent studies, the consumption of ultra-processed food is a major issue that leads to fatal outcomes within the United States, which is relevant because this type of food has become more accessible over the years. Using data from the National Health And Nutrition Examination Survey III (NHANES III), previous researchers found that frequent consumption of ultra-processed foods was associated with greater chances of all-cause mortality in U.S. adults, but little research has focused on factors that can impact ultra-processed food consumption, such as food environment. The purpose of this quantitative longitudinal study was to examine the effect of food environment on the relationship between ultra-processed food intake and all-cause mortality in U.S. adults. The social ecological model of health was used to explore if additional factors suggested in the literature play a role in how ultra-processed food intake effects all-cause mortality in the United States. Secondary data from NHANES (2009-2010) was used for this study. A sample of 191 participants were included in this study. The study found that there was no statistically significant relationship between food environment and all-cause mortality and between food environment and ultra-processed food intake, and that food environment does not moderate the relationship between ultra-processed food intake and all-cause mortality. Limitations included the dataset was old and not designed for the study, my study was underpowered, and there were not enough covariates to capture consumption behavior. Further research is needed to add to the field and help influence policies to increase healthy food sources for society which would hopefully minimize cardio related illnesses, thus leading to positive social change.

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Chapter 1: Introduction of the Study

Ultra-processed food is a major issue within the United States because not only does it lead to increased disease occurrence, but it also leads to fatal outcomes (Kim et al., 2019). Adults that consume a nutritious diet, consisting of mostly fruits, vegetables, and nonprocessed meats, live longer and have a minimized risk of obesity, heart disease, diabetes, and various cancers (Centers for Disease Control and Prevention [CDC], 2021). While consumption of ultra-processed foods is a major contributor to negative health outcomes, such as stroke, heart attack, cancer, nerve damage, kidney failure and death, it is possible that other influences contribute as well (Baraldi et al., 2018). It has also been suggested that minimized physical activity and excessive alcohol and cigarette use also give rise to specific chronic diseases. The current literature has suggested that additional investigation into other factors, such as price, education about negative health outcomes, convenience, taste, and food environment, should take place (Adaji et al., 2017).

I conducted this study to further investigate additional factors that may affect how ultra-processed foods play a role in mortality within the United States. The main objective of this study was to specifically understand the effect of food environment on the relationship between ultra-processed food intake and all-cause mortality in adults within the United States.

Background

A significant number of deaths that occur in the United States. can be traced back to the consumption of ultra-processed foods (Mokdad et al., 2018) Virani et al. (2021) suggested that approximately half of all adult deaths in the United States were related to cardiometabolic diseases that can be linked to unhealthy food choices (National Institute of Health, 2017). In addition to food consumption, other individual behaviors, such as physical activity, knowledge, and attitudes, and community social factors, such as exposure and availability of resources, impact health (Office of Disease Prevention and Health Promotion, n.d.). Foods that are less healthy are cheaper and are therefore easier to access in various environments, and this increased availability and abundance of unhealthy foods contributes to increased chronic diseases, such as obesity and cardiac-related diseases (Marti et al., 2019; Montero-Salazar et al., 2020; Yang et al., 2020).

Past researchers have highlighted that excess consumption of ultra-processed foods not only leads to increased risk of chronic diseases but also increases an individual's risk of dying (Blanco-Rojo et al., 2019; Fardet et al., 2018, Kim et al., 2019; Moreira et al., 2015; Rico-Campa et al., 2019). There are also significant differences in ultra-processed foods among ethnicities, with income and education level significantly impacting consumption the most (Hao, 2020; Krishnadath et al., 2018; Venrooij et al. 2018).

While there is an understanding that ultra-processed food intake impacts health, there is a need to further investigate how other factors impact consumption behavior. These other factors include knowledge of health risks associated with consumption, perceived convenience, taste, price, and food environment (Kim et al., 2019; Srour et al., 2019; Steele et al., 2019). In this longitudinal study, I utilized a sample of the U.S. adult population included in the National Health and Nutrition Examination Survey (NHANES; 2009–2010) and linked all-cause mortality data from up to the year 2015.

While food environment's impact on health has been investigated in some recent studies, there is a lot that is unknown on how various factors interact with each other (e.g., whether moderation occurs at all, and if so, what direction and strength of the relationship occurs when considering food environment with other variable that relate to ultra-processed food intake and all-cause mortality). The current study was centered around the topic of food environment (i.e., the location where food is obtained) being an additional factor that affects the relationship between ultra-processed food intake and all-cause mortality for which a gap still exists within the literature.

Problem Statement

Lifestyle choices can influence health from both an individual and a community perspective. For instance, chronic diseases that are rampant within the United States are often partially caused by lifestyle choices (Farhud, 2015). Obesity, a health issue that can be related to various chronic diseases, such as heart disease, diabetes, chronic kidney disease, and cancer, occurs because of specific lifestyle behaviors, such as overeating, eating unhealthy foods, and sedentary habits (Farhud, 2015). As of 2017, the prevalence of obesity in the United States was 42.4% (CDC, 2020). Underrepresented groups (i.e., African Americans, Hispanics, and Asians) and individuals that are middle-aged or older have higher prevalence of obesity. Obesity and associated diseases can lead to premature death (CDC, 2020).

A possible explanation for the prevalence of obesity, heart disease, diabetes, and other chronic diseases is that individuals are more likely to consume unhealthy foods than healthier alternatives (Baumann et al., 2017). Past research using data from NHANES III found that frequent consumption of ultra-processed foods was associated with greater chances of all-cause mortality in U.S. adults (Kim et al., 2019). However, little research has considered factors that can impact ultra-processed food consumption, such as food environment. With this longitudinal study, I attempted to fill this gap in the literature by utilizing a more current data set (NHANES 1999–2000) that assessed meal place, the environment in which survey participants consumed their meals. If the moderating effect of food environment on the relationship between ultra-processed food intake and all-cause mortality through December 2015 is significant, this will provide impetus for public health practitioners and other officials to push to increase access to healthier foods in specific food environments. In this quantitative study, I used secondary data from the NHANES and a linked National Data Index.

Purpose of the Study

The main purpose of this study was to investigate the effect of food environment on the relationship between ultra-processed food intake and all-cause mortality in adults from the year 2015 within the United States. Secondary data were derived from the NHANES (2009–2010). This data provided information about food intake, food environment, and all-cause mortality within the United States and were analyzed to understand if the moderator (i.e., food environment) impacts the relationship between the independent variable (i.e., ultra-processed food intake) and outcome (all-cause mortality; see Field-Fote, 2019). The presence of moderation would suggest that a third variable may either strengthen or weaken a relationship between two variables. This study was different from Kim et al.’s (2019) because I incorporated food environment as a second predictor variable of the all-cause mortality outcome. Kim et al. may have failed to investigate additional factors that could impact the overall relationship between ultra-processed food intake and mortality. The factors that were not included in NHANES III were food environment, price of ultra-processed foods, perceived convenience, and knowledge of potential adverse health outcomes; however, food environment was addressed in a later survey, NHANES (2009–2010) that was used in the current study. Using the new data set that includes the additional variable, I investigated how this variable impacts the correlational relationship focused on by Kim et al.

Research Questions and Hypotheses

The following research questions and hypotheses guided this study:

Research Question 1: To what extent, if at all, is there a statistically significant relationship between food environment and all-cause mortality?

H_a1: There is a statistically significant relationship between food environment and all-cause mortality.

H_01: There is no statistically significant relationship between food environment and all-cause mortality.

Research Question 2: To what extent, if at all, does individual food environment moderate the potential relationship between ultra-processed food intake and all-cause mortality?

H_a2: Individual ultra-processed food intake does moderate the potential relationship between food environment and all-cause mortality.

$H_0$2: Individual ultra-processed food intake does not moderate the potential relationship between food environment and all-cause mortality.

Research Question 3: To what extent, if at all, is there a statistically significant relationship between food environment and ultra-processed food intake?

H_a3: There is a statistically significant relationship between food environment and ultra-processed food intake.

$H_0$3: There is no statistically significant relationship between food environment and ultra-processed food intake.

Theoretical Framework for the Study

The theoretical framework used in this study was the social ecological model of health (see Golden & Earp, 2012). While there are at least five different levels to this theory, including individual, interpersonal, organizational, community, and public policy, the community level within this model was the primary focus for this study. Within this area of the social ecological model, it was suggested that interaction with specific environment can affect an individual's health (Doran et al., 2017). Environment can include many different locations, such as the actual place in which an individual exists, including habitation, learning, work, and recreation. I based this study on the knowledge of how these environments can impact individual health. There are various environments in which individuals can obtain food, such as local grocery stores, public restaurants, and convenience stores. While all food provides some energy, excess consumption can have a negative impact on an individual's health.

Nature of the Study

In this quantitative study, I employed a longitudinal design, which is an approach that is common within the epidemiologic field among investigations that utilize survival data (Caruana et al. 2015). Caruana et al. suggested that longitudinal studies are useful in the field of epidemiology because they allow the researcher to follow subjects that have been exposed to a specific risk factor over time. An understanding of the effect of food environment on the relationship between ultra-processed food intake and all-cause mortality will provide vital information needed for creating policies that could be implemented to advocate for minimizing the environments that promote unhealthy eating and maximizing healthier food environments.

I used a quantitative approach to test the established hypotheses, which were critical because they highlighted the overall expectations for the study. An analysis of the descriptive statistics was performed to provide details about the sample distribution of participants that were included in the study. This provided information on the variability of the data. Measures of central tendency, including mean and median values, were also calculated. The Pearson's *r* correlation was used to test for a potential relationship for RQ1 and RQ3. This value was generated through Statistical Package for the Social Sciences (SPSS). The Pearson's *r* correlation provided details on whether a linear correlation exists, and if it does, whether the correlation is positive or negative (see Warner, 2013). I selected this form of analysis based on the research question and the type of variables used in the study. The two variables (i.e., food environment and all-cause mortality) were converted to continuous variables in SPSS to satisfy the requirement for this correlation. This software allowed me to assign numbers to responses in the data. For example, if the data showed that a participant had died, a number was assigned to indicate 0 for individuals from NHANES (2009-2010) that survived and a value of 1 could be assigned to individuals that did not survive and are present in the linked mortality file. This allowed these variables to be quantifiable in the analysis. I used a Cox regression to test RQ2. The odds of respondents' all-cause mortality were determined using the hazard ratios that was generated through SPSS. Assumptions of this regression (i.e., random censoring, survival times are independent, proportional hazard function assumption, and the relationship between log hazard and covariates are linear) were tested to determine whether H_a2 or H_02 would be accepted (see Kuitunen et al., 2021).

The linked mortality files consist of 10,604 unique cases, and only includes adult participants from NHANES and a total of 5,000 cases in NHANES (2009–2010). Data were cleaned by recoding the missing values into different categories and excluding participants with missing values. Based on the power analysis, the minimal sample size required for this study was 191 participants.

Definitions

All-cause mortality was established as the dependent variable, while ultra-processed food intake and food environment were established as the independent variables. Terms that may not be commonly used outside of this study are defined below:

All-cause mortality: All possible causes of death within a given population, which includes U.S. individuals that were included in NHANES (Kim et al., 2019).

Food desert: Areas where there are minimal source locations for food that are commonly found in both rural and urban areas, where an individual may have to travel several miles to find another food source location (Fielding et al. 2011).

Food environment: The area or location in which food can be obtained, such as a grocery stores, convenience stores, and/or restaurants (Wahl et al., 2017).

Food swamps: Areas where there are high concentrations of source locations for food, specifically those of convenience (Fielding et al., 2011).

Moderation: Another term for interaction; it occurs when there is an interaction between two predictors on the outcome (Marsh et al., 2013).

Ultra-processed food intake: Consumption of food that contains minimal nonprocessed ingredients, including salty snacks, fast-food meals, sodas, and candy (Kim et al., 2019).

Assumptions

I assumed the responses provided by the NHANES participants to be true; however, there is potential that participants did not answer accurately. Unfortunately, there was no way of proving whether responses were accurate regarding a participant's real-life environment and behaviors but given that all participants were consented volunteers, I assumed that their responses were truthful. This assumption could also be made with a level of confidence because it was clearly emphasized within survey details that only voluntary participation took place (see CDC, 2015). Participants could withdraw consent at any point without any form of penalty; however, given that all participants were given anonymity, there was some potential that they could have answered dishonestly because they may have felt that their eating habits were worse than others (see CDC, 2015). In addition, all participants had a thorough understanding of the instructions provided by the surveyor (see CDC, 2015). There was no way of completely determining if the participants were able to understand survey details.

When it comes to the variables that were used in the current study, certain assumptions were made as well. For example, based on the survey responses, I assumed that some of the variables, such as food environment and all-cause mortality, could be converted to continuous variables because the current survey data had them listed as categorical variables. However, for the regression that was used in this study, these variables were converted to continuous variables.

Scope and Delimitations

The overall scope of this study was limited to the additional variable known as food environment, which was thoroughly defined. While there are other potential variables that could have been investigated, I chose this variable based on substantial issues concerning access to healthier food alternatives and the availability of data within the data sources. A more thorough investigation into additional factors would not only build on the current literature but would also offer further detail on areas in which researchers should prioritize to minimize negative outcomes. Regarding internal validity, there is a possibility of individuals dropping out of the study prematurely for various personal reasons. To account for this possibility, the sequence numbers, gender, age, and race of participants are available for linking participants in both data relating to food intake and mortality. Regarding external validity, given that the sample size is large (i.e., 5,000 participants) and includes a broad selection of races among the U.S. adults, it can be assumed that the sample is representative of the U.S. population (see CDC, 2020). However, there could be some potential that there is a small portion of the racial demographic that was not included in the enrollment process.

Limitations

Just as a study has specific strengths that further highlight the validity and accuracy of a researcher's findings, it is important that the researcher also makes note of the limitations that could also be present to have an accurate understanding of how the study could be possibly applied to other scenarios (Ioannides, 2007). A current limitation of this study was that while this study is generalizable to most ethnicities within the United States, it may not be generalizable to ethnicities outside the United States due to various policies and cultural norms that could play a role in environments being different than those within the United States. Furthermore, the secondary data used for this study came from past years, and currently there are new diseases, such as COVID-19, that could impact mortality. Therefore, the lack of access to information with deaths relating to these new diseases may impact the implications of the current study findings when considering more recent mortalities and more current data sets with mortality data. There is a potential for recall bias within the data because individuals are expected to remember specific eating behaviors, and they may not be able to remember those exact behaviors for a specific period.

There were also limitations associated with the variables. The variables in this study were limited to the data set that was available for public use. Thus, there are some variables that could possibly better portray food environments, such as actual names of food environments, but this information was not present within the NHANES data set. In addition to the variables, the fact the data set was older, and secondary could also be a limitation to this study as more recent data sets may be more detailed and broad in the information is being captured for the variable as well as capturing exactly what was intended specifically for this study.

Lastly, missing values could have limited this study. If values were missing, the participant may have had to be excluded from the study. This could have impacted the strength of the findings.

Significance

Past researchers have suggested that an individual's food choices influence their health outcomes (Wahl et al., 2017). Wahl et al. (2017) analyzed electronic surveys from 1,044 healthy participants who attended the University of Konstanz and confirmed that individuals consume high caloric foods because they taste better and make individuals feel happy (Conner et al., 2017). However, this may not be the only reason that individuals choose to eat unhealthy foods. There may be a lack of access to healthier alternatives. The results from the current study may provide further insight into whether other factors, such as taste and convenience, play a pivotal role in unhealthy food consumption that results in fatal health outcomes, including death related to heart disease, cancer, and chronic kidney disease. These results should aid researchers in understanding whether there may be additional environmental factors that contribute to obesity in addition to personal behaviors, which could suggest that there are some things that individuals may not be able to directly control on a personal level. Thus, in addition to behavioral changes, there would be a need for collaboration between researchers and professional and government officials so that food environment changes can occur in future initiatives. Insight on the food environments that are popular among participants can give researchers the information necessary to provide access to places that promote improved population health. Given that underrepresented groups often experience the greatest disparities when it comes to health, improved access to better food environments and healthier foods will minimize this health gap. Improved access to healthier food choices will provide an alternative that would otherwise be unavailable without professional involvement, thus leading to positive social change.

Summary

There is an increase in chronic disease prevalence in the United States connected to unhealthy eating habits (Marti et al., 2019). These eating behaviors eventually lead to fatal outcomes. While poor eating behaviors contribute to mortality, food environment may also influence this relationship (Kim et al., 2019). I conducted this quantitative study of how food environment moderates the relationship between ultra-processed food intake and all-cause mortality to help individuals within the public health field have a thorough understanding of this relationship so that they may create interventions that minimize fatal outcomes. In the next chapter, I will present an extensive review of the literature regarding ultra-processed food intake, all-cause mortality, and the social ecological model.

Chapter 2: Literature Review

The aim of this study was to further highlight that the abundance of specific food environments within the U.S. adult population affects increased junk food consumption, resulting in fatal outcomes. With this thorough investigation of additional variables that relate to food environment, I provided more detail on whether other factors in addition to behavior play a pivotal role in contributing to increased mortality among U.S. adults. Contributing to this area of research will narrow the gap in current literature regarding the additional factors that may influence ultra-processed food intake (see Kim et al., 2019). This information could be used to develop and/or refine local policies that are meant to improve population health.

In this chapter, I discuss the extant literature related to understanding how food environment moderates the relationship between ultra-processed food intake and all-cause mortality. The literature search strategy is explained in detail. The literature review section also includes an analysis of previous quantitative studies to present what has already taken place in this area of research and where further research is warranted.

Literature Search Strategy

I located literature for this review using scholarly repositories, such as MDPI Open, Cambridge University Press, Nature Research Open, and PubMed. Google Scholar was also used to search for additional sources. The key search terms used were *moderating effect in obesity*, *food environment, ultra-processed food intake*, *all-cause mortality*, *food swamps,* and *food deserts*. In reviewing the resulting literature from my searches, I narrowed down article selection based on publication date. I also filtered most searches to include peer-reviewed articles that were published between 2015 and 2020. However, I manipulated the publication date range for the searches related to the theoretical foundation to include an earlier minimum date of 2000. The theoretical foundation for this study was built on the social ecological model. The main keywords used in the search related to the theoretical foundation were social ecological model, eating behaviors, and *disease prevention*. Approximately 300 studies were produced in the query. The studies were analyzed and sorted based on relevance and approach. Non-U.S. studies were included in situations in which U.S. studies could not be found that fit into the 2015–2020 publication date range. In reviewing 10 quantitative studies, I confirmed that the topic of factors that influence ultra-processed food consumption should be investigated; therefore, my goal with this study was to further fill in the gap in the literature related to this topic.

Theoretical Foundation

The social ecological model is a theory that is often considered and used when tailoring interventions that promote improved health (Doran et al., 2017). According to this theory, an individual's interaction with an environment impacts their health outcome (Doran et al., 2017). The CDC (2020) broke the social ecological model down into four levels: individual, interpersonal, organizational and community. In this study, I focused on the societal, community, and individual levels to investigate how a specific built environment within society and communities possibly influences individual behavior that leads to a specific outcome. A model displaying this framework is presented in Figure 1.

Figure 1

Social Ecological Model

Note. This model depicts that there is an interaction between factors. From *The Social-Ecological Model: A Framework for Prevention, by Centers for Disease Control and Prevention*, 2020 (https://www.cdc.gov/violenceprevention/publichealthissue/social-ecologicalmodel.html). In the public domain.

The social ecological model has been shown to be useful in understanding phenomena that are occurring within specific communities. In an explorative study involving college adults at Cornell University, Sogari et al. (2018) investigated barriers and enablers to unhealthy eating among students. One of the greatest barriers found was access to convenience foods that were high in calories. They highlighted that healthy foods are not readily available in college environments, which leads to poor eating habits that could further lead to negative health outcomes. Their findings provided further background for the current study by showing that a researcher can further investigate whether lack of access to locales that have healthy foods readily available affects whether someone eats unhealthy foods and whether this impacts their health.

The social ecological model can also provide insight into where policies are most needed. As mentioned earlier, an important aspect of this model involves understanding specific behaviors in specific community settings. A detailed analysis of where the issue is taking place will give the researcher information on where help is warranted. In a cross-sectional study involving secondary data collected from metropolitan and nonurban areas within the United States, Shi et al. (2005) investigated the association between primary care, income inequality, and all-cause heart disease and cancer mortality within various U.S. counties. After analyzing the data using one-way ANOVA and multivariate least squares regression, the researchers were able to identify that the biggest disparity was among rural populations and suggested that policies should be directed to aid individuals in these communities. Likewise, a future researcher could use nationwide secondary nutrition and health data and a statistical regression model to determine if urban areas where there is an abundance of fast-food sources impact all-cause mortality. Policymakers could then tailor policies that limit fast food sources within a certain distance of each other or within a certain territory.

Effects of Ultra-Processed Food Consumption on Health

As of 2017, approximately 42.4% of the U.S. population are obese, and at least 73.6% of these individuals are adults (CDC, 2018). The prevalence of obesity has been associated with the consumption of ultra-processed foods (Sandoval-Insausti et al., 2020). When considering exposure to ultra-processed foods, individuals are more likely to consume larger amounts of ultra-processed foods versus healthier alternatives (Hall et al., 2019). Increased consumption of these foods further leads to higher caloric intake and increased weight gain as opposed to unprocessed diets. The increased chance of obesity from the consumption of ultra-processed food is a problem because it leads to an increased likelihood that an individual will develop other chronic diseases, such as diabetes and high blood pressure, and if these diseases are uncontrolled, there is a significant likelihood that fatal outcomes may occur (Li et al., 2019).

Ultra-processed food consumption also increases an individual's chances of diabetes by 44% (Levy et al., 2020). As of 2018, approximately 34.2 million individuals within the U.S. population have diabetes (CDC, 2020). Past literature has suggested that obesity, unhealthy food consumption, and sedentary lifestyle behaviors are the main risk factors for Type 2 diabetes (Zheng et al., 2017). Diabetes is one of the leading causes of death and has increased by 15.4% from 2015 to 2020 within the Unites States (Ahmad et al., 2020).

Heart disease has been the leading cause of death since 2015 and continues to be as of 2020 (Ahmad et al., 2020). The number of deaths related to heart disease have remained at over 3 million since 2015. Individuals that consume ultra-processed foods are 23% more likely to acquire risk factors for heart disease, such as hypertension, and high cholesterol, and like diabetes, uncontrolled heart disease can lead to fatal outcomes (Ahmand et al., 2020). There are similarities in explanation of consumption of ultra-processed foods, such as convenience and price (Mochada et al., 2017). However, many previous researchers either failed to mention whether food environment plays a role in increased disease prevalence and mortality or suggested that an understanding of how food environment influences ultra-processed food intake needs to be further investigated (Kim et al., 2019). I investigated this gap in the literature within this study.

Variables

I conducted this literature review to outline what research already exists in relation to the impact of ultra-processed foods on mortality. In the beginning of this search, I analyzed studies that examined adverse or unhealthy outcomes. For example, Montero-Salazar et al. (2020) found that consumption of 500 grams of ultra-processed foods daily was associated with an increased prevalence of subclinical coronary atherosclerosis compared to consumption of 100 grams per day without the inclusion of other cardiovascular risk factors in workers at a car manufacturing plant. Another population cohort study suggested that an increase in ultra-processed food consumption resulted in a 10% increase in cancer risk (Srour et al., 2018). Kim et al. (2019) also confirmed that increased ultra-processed food intake increases an individual's chances of all-cause mortality, but they were limited in their findings due to other variables not being available in the secondary data set. These articles are similar because they confirmed that there is some type of relationship between ultra-processed food intake and unhealthy and/or fatal outcomes. Findings such as these highlight that ultra-processed foods lead to chronic disease and fatal outcomes, but there is a need to understand if other factors contribute to this relationship.

Food Environment

Using the social ecological model, past researchers have identified two types of food environments that can impact health: food swamps and food deserts (Cooksey-Stowers et al., 2017). Food swamps are defined as areas that have high concentrations of fast food and convenience locations with high calorie foods, while food deserts are areas in which there are only a select amount of food locations. Using sociodemographic and survey data, Cooksey-Stowers et al. (2017) determined that food swamps were greater predictors of obesity than food deserts. Likewise, this same logic can be used to determine the likelihood of an individual dying based on their proximity to food swamps. A thorough investigation of whether there are differences in ultra-processed food intake consumption in highly concentrated convenience location areas versus those that were less concentrated would further give insight on the impacts of food environments on the relationship between ultra-processed food and all-cause mortality because this was not investigated in the literature.

Ultra-Processed Food Intake

. The NOVA food classification categorizes food into four main groups: unprocessed, processed ingredients, processed foods, and ultra-processed foods (Cediel et al., 2017). Ultra-processed foods are those that have very little unprocessed materials and include sodas, candy, salty snacks, and fast-food meals. Cediel et al. (2017) performed a cross-sectional study to determine if consumption of ultra-processed foods was associated with increased sugar in Chilean diets. Using recall survey data, the researchers determined that consumption of ultra-processed foods contributed to the intake of added sugars. Cediel et al.'s findings can be used to prove that there may be possible correlations to fatal diseases that are associated with consumption of added sugars.

Ultra-processed foods were thoroughly investigated in a cross-sectional study by Steele et al. (2017) who analyzed nutritional quality versus the actual energy contribution that U.S. diets provide. Their results suggested that the amount of essential nutrients, such as protein, fiber, and vitamins, in U.S. diets significantly decreased in ultra-processed foods, but unhealthy components, such as sugars and carbohydrates, increased. The researchers suggested that minimizing dietary shares of ultra-processed foods would improve the overall diet quality within the United States. As with many of the other studies within the literature, one limitation of Steele et al.'s study involved the lack of investigation of the place of meals, which would have provided further insight into whether ultra-processed foods were more concentrated in certain areas. This limitation aligned with the gap that I attempted to fill with this study. Cediel et al. (2017) and Steele et al. (2017) both provided insight on the overall importance of food that are of higher quality for improved health.

Relation to All-Cause Mortality

Past literature also suggested that in addition to increased chronic disease occurrence, ultra-processed food intake also leads to increased all-cause mortality. In a prospective cohort study involving over 19,000 adults between the ages of 20–91 years old, researchers determined that consumption of at least four servings per day of ultra-processed foods was associated with a 62% greater hazard for all-cause mortality (Rico-Campa et al., 2019). Campa et al. (2019) further suggested that additional ultra-processed food servings increased all-cause mortality by 18%. They also highlighted limitations that suggest that food environment should be investigated. Although there were a variety of ages that were included in their study, the sample only included individuals that attended the university, but they failed to use a sample outside of that environment that would be more representative of the actual population. Inclusion of other geographical areas would have allowed for an understanding of whether additional factors, such as environment, education, and socioeconomic status, contribute to increased ultra-processed food intake.

Junk food consumption contributes to increased chances of mortality, regardless of race and gender (Boggs et al., 2015). Boggs et al. (2015) investigated the impact of quality diet in underrepresented women using secondary data covering a date range from 1995–2011 and determined that there was an inverse relationship between higher quality diets and mortality. It is important to note that there were high-quality diets that were examined within their study, the Dietary Approaches to Stop Hypertension (DASH) diet and Western diets, and an understanding of quality diets such as these is useful because they highlight possible alternatives and requirements that may be needed in areas that currently have high concentrations of food swamps.

Another study linking ultra-processed foods to all-cause mortality and providing an alternative to this type of food involved an investigation of whole grain food consumption (Huang et al., 2015). In a prospective study containing 367,442 participants, Huang et al. (2015) found that consumption of at least 80 grams of whole grain per day reduced an individual's risk of mortality associated with cardiovascular disease, chronic heart disease, and cancer. The study was limited because it did not study causal inferences related to whole-grain intake and mortality. There could have been confounding variables present as well as other unmeasured factors that affect the relationship between the predictor and the outcome. Therefore, an analysis of other possible factors that affect this relationship is warranted.

Rico-Campa et al. (2019), Boggs et al. (2015), and Huang et al. (2015) all found that ultra-processed food consumption contributes to fatal outcomes; however, these studies did not seem to investigate food environment. While food environment is mentioned in Rico-Campa et al. (2019), it is only described as a limitation. Further investigation would allow for the determination if food environment affects ultra-processed food consumption, resulting in fatal outcomes.

Summary

With this review of the literature, I confirmed that there are similarities in approaches and frameworks to those which were used in the current study when it comes to highlighting a correlation between a behavior related to ultra-processed food intake and negative health outcomes. The researchers in these previous studies assessed issues related to ultra-processed food consumption and did not fail to highlight the strengths and weaknesses that were present. The variables chosen for the current study were based on the literature review and the current gaps that existed, which included lack of knowledge on how other factors influence consumption of ultra-proceed food. Food environment exists as the moderating independent variable that relates to the current gap in the literature. All-cause mortality (i.e., the dependent variable) and ultra-processed food intake (i.e., the independent variable) were similar variables used in previous studies such as Kim et al. (2019) and Montero-Salazar et al. (2020). The current study was similar to past studies because it included the relationship between ultra-processed food intake and all-cause mortality, but an extra variable (i.e., food environment) was included to further strengthen what was not investigated in the past. Including food environment as a variable in this study was intended to further strengthen the findings presented in the literature, especially those found in Kim et al. (2019), as additional factors were considered.

Throughout the literature, past research involving food environment as an additional factor in the relationship between ultra-processed food intake and all-cause mortality was minimal, creating a need for further investigation. In the next chapter, I will explain the methodology used in this study, including the overall research design, instrumentation, data analysis plan, variable functions, validity, and ethical considerations.

Chapter 3: Research Method

The main objective of this study was to provide further knowledge on additional factors that influence fatal outcomes when ultra-processed foods are consumed among adults within the United States. Additional factors included food environment that could potentially act as a moderator between the independent variable of ultra-processed food intake and the dependent variable of all-cause mortality. The intent of this study was to further fill the gap in the literature that suggests that food environment is a factor that contributes to the relationship between ultra-processed food intake and all-cause mortality (see Kim et al., 2019). There was minimal information on how food environment affects this relationship, especially with regards to the U.S. population (Kim et al., 2019; Mochada et al., 2017).

In Chapter 3, I provide a brief overview of the research design that was aligned with the research questions tested in this study. In addition, the variables, population, research methodology, and sampling procedures are discussed. The rest of this chapter then focuses on the operationalization of constructs, data analysis plan, threats to validity, and ethical procedures. I conclude the chapter with a summary and transition to Chapter 4.

Research Design and Rationale

In this study, I analyzed the effect of food environment as a moderator of the relationship between ultra-processed food intake and all-cause mortality among U.S. adults. The data used for this study, which included independent, dependent, and moderating variables, were pulled from the codebook for NHANES (2009–2010) and 2015 linked mortality file (see Table 1).

Table 1

Summary of Variables in the Study

Category	Measure	Description
Independent variables: Ultra-processed food intake		
How often eat pizza?	DTQ140U	The number of times per day/week/month consumed pizza
How often eat processed meat?	DTQ180U	The number of times per day/week/month consumed processed meat
How often eat cheese?	DTQ190U	The number of times per day/week/month consumed cheese
How often eat chocolate or candy?	DTQ220U	The number of times per day/week/month consumed candy
How often eat pastries?	DTQ230U	The number of times per day/week/month consumed pastries
How often eat cookies/cake?	DTQ240U	The number of times per day/week/month consumed cake
How often eat popcorn?	DTQ260U	The number of times per day/week/month consumed popcorn
Dependent variables: Mortality		
Final mortality status	MORTSTAT	Assumed status of alive or deceased based on follow-up survey information
Underlying leading cause of death: Recode	UCOD_LEADING	The cause of death experienced by participant

Year of death	DODYEAR	Year of death
Number of person months of follow-up from NHANES interview date	PERMTH_INT	Number of person-months of follow-up from NHANES interview date
Moderating variable: Food environment		
# of meals not home prepared	DBD895	The number of meals per day/week/month prepared away from home in restaurants, especially fast food restaurants, food stands, and grocery stores, or from vending machines
# of meals from fast food or pizza place	DBD900	The number of meals per day/week/month consumed at a fast food restaurants or pizza places

In this quantitative study, I employed a longitudinal design because survival data were studied over periods of time (see Caruana et al., 2015). A quantitative methodology was chosen to quantify the effect of food environment on ultra-processed food intake and mortality. The longitudinal study design allowed me to understand whether eating behaviors and eateries were vital to preventing mortality in the United States. I was also able to see if trends occurred within the data and determine how these trends could be applied in prevention throughout the nation. Because secondary data were used for this study, there were minimal time and resource constraints. The finding of the literature review presented in Chapter 2 suggested that the current research design was appropriate and aligned with similar studies that have been conducted in the past.

Methodology

Population

The NHANES was a broad program of studies that consisted of health and nutritional data from both adults and children within the United States (CDC, 2017). A nationally representative sample of approximately 5,000 participants from 50 states within the United States and the District of Columbia was surveyed. Since 1999, survey participants have been followed annually for approximately 15 years. Various ages and ethnicities and both genders were included to further align with the U.S. population. I used the conventional power of 0.8 or 80% to determine the sample size for this study, which yielded a minimum sample size of 191 using the G*Power system (see Cohen, 1992).

Sampling and Sampling Procedures

As mentioned earlier, I used the NHANES (2009–2010) data set for this study. The conventional power of 0.8 was used, which gave a beta of 0.2 or 20% (see Cohen, 1988). The power calculation is 1 – B = P (i.e., probability of not making a Type 2 error). As done with samples prior to this data set, a four-stage design was used by NHANES (Curtin et al., 2013). Stage 1 consisted of respondents from all counties within the United States and the District of Columbia. Stage 2 consisted of areas experiencing substantial growth since the year 2000 based on census data from that same year so that the primary sampling units had equal numbers of participants. These areas were considered groups or clusters of households selected for sampling. Stage 3 consisted of dwelling units, which also included noninstitutionalized group quarters, such as dormitories. A subsample was pulled from these dormitories to create a national and equal probability sample of specific households. Stage 4 consisted of individuals from occupied households and apartments as well as a subsample of this group selected based on race, age, sex, and income. This form of subsampling allowed for self-weighting samples for each subdomain to give the greatest number of sampled participants in each household.

Archival Data

After signing a consent form, participants that were 18 and older were interviewed in their homes by an NHANES surveyor. Guardians of individuals below the age of 18 were granted permission to participate by signing a consent form as well. In this study, I only looked at individuals that were over the age or 18, and individuals that were younger were excluded from the sample. All individuals that answered numerical values for ultra-processed food intake variables from these surveys were included in the study and received biometric screening and examination for specific health characteristics (Zipf et al., 2013). There were three types of household interviews: screening, individual and group interviews with the entire family. Given that specific household and groups within these households were included, the potential for bias could have occurred because there may have been a lack of randomization because individuals from the same household may have been more likely to respond to survey questions in the same manner. One way to account for this possible accidental bias involved the use of intraclass correlation to determine if there was correlation of responses among the same groups (Lilejquist et al., 2019). I addressed this possible bias in the descriptive statistics for this study. There was no need to ask for permission to use this data for my study because the data were available for public use via the NHANES tab of the CDC website.

Instrumentation and Operationalization of Constructs

The main instrument used in this study were surveys from NHANES (2009–2010) and the 2015 linked mortality files. The linked mortality files consisted of 10,604 unique cases and only included adult participants from NHANES. The surveys were administered using computer-assisted audio software, where questions can be logged into the computer and the interviewer can also record the data into the computer. Written instructions were provided and reviewed by the survey administrator. The values for the variables included in this study came directly from these data sources. Ultra-processed food intake served as the independent variable within this study. This variable was quantified using a series of dietary screener questions that asked how often within the last month the participant consumed processed foods (e.g., pizza, processed meat, cheese, candy/chocolate, pastries, cookies/cake, and popcorn). The amount of time that individuals consumed processed foods included a range of values from 0 to 30 days, and NHANES later coded responses to 1 for days, 2 for weeks, and 3 for months. The dependent variable mortality was quantified using the year of death and the number of person/months for follow-up.

Data Analysis Plan

I used SPSS Version 25 to perform the various analyses for this study. Data cleaning took place before proceeding with statistical procedures. Data were cleaned by recoding the missing values into different categories. I analyzed categorical variables using descriptive statistics, including the minimum, maximum, mean, variance, skewness, and kurtosis of the data (see Frankfort-Nachmias et al., 2018). The minimum was the lowest frequency value, and the maximum was the highest frequency values. The mean provided insight on the average, and the skewness provided insight on whether the distribution is more concentrated towards a specific tail within the sample distribution.

Kurtosis provided details on whether the distribution will have more of a peak or flat shape.

RQ1: To what extent, if at all, is there a statistically significant relationship between food environment and all-cause mortality?

$H_0$1: There is no statistically significant relationship between food environment and all-cause mortality.

H_a1: There is a statistically significant relationship between food environment and all-cause mortality.

RQ2: To what extent, if at all, does individual food environment moderate the potential relationship between ultra-processed food intake and all-cause mortality?

$H_0$2: Individual food environment does not moderate the potential relationship between ultra-processed food intake and all-cause mortality.

H_a2: Individual food environment does moderate the potential relationship between ultra-processed food intake and all-cause mortality.

RQ3: To what extent, if at all, is there a statistically significant relationship between food environment and ultra-processed food intake?

$H_0$3: There is no statistically significant relationship between food environment and ultra-processed food intake.

H_a3: There is a statistically significant relationship between food environment and ultra-processed food intake.

For RQ1 and RQ3, I utilized a Pearson correlation. Both the independent variable of food environment and the dependent variable of all-cause mortality were analyzed as continuous variables in RQ1, and the independent variables of food environment and ultra-processed food intake were analyzed as continuous variables for RQ3. This correlation analysis was performed with two-tailed significance. If $p < 0.001$, this suggests that there is a statistically significant linear relationship (Warner, 2013). The r value provided the overall strength of the association.

For RQ2, the independent variable of ultra-processed food intake, dependent variable of all-cause mortality and moderator of food environment were coded as categorical variables. I used the Omnibus test to determine the overall model fit. A p value that is significant at $p < 0.001$ suggests that there is an improvement and fit relative to the null hypothesis. The coefficients of the variables in the equation provided insight on the hazard ratios and contributions of the individual covariates to the overall model fit (Warner, 2013). The Exp (B) provides the hazard ratio. A hazard ratio less than 1 indicated that an individual who consumed ultra-processed foods and was exposed to fast-food environments was less likely to experience a fatal outcome; a hazard ratio greater than 1 indicated that an individual who consumed ultra-processed foods and was exposed to fast-food environments was more likely to experience a fatal outcome. Continuous variables have a stronger statistical power and more specific inferences can be made (Royston et al., 2014). Given that research RQ1 used continuous variables, but RQ2 used categorical variables, RQ1 can be used to inform the interpretation of RQ2 results, but the power and inferences were weaker because the variables are not the same.

This was an area of limitation that I considered when analyzing the overall results of the study.

Threats to Validity

External Validity

A possible threat to external validity for this study was the use of survey data. When it came to recalling the number of processed foods consumed and where the processed foods came from, there was potential that respondents may not have answered accurately. For some of the NHANES data sets, it has been suggested that the participant responses may be inaccurate because some accounts of food and beverage intake would make it difficult for an individual to survive (Archer, 2017). Archer (2017) tested the accuracy of the possibility of individuals being able to actually survive based on average intake of food and beverages and found there were inaccuracies present. In regard to this study, it was important to determine if nondifferential or differential misclassification of exposure could occur. If exposure is unrelated to the outcome or if misclassification of exposure is the same for individuals that do or do not experience fatal outcomes, it would be considered nondifferential (Rothman, 2012). Misclassification of exposure was differential (i.e., if potential for misclassification was different for individuals that do or do not experience fatal outcomes). Potential biases such as these may interfere with the reproducibility of the study in different areas of research. While it was important to consider the potential of this form of inaccuracy within the data, surveys from other data sources could have faced the same type of threat.

Another external threat that was considered in this study involved the representativeness of the sample. There was a possibility that some groups of the population may have been left out of the NHANES. For example, the NHANES used noninstitutionalized groups (CDC, 2020). Any individual that was part of an institutionalized party, such as prison inmates and individuals within military services, were excluded but are yet part of the U.S. population. While the NHANES goes to great lengths to ensure that the sample was representative of the U.S. population, I considered this aspect when interpreting the study findings.

Internal Validity

The main threat to internal validity within this study involved the possibility that there could be other confounding variables that impact the relationship between ultra-processed food intake and all-cause mortality (Warner, 2013). For example, an individual may have also failed to participate in physical activities in addition to failing to adhere to medicine regimens prescribed by their physician if they have a chronic disease. There was no way of testing for these confounders because they were not present in the data set (CDC, 2017).

Construct Validity

Since I used a Pearson correlation to test RQ1 and RQ3, there could be threats related to the overall relationship. Pearson's correlation assumes that the relationship between variables is linear; however, if a nonlinear relationship exists between variables, the r values will be smaller, despite there being a strong relationship between variables (Karras, 1997). Cox regression was used to test RQ2. A possible threat to this statistical test involves the potential for heteroskedasticity to occur between variables (Warner, 2013). This occurs when standard errors are collected over time that are not constant. This form of threat tends to get worse as time progresses within data collection and analysis.

Ethical Procedures

Prior to accessing any data, I obtained permission to conduct this study from the Walden University Institutional Review Board (Walden IRB). The Walden IRB approval number was 01-07-22-0972234. The original data collectors thoroughly ensured the protection of participants by generating both sequence numbers and identification numbers for each participant; therefore, participants cannot be identified by any individuals that access the data publicly (CDC, 2019). This was also true with the linking mortality data. The same identification numbers from NHANES were used to match individuals in the linked mortality file to determine if a participant died without fully exposing their identity. Given that all participants have been de-identified, there was very few ethical considerations that created concern for this study. I stored the study data on a desktop and USB drive that were password protected. Only my dissertation committee and I will have access to this data. The data will be destroyed once the dissertation is defended and the degree is conferred.

Summary

I began this chapter with a brief introduction of the study. The variables for this study were thoroughly described and an excerpt of the data codebook was provided. In this study, I used secondary data that were collected by NHANES. Samples were selected using a four-stage process to create a nationally representative sample of the U.S. population. Pearson correlation and Cox regression were used to statistically test the research questions for this study. Threats to validity were mostly associated with potential errors in responses from participants and statistical errors. Since secondary data were used in this study and all participants have been de-identified by the original data collectors, there were minimal ethical concerns for this study. The next chapter will provide a thorough description of the results from the final study.

Chapter 4: Results

In this section, I provide the results of the study. The main goal of this study was to highlight additional factors that influence fatal outcomes in U.S. adults after consuming ultra-processed foods. The following research questions and hypotheses guided this study:

Research Question 1: To what extent, if at all, is there a statistically significant relationship between food environment and all-cause mortality?

H_a1: There is a statistically significant relationship between food environment and all-cause mortality.

H_01: There is no statistically significant relationship between food environment and all-cause mortality.

Research Question 2: To what extent, if at all, does individual food environment moderate the potential relationship between ultra-processed food intake and all-cause mortality?

H_a2: Individual food environment does moderate the potential relationship between ultra-processed food intake and all-cause mortality.

H_02: Individual food environment does not moderate the potential relationship between ultra-processed food intake and all-cause mortality.

Research Question 3: To what extent, if at all, is there a statistically significant relationship between food environment and ultra-processed food intake?

H_a3: There is a statistically significant relationship between food environment and ultra-processed food intake.

$H_0$3: There is no statistically significant relationship between food environment and ultra-processed food intake.

As mentioned previously, a minimum sample size of 191 participants were needed for this study. Any participant with missing data was excluded from this study. The data set was large enough to include only cases that had all the variables. I recorded a set of descriptive statistics to provide a visualization of participants for this study. The descriptive statistics included both frequencies and percentages for the categorical variables that were recorded in the NHANES 2009–2010 data set. The minimum, maximum, mean, and standard deviation were calculated for continuous measures within the study. After the descriptive summarization of the data, I performed two Pearson correlation analyses and one Cox regression analysis.

Results

Table 2 displays the demographical data for the study participants. Regarding participants' gender, 47.6% were male and 52.4% were female. Regarding the proportions for vital status at the end of the study period, 92.7% were assumed alive and 7.3% were assumed deceased.

Descriptive statistics

Table 2

Frequencies of Categorical Measures: Demographics

Measure	***n***	Valid %
Gender		
Male	91	47.6%
Female	100	52.4%
Valid total	191	100.0%

Mortality status		
Assumed alive	177	92.7%
Assumed deceased	14	7.3%
Valid total	191	100.0%

With regard to continuous variables that were collected for this study, the mean number of meals that were not home prepared per week was 2.73 (*SD* = 3.231), with a range of zero to 19 meals. The mean for the variable that measured the number of meals from a fast food or pizza restaurant per week was 1.68 (*SD* = 2.133), with a range of zero to 14 meals. The variable for how often an individual eats pizza per week had a mean of 1.77 (*SD* = 2.702) and a range of zero to 20 meals. The variable for how often individual eats processed meat per week had a mean of 3.64 (*SD* = 5.264) and a range of zero to 34 meals. The variable for how often an individual eats cheese per week had a mean of 4.10 (*SD* = 5.812), with a range of zero to 40 meals. These values are depicted in Table 3.

Table 3

Descriptive Statistics of Continuous Measures

	N	Minimum	Maximum	*M*	*SD*
Number of meals not home prepared	191	0	19	2.73	3.231
Number of meals from fast food or pizza place	139	0	14	1.68	2.133
How often eat pizza	160	0	20	1.77	2.702
How often eat processed meat	159	0	34	3.64	5.264
How often eat chocolate or candy	159	0	30	3.13	4.691
How often eat cheese	159	0	40	4.10	5.812
How often eat pastries	160	0	30	1.80	3.711
How often eat chocolate chip cookies	159	0	30	2.14	3.563

Note. All items measured per week.

I used Pearson correlation to answer Research Questions 1 and 3, which investigated the potential of a statistically significant relationship between food environment and all-cause mortality and food environment and ultra-processed food intake, respectively. The variables were continuous and normally distributed. I also determined there was a linear relationship between variables after reviewing them via scatter plot prior to doing the analysis.

Research question 1

For Research Question 1, the variables for food environment, which included number of meals not home prepared and number of meals from fast food or pizza place, were correlated with the final mortality status. Both the number of meals not home prepared (*r* = -.126) and the number of meals from fast food or pizza place (*r* = -.021) had small strength negative correlations with all-cause mortality. However, the *p* values for number of meals not home prepared and number of meals from fast food or pizza place were 0.82 and 0.803, respectively. This suggested that while there was a small negative correlation within the sample, there was not enough evidence to suggest that this correlation was significant for the population.

Research questions 3

For Research Question 3, there were positive correlations between how often an individual eats pizza and the number of meals not home prepared as well as how often an individual eats pizza and the number of meals from a fast food or pizza place, *r* = .204 and *r* = .364, respectively. All *p* values for food environment variables were less than 0.05 after performing a Pearson correlation against ultra-processed food intake variables: how often an individual eats pizza and number meals not home prepared (*p* = .010) and how often an individual eats pizza and the number of meals from a fast food or pizza place (*p* < .001). This suggested that there is a small positive correlation and enough evidence to suggest that the correlation is significant for the population. There were some negative and some positive correlations for all other variables for food environment and ultra-processed food intake; however, there was no significance (*p* > 0.05). These values can be observed in Table 4. I failed to reject the null hypotheses for Research Questions 1 and 3.

Table 4

Pearson Correlations

Correlations		#meals not home prepared	@meals from fast food or pizza place	Final Mortality Status
SEQN	Pearson correlation	0.036	0.123	0.107
# of meals not home prepared	Pearson correlation	1	.537**	-0.126
# of meals from fast food or pizza place	Pearson correlation	.537**	1	-0.021
Final mortality status	Pearson correlation	-0.126	-0.021	1
How often eat pizza	Pearson correlation	.204**	.364**	-0.075
How often eat processed meat	Pearson correlation	0.001	-0.032	.489**
How often eat cheese	Pearson correlation	0.005	-0.036	.489**
How often eat chocolate or candy	Pearson correlation	0.008	-0.022	.490**
How often eat pastries	Pearson correlation	0.042	0.125	-0.056
How often eat chocolate chip cookies	Pearson correlation	0.003	-0.028	.493**
How often eat popcorn	Pearson correlation	0.106	0.119	-0.073

Note. SEQN = sequence Number
****p < 0.005.**

Research question 2

I used Cox regression to answer Research Question 2. The outputs for the Cox regression analysis were generated using SPSS and can be seen in Table 5. The Omnibus test was generated but was not included because it was only needed to confirm significance of the overall model. The Omnibus test proved to be insignificant with p = 0.097, suggesting that the overall model was not significant. This can be further confirmed after analysis of the hazard ratios, which can be seen in Table 5. All variables associated with ultra-processed food intake and food environment had hazard ratios that were less than 1. This suggested that an individual that consumed ultra-processed foods and was exposed to fast-food environments was less likely to experience a fatal outcome; however, there was no significance in values as $p > 0.05$. There were several cases in which the hazard ratios were close to 1, which would suggest that there was no meaningful difference in hazards for individuals that consumed ultra-processed foods and were exposed to fast-food environments. These variables included: How often an individual eats processed meat (Exp(B) = 0.962), how often an individual eats cheese (Exp(B)= 0.996), how often an individual eats chocolate or candy (Exp(B)= 0.992), how often an individual eats chocolate chip cookies (Exp(B)= 0.996), how often an individual eats popcorn (Exp(B)= 0.989), and the number of meals from fast food or pizza places (Exp(B) = 0.962). Therefore, I failed to reject the null hypotheses for Research Question 2.

Table 5

Cox Regression Results

	SE	Wald	*df*	Sig.	Exp(B)
# of meals not home prepared	4.102	0.259	1	0.610	0.124
# of meals from fast food or pizza place	0.141	0.075	1	0.784	0.962
How often eat pizza	2.541	0.567	1	0.452	0.148
How often eat processed meat	0.005	0.567	1	0.452	0.996
How often eat cheese	0.044	0.034	1	0.853	0.992
How often eat chocolate or candy	0.005	0.567	1	0.452	0.996
How often eat pastries	2.541	0.567	1	0.452	0.148
How often eat chocolate chip cookies	0.195	0.003	1	0.954	0.989
How often eat popcorn	0.106	0.340	1	0.560	0.940

Summary

I performed statistical analyses to answer the research questions for this study. Demographic data were first analyzed and confirmed that there was a fairly equal distribution of participants within the sample with respect to gender. Reviewing a scatter plot prior to doing the analysis showed that a linear relationship was present between variables. Both Pearson correlation analysis for Research Questions 1 and 3 and Cox regression analysis for Research Question 2 resulted in failures to reject the null hypotheses for all three research questions. I determined that there was no statistically significant relationship between food environment and all-cause mortality, there was no statistically significant relationship between food environment and ultra-processed food intake, and individual food environment did not moderate the potential relationship between ultra-processed food intake and all-cause mortality In the next chapter, I will further present the results, incorporating details mentioned in the literature review as well as discuss limitations associated with this study and ideas for related future research.

Chapter 5: Discussion, Conclusions, and Recommendations

In this chapter, I interpret the study results, including an explanation of how they relate to the extant literature and theoretical foundation. In addition, study limitations and opportunities for future research are discussed. The main purpose of this study was to determine if additional factors influence ultra-processed food consumption, which in turn leads to fatal outcomes among U.S. adults. When it comes to the overall results, there were both similarities and differences to previous results found in the literature. The main findings of the current study indicate that there are no significant correlations between food environment and all-cause mortality or between food environment and ultra-processed food intake. The limitations identified in the study included the utilization of NHANES as a source of information for dietary behavior, the use of correlation coefficients, and the strength of power for the model. Future research on this topic would further add to findings in this field by addressing these limitations and focusing on what has not yet been studied.

Interpretation of the Findings

The following research questions and hypotheses guided this study:

Research Question 1: To what extent, if at all, is there a statistically significant relationship between food environment and all-cause mortality?

H_a1: There is a statistically significant relationship between food environment and all-cause mortality.

H_01: There is no statistically significant relationship between food environment and all-cause mortality.

Research Question 2: To what extent, if at all, does individual food environment moderate the relationship between ultra-processed food intake and all-cause mortality?

H_a2: Individual food environment does moderate the relationship between ultra-processed food intake and all-cause mortality.

H_02: Individual food environment does not moderate the relationship between ultra-processed food intake and all-cause mortality.

Research Question 3: To what extent, if at all, is there a statistically significant relationship between food environment and ultra-processed food intake?

H_a3: There is a statistically significant relationship between food environment and ultra-processed food intake.

H_03: There is no statistically significant relationship between food environment and ultra-processed food intake.

The study findings were that there was no statistically significant relationship between food environment and all-cause mortality and no statistically significant relationship between food environment and ultra-processed food intake. These findings suggest that the places in which an individual obtains food do not influence all-cause mortality or the consumption of ultra-processed food. In the third analysis carried out, I found that food environment does not moderate the relationship between ultra-processed food intake and all-cause mortality. This finding suggests that the areas in which an individual obtains food do not affect the relationship between all-cause mortality and ultra-processed food consumption. The results of the Pearson correlation and the Cox regression analyses led to the failure to reject the null hypotheses for all three research questions.

Theoretical and/or conceptual framework

While the overall results did not support the social ecological model of Brofenbrenner, (1974), there were some aspects of the findings that did align with the model in suggesting that food environment impacts an individual's health and behavior; however, there was not enough evidence to indicate that these findings were significant. In this study, I primarily investigated where food was obtained to determine whether that affects health outcomes and the likelihood of consuming unhealthy foods. There are also other factors beyond food environment and ultra-processed food intake that could affect an individual's health outcomes and the likelihood of consuming unhealthy foods, but these factors were not looked at in the current study (see CDC, 2020).

The findings in this study did not support those of Kim et al. (2019) or Montero-Salazar et al. (2020) because of differences in variables, data sets, and/or analysis models used in comparison to this study. While Kim et al. found that all-cause mortality is more likely among individuals that consume more ultra-processed food, the current study did not. There could be valid reasons while the results did not match. For example, Kim et al. used an older data set in which the variables were more detailed with food items that the participants indicated that they ate being based on an 81-item food frequency questionnaire. In addition, in the Kim et al. study, the foods were classified as ultra-processed foods using a specialized classification process known as NOVA. The researchers were able to use this information to record ultra-processed food intake. The data set used in the current study did not have as detailed survey questions because it only had a few options to indicate ultra-processed food intake, such as pizza, processed meat, candy, cheese, and chocolate chip cookies. Less food options to choose from could have caused participants to misclassify the food that they ate, which may have led to different trends in ultra-processed food intake between the studies. Kim et al. also adjusted for covariates such as socioeconomic factors like poverty level, education level, and health behaviors. To minimize the complexity of the current study, I did not include the same covariates.

While Montero-Salazar et al. (2020) found that the consumption of ultra-processed foods led to negative health outcomes, the current study did not. Similar to Kim et al. (2019), the data set used by Montero-Salazar et al. was more detailed than the NHANES (2009–2010). The participants in the Montero-Salazar study had approximately 136 different items that could be classified as ultra-processed foods. In addition, Montero-Salazar et al. adjusted for covariates, such as age, education, and physical activity, which were not included in the current study. Despite the differences between studies mentioned above, the current study does add to the literature because its findings showed a correlation between ultra-processed food-intake and food environment.

Limitations of the Study

I identified a considerable number of limitations for the current study. I used the NHANES as a data source for food environment and food consumption. While the NHANES records some dietary information, this is not the primary purpose of the survey; therefore, the information related to dietary behavior was limited. This could have been a result of the data set being an older data set. Furthermore, the survey information from the NHANES was based on recall information. This can present a limitation because participants may not always accurately remember their dietary behaviors and may answer based on what they think occurred as opposed to what actually happened. For example, some individuals answered 30 and 40 meals per week as the number of meals they consumed, which means that they consumed close to five to six meals per day. While this is possible, it could indicate that there may have been errors in recalling information. In addition, the NHANES data set that was used in the current study did not provide specific details on where the individual ate. The NHANES only provided information on whether the participant ate at a fast food or pizza place in the survey question. An ideal data set might provide information on exactly where respondents ate (e.g., McDonalds, Burger King, etc.) as well as a detailed description of what was eaten (e.g., hamburgers, French fries, pancakes, etc.) and when exactly it was eaten. In future studies that involve food environment, it might be worth investigating other moderators in addition to food environment, such as convenience and price.

Another limitation of the current study involved the use of correlation coefficients. While variables may seem to move in a similar direction, that does not necessarily mean that one behavior causes the other (Janse et al., 2021). For example, there were negative correlation coefficients for consumption of meals from fast-food places, pizza places, and all-cause mortality as well as for meals not prepared at home and all-cause mortality. Negative correlation means that as one variable increases, the other decreases; however, there is no evidence based on the results that either variable impacts the other.

It is also important to state that the study was underpowered. I used the conventional 80% and perhaps should have use a 90% probability that I would not commit a type II error. I would have experienced a stronger power, and this would have led to my sample size being large as well. The sample size may have been too small to give me the power to reject one or more null hypotheses in the study. The sample size calculation of 191 was based on the Pearson correlation analyses; however, this sample size may have been too small for the Cox regression analyses that used nine independent variables (# meals not home prepared, # meals from fast food or pizza place, how often eat pizza, how often eat processed meat, how often eat cheese, how often eat chocolate or candy, how often eat pastries, how often eat chocolate chip cookies, how often eat popcorn).

Recommendations

The limitations mentioned in the previous section, which included the data set, correlation coefficients and the sample size can be utilized as a guide for what is needed in future research. Future studies should first begin with obtaining a data set that has variables that will enable the investigator to answer the research questions. In this study, I attempted to determine whether food environment moderates the relationship between ultra-processed food intake and all-cause mortality. However, there was no relationship between ultra-processed food intake and all-cause mortality for food environment to moderate. While the NHANES provided information about some eating behaviors and where food can be obtained, it did not necessarily provide a detailed and accurate account. An ideal data set for future studies would document whether an individual obtained food from a specific fast-food or convenience store.

In this study, I used secondary data to minimize complexities as well as the time and financial constraints associated with using primary data. However, primary data could provide more accurate accounts of how many meals an individual consumed and when he/she consumed them. For example, instead of using surveys, perhaps in future studies, participants could use an app on their mobile device that records when they ate a meal and where it was obtained, so that the researcher would have an accurate account from when the individual logged in the information versus having the participant recall this information at a later time. While it may have been more complex to use a stronger power analysis and a larger sample size that would accommodate the several variables used in the Cox regression, use of a larger sample size would have worked better for that model and may have given results that would have enabled rejection of one or more of the null hypotheses. Incorporating methodology to reduce these limitations could produce studies that will add to the literature in this area of public health.

Implications

In this study, there was no relationship found between ultra-processed food intake and all-cause mortality, so food environment moderating that relationship is a moot point. However, these findings do not necessarily prove that food environment should be ignored for future studies. Some of the values confirmed a correlation could exist but need to be accounted for with additional variables and stronger power analysis. It is worth investigating food environment further with larger, more recent and live data sets to see whether any of the findings change. Different findings could provide a better understanding of food consumption behavior in relation to health outcomes. This could lead to the creation of policies that improve population health, further creating positive social change. For example, results that align with the alternative hypotheses could help policy makers present evidence that there may be an overabundance of unhealthy food locales and not enough healthy alternatives. They could then push to have policies that limit fast food restaurants in a specific area or require healthy alternatives at reasonable prices. If better food choices are available, an individual may be more likely to practice healthier eating behaviors, and this could lead to less heart-related illnesses, resulting in fewer deaths.

Conclusion

I conducted this study to develop a better understanding of how the abundance of specific food environments within the U.S. adult population impacts increased their junk food consumption, resulting in fatal outcomes. These cardiac related deaths can be traced to the types of foods that an individual consumes (Mokdad et al., 2018). This has been highlighted in other studies recently performed by researchers in the field, including Kim et al. (2019), Baraldi et al. (2018), and Montero-Salazar et al. (2020). While the findings of the current study which stated that there were no statistically significant relationship between food environment and all-cause mortality, and food environment and ultra-processed food intake; and food environment does not moderate the relationship between ultra-processed food intake and all-cause mortality, did not support previous findings in the literature; the results and limitations provide details needed to develop further understanding about this issues that lead to cardiac related illnesses from food consumption. Therefore, future researchers can attempt to minimize the limitations identified in this study in future studies to help contribute to knowledge in the field and influence policies for the betterment of society as potential premature deaths could be minimized.

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