Food Addiction: From Popular Conception to Scientific Validation

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ABSTRACT

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In recent years, food addiction has become a popular construct believed to have serious behavioral, emotional and physical consequences. However, its scientific validity is still under investigation. This dissertation evaluated whether food addiction is a valid mental disorder, substance-related disorder, and addiction in three parts. Part 1 reviewed the phenomenological, animal and neurological evidence to assess whether food addiction has face validity and conducted a systematic literature review of studies estimating the prevalence, validating measures, and/or assessing correlates of human food addiction to evaluate construct validity. Part 2 used two community-based convenience samples to assess whether operationalized measures of food addiction are reliable and valid. Part 3 used two large cohorts of nurses to evaluate whether food addiction is associated with potentially positively reinforcing nutrients, food items and food groups. The literature review established that food addiction has face validity, and to some degree, construct validity. The first analytic paper found that the internal and test-retest reliabilities of both scales were moderate to good, and the shorter Modified Yale Food Addiction Scale compared with the original Yale Food Addiction Scale had good sensitivity and negative predictive value. The second analytic paper found strong positive associations between food addiction and consumption of fats and sodium, non-sweet fatty foods, diet foods, and some salty and sweet foods, no association with most starchy and salty food items, and an inverse association with fruits and vegetables. It also found unexpected strong inverse associations between sugar and food addiction, contradicting the popular “sugar addiction” hypothesis. Prospective analyses should reexamine these findings to eliminate potential reverse causation bias. Taken together, this dissertation supported food addiction as a valid mental disorder, substance-related disorder and addiction, although some findings contradicted a priori hypotheses, and gaps in the literature remain.

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Dedication

For Jay, Ezra, and Eli—my pride, my happiness, my home.

Chapter 1. Introduction

In 1956, American physician and researcher Theron Randolph introduced the construct of food addiction to the scientific community, theorizing that foods such as corn, wheat, coffee, milk, eggs, and potatoes had "addictive" potential.[1] Over the past 50 years, the lay[2-4] and scientific[5-9] communities have continued to speculate about the potential disorder, currently suspecting that foods high in fat, salt, and/or sugar may be positively reinforcing.

Since 2009, when researchers first validated a standardized food addiction tool,[10] nearly forty peer-reviewed scientific papers have examined the prevalence of food addiction, the reliability and validity of scales used to measure the disorder, and potential correlates of the condition in several populations. Thus far, the literature suggests that the prevalence ranges between 5% and 10% in the general population[11, 12] to over 50% in obese populations.[13, 14] Studies also indicate that the food addiction scale is reliable and valid,[10, 13, 15-19] and that food addiction may be correlated with other, theoretically-related variables, such as body mass index, binge eating disorder, depression, and food cravings. While scientists have made progress understanding the potential disorder, food addiction is not currently included in the Diagnostic and Statistical Manual of Mental Disorders, and researchers continue to question whether it is a valid mental disorder in general, and substance-related disorder in particular.

The aim of this dissertation is to advance our understanding of whether food addiction is a valid construct by addressing a few key gaps in the literature. In Part 1 of Chapter 2, we deconstruct the face validity of food addiction by evaluating whether it could be a mental disorder and/or substance-related disorder according to criteria provided by the Diagnostic and Statistical Manual of Mental Disorders, Jerome Wakefield's definition of dysfunction, and the

National Institute on Drug Abuse's definition of addiction. We then review whether animal and neurological evidence support the food addiction construct, and conclude with an overall assessment of whether we believe the condition has face validity.

In Part 2 of Chapter 2, we conduct a systematic literature review of human food addiction studies to evaluate whether the operationalization of the construct can be measured in populations and behaves as expected. We examine studies that estimated the prevalence, validated measures, and/or assessed correlates of food addiction in humans. Specifically, we determine whether our hypotheses about associations between food addiction and certain potential correlates of food addiction are supported. We examine food related-variables (e.g., craving, liking, and snacking), age, binge eating disorder, body mass index, depression and substance-related disorders. We conclude Part 2 with an assessment of food addiction's construct validity.

While several studies have examined the reliability and validity of measures of food addiction in adults, certain psychometric properties have never been evaluated. In Chapter 3, we use two community-based convenience samples to assess the internal and test-retest reliability of the original and shortened versions of the Yale Food Addiction Scale. We also evaluate whether the shorter scale has good sensitivity and negative predictive value using the original scale as the standard. In addition, we estimate the prevalence of food addiction in these samples overall and stratified by gender.

Despite examination of over 100 potential correlates, researchers have not yet assessed what is fundamental to the validation of food addiction as a substance-related disorder: the compulsive relationship between eating and food, itself. As such, in Chapter 4, we use two large cohorts of nurses to evaluate associations between food addiction and consumption of potentially

positively reinforcing nutrients, foods, and food groups. Specifically, we examine fat, sodium, and sugar nutrients, fatty, salty, sugary, and starchy food items and beverages, and different food groups (non-sweet fatty, salty, sweet, starchy, and fruits and vegetables).

In Chapter 5, we conclude with a discussion of the implications of validating food addiction as a new substance-related disorder. We summarize our findings, discuss their implications, and suggest future directions.

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Chapter 2. The Face and Construct Validity of Food Addiction

Introduction

In recent years, the concept of food addiction has entered public consciousness. Individuals who identify as food addicts and compulsive eaters belong to self-help groups such as Food Addicts Anonymous, Overeaters Anonymous, and Food Addicts in Recovery Anonymous. Dozens of books on food addiction are available, such as *Food Addiction: Healing Day by Day: Daily Affirmations* (2003) and *Shades of Hope: How to Treat Your Addiction to Food (*2013), and many television programs feature obese individuals who identify as food addicts. While food addiction has a prominent presence in popular culture, it is not currently included in the Diagnostic Statistical Manual of Mental Disorders. Whether it has scientific validity as a mental disorder in general and substance-related disorder in particular is still under investigation.

What is considered normal versus pathological can have enormous social, political, and research consequences.[1, 2] Psychologist Jerome Wakefield suggests that a primary challenge in defining a mental disorder is to "…validly distinguish bona fide mental disorders from intense normal … reactions. The proposed diagnostic criteria must be supported by solid evidence that they identify a class of disorders with reasonable validity, rather than largely pathologizing variants of normal [behavior]."[3] The construct of food addiction suggests that humans can become addicted to eating, a seemingly normal, non-deviant behavior upon which we all rely for survival. Untangling normal from disordered eating is therefore at the crux of whether food addiction could usefully be conceptualized as a valid mental illness and substance-related disorder.

There are many characteristics that contribute to the validity of a psychiatric disorder.[4] First, a health condition should have qualities or characteristics of a mental disorder. This is known as "face validity." In addition, a condition should have a presence in populations, i.e., studies should be able to estimate a prevalence of the disorder in different samples. Finally, and arguably most challenging to establish, a condition should have construct validity, i.e., the operationalization of the construct should measure what is intended.[5, 6] In practice, construct validity can be determined by assessing whether measures of a construct are associated with other theoretically-related constructs (convergent validity) and distinct from existing ones (discriminant validity).[4]

We evaluate whether food addiction has face and construct validity as a mental illness and/or substance-use disorder in two parts. In Part 1, we determine whether the condition has face validity by assessing whether it could meet criteria for a mental disorder, substance-related disorder and/or neurological addiction. In Part 2, we evaluate the construct validity of food addiction through a systematic literature review of studies that have measured food addiction's prevalence, reliability and validity of scales, or its correlates. In this section, we focus on whether studies found that food addiction is associated with other constructs in hypothesized directions. We describe our methods and results, and discuss potential methodological issues that may threaten the internal validity of the studies included in our review.

Part 1. Face Validity

In this section, we assess whether food addiction has face validity. We accomplish this by assessing whether food addiction could meet criteria for a mental disorder and substance-related disorder according to the definitions provided by the Diagnostic Statistical Manual of Mental Disorders. Next, we define addiction according to the National Institute on Drug Abuse, which

focuses on addiction being a neurological disorder, and we review whether animals and humans could experience neurological changes in response to consumption of certain foods similar to ones observed after drug use.

In this section we review the literature on 1) criteria for defining mental disorders, substance-related disorders and addiction in general, 2) food addiction in animals, 3) the relationship between obesity and addiction, and 4) food addiction as a neurological disorder. In this section we did not conduct a formal systematic review, but aimed to provide a broad, comprehensive overview of the literature.

Food Addiction as a Mental Disorder

A fundamental first step in evaluating whether food addiction can be conceptualized as a valid mental disorder is defining the term "mental disorder" and determining whether food addiction, at face value, fits this definition. This paper relies on the definition in the Diagnostic Statistical Manual of Mental Disorders, Version 5:[7]

"A mental disorder is a syndrome characterized by clinically significant disturbance in an individual's cognition, emotion regulation, or behavior that reflects a dysfunction in the psychological, biological, or developmental processes underlying mental functioning. Mental disorders are usually associated with significant distress in social, occupational, or other important activities. An expectable or culturally approved response to a common stressor or loss, such as the death of a loved one, is not a mental disorder. Socially deviant behavior (e.g., political, religious, or sexual) and conflicts that are primarily between the individual and society are not mental disorders unless the deviance or conflict results from a dysfunction in the individual, as described above."[8]

Perhaps the two most essential elements of this definition, informed by Wakefield, are that a mental disorder be characterized by dysfunction, and that this dysfunction causes harm or distress to the individual and/or his/her relationships.[9] Wakefield defines a dysfunction as a "failure of some internal (mental or physical) mechanism to perform a natural function for which

it was designed by natural selection."[7] This internal dysfunction, which is informed by the failure of a mechanism, must cause distress or impairment, which are arguably subjective evaluations informed by 'cultural values.'

If food addiction, then, is a mental disorder, it should be characterized by an internal dysfunction that causes harm or impairment. Furthermore, if it is a mental disorder that should be categorized as an addiction, the internal dysfunction should be one that is shared with other addictions. While there are many possible definitions for the internal dysfunction of addiction, one that encompasses both behavioral and neurological aspects is as follows:

> "A key element … is the way in which an individual's behaviour associated with various addictive objects (alcohol, other drugs, electronic gambling machines, pornographic websites, hedonic food, etc.) becomes increasingly compulsive. Although not understood fully at a neurobiological level, the normal flexibility of human behavior guided by neocortical 'higher power' appears to become increasingly eroded towards a dehumanized state of compulsive behavior, the 'sticky' repertoire of habitual behavior that constitutes the addictive lifestyle, mediated by a 'compulsive circuit' (nucleus accumbens, ventral pallidum, thalamus and orbitofrontal cortex)."[10]

According to this definition, the internal dysfunction of addiction is the increasingly compulsive relationship between an individual's behavior and an "addictive object," (i.e., a "substance") and the changes in the brain associated with compulsion over time. If food addiction has the same internal dysfunction as an addiction, the internal dysfunction would be the compulsive relationship between eating (the behavior) and addictive foods (the substance) and associated neurological manifestations.[11, 12]

For food addiction to fully meet the criteria for a mental disorder, the compulsive relationship between eating and addictive foods would need to cause harm or distress. This seems plausible as compulsive eating could lead to negative feelings (e.g., guilt, sadness, anger) or health problems (e.g., obesity, diabetes, heart disease). At face value, it seems reasonable that

food addiction could meet the criteria for a mental disorder in general, as it could be characterized by dysfunction leading to significant harm or impairment. While the lay literature[13, 14] on food addiction supports this, we need to examine the evidence.

Food Addiction as a Substance Use Disorder

We next assess whether food addiction could meet the criteria for a substance-related disorder as defined by the Diagnostic Statistical Manual of Mental Disorders. In the first and second editions of the Diagnostic and Statistical Manual of Mental Disorders, published in 1952 and 1968, respectively, "Substance-Related Disorders" were under the category "Sociopathic Personality." "Substance-Related Disorders" became its own category in 1980 in the Diagnostic and Statistical Manual of Mental Disorders, Third Edition, and remained its own category for more than 30 years.[15] This umbrella category included disorders related to intoxication, dependence, abuse, and substance withdrawal caused by legal and illegal substances. Substances included alcohol, amphetamines, caffeine, inhalants, nicotine, prescription medications, opioids, marijuana, cocaine, hallucinogens, and phencyclidine (PCP).[16]

In the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, "Substance Dependence" was listed under "Substance Use Disorders," which was under the umbrella category of "Substance-Related Disorders." Substance dependence was defined as "a maladaptive pattern of substance use leading to clinically significant impairment or distress, as manifested by three (or more) of the following, occurring any time in the same 12-month period:"

1. Tolerance (marked increase in amount; marked decrease in effect)
2. Characteristic withdrawal symptoms; substance taken to relieve withdrawal
3. Substance taken in larger amount and for longer period than intended

4. Persistent desire or repeated unsuccessful attempt to quit
5. Much time/activity to obtain, use, recover
6. Important social, occupational, or recreational activities given up or reduced
7. Use continues despite knowledge of adverse consequences

In May 2013, "Substance-Related Disorders" in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition became "Addiction and Related Disorders" in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. Within "Addiction and Related disorders," the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition category "Substance Dependence" became "Substance-Related Disorder."[17] The criteria are the same as in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, but additionally include:

8. Recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home
9. Recurrent substance use in situations in which it is physically hazardous
10. Continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the substance
11. Craving or a strong desire or urge to use a specific substance

Criteria 8 through 10 were in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition under the "Substance Abuse" category, which no longer exists in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. The 11th criterion is new. The diagnosis threshold for a substance-related disorder is less stringent, needing only 2 out of 11 criteria in the past 12 months. In addition, the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition allows researchers and practitioners to specify the severity of substance

dependence according to the number of criteria met: mild (2-3), moderate (4-5), or severe (6 or more). It is also possible to distinguish whether the disorder is with or without physiological dependence (i.e., tolerance or withdrawal), implying that a disorder need not entail this type of dependence.

A maladaptive pattern is characteristic of an internal dysfunction, and this must lead to "clinically significant impairment or distress," both defining characteristics of a mental disorder. Of the 11 listed above, (while not mutually exclusive), criteria 1, 3, 4 and 11 could be indicators of dysfunction, and criteria 2 and 5-10 could be indicators of harm or distress. Understanding the criteria that define a substance-related disorder is necessary if we wish to determine whether certain foods could be consumed in such a way that the Diagnostic and Statistical Manual of Mental Disorders criteria could be met.

Evidence from Animal Studies Supporting the Diagnostic and Statistical Manual of Mental Disorders Criteria

Although food addiction could meet the definitions for a mental disorder and substance-related disorder, does evidence substantiate this? While, ultimately, we would like to know whether people might consume certain foods in an addictive, maladaptive way, we first turn to the animal evidence. Preliminary research[15, 18-29] suggests that animals that eat large quantities of fatty and/or sugary foods over time show symptoms of dependence.

Tolerance

Several studies[4, 30-34] have found evidence of tolerance in animals, i.e., a need for markedly increased amounts of particular types of food to achieve a desired effect or markedly diminished effect with continued consumption of the same amount of food. Several studies have found that rats eat more sugar over time, especially after a period of abstinence. For example,

one study[30] found that given the opportunity, rats eat more sugar solution over time and increase their sugar consumption after a period of abstinence. Another study[33] found that sucrose-bingeing rats increase their sucrose intake over time and have a delayed satiation response. Similarly, another research group[32] found that rats with intermittent access to a 25% glucose solution doubled their intake over time.

Other studies have found that rats eat more fatty food over time. One study[31] found that rats given intermittent access to high-calorie food (vegetable shortening (90%) sweetened with sucrose (10%)) increased their calorie consumption over a 6-week period compared to rats offered regular chow. Similarly, a study[34] found that rats given intermittent access to shortening exhibited binge-like eating behaviors.

These studies demonstrate that rats consuming palatable (i.e., savory, tasty, or agreeable in flavor) food, especially when given intermittent access, increase their consumption, suggesting that rats need more of these foods over time to achieve a desired effect. This research suggests that rats show signs of tolerance to palatable foods.

Withdrawal

Studies about withdrawal from certain types of foods are more limited. One research group[30, 35] found that sucrose-bingeing rats show signs of opiate-like withdrawal such as chattering teeth, forepaw tremor, and head shakes when deprived of sugar.

Eating certain foods despite knowledge of adverse consequences

Studies about eating despite adverse consequences are also limited. One study[18] found that animals continue to eat palatable foods despite anticipation of adverse consequences. In this study, [18] three groups of rats were given different types of diets for 40 days. The groups received regular rat chow, restricted access to "cafeteria food" (bacon, sausage, cheesecake, pound cake,

frosting and chocolate), or extended access to cafeteria food. The researchers then exposed a sub-sample from each diet group to a fear-conditioning procedure (electrical shock plus a light cue) and subsequently offered the rats cafeteria food in the presence of the fear-inducing light. The light prevented cafeteria food intake in the groups that had received chow only or limited access to cafeteria food, but not in the group that had extended access to cafeteria food. This study provides evidence that eating certain foods can lead to continued use despite anticipation of problems caused by use.[18]

There is no animal research to date examining other substance dependence criteria such as *eating larger amounts than intended*, *persistent desire or repeated unsuccessful attempts to stop eating certain foods,* or *craving.* This may be due to the difficulty of measuring concepts such as *intention* and *desire* in animals. However, animal research could still evaluate whether consumption of certain food leads to *failure to fulfill major role obligations* (e.g., taking care of young), *use in situations in which it is physically hazardous*, or *use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the substance.* While there is preliminary evidence of food addiction in animals, it is not clear whether substance-related disorder symptoms result from the consumption of food due to the body's response to the food per se (e.g., because of its flavor or effects on the body), the rats' response to the intermittent reward schedule established by eating the food (i.e., through operant conditioning), or some combination of both the qualities of the food itself and the consequences of the type of access.

The above section provided theoretical and biological evidence that food addiction could meet the criteria for a mental disorder and substance-related disorder according to definitions provided by the Diagnostic and Statistical Manual of Mental Disorders. Neurological research

may also contribute to the face validity of food addiction. We now describe how food and drugs of pleasure affect the brain and whether certain types of food may cause neurological effects analogous to those of recognized addictive substances.

Neurological Evidence

While epidemiologic research on drug addiction typically relies on the definition for a substance-related disorder provided by the Diagnostic and Statistical Manual of Mental Disorders, the National Institute on Drug Abuse defines addiction as "a chronic, often relapsing brain disease that causes compulsive drug seeking and use, despite harmful consequences to the addicted individual and to those around him or her."[36] While not substantially different from one another, the National Institute on Drug Abuse definition focuses on the presumed biological substrate (i.e., brain circuitry), while the Diagnostic and Statistical Manual of Mental Disorders focuses on the behavioral and emotional symptoms underlying addiction. The National Institute on Drug Abuse's definition of addiction would still meet the criteria for a mental disorder, as it specifies both the dysfunction ("compulsive drug seeking") and harm ("harmful consequences").[a]

When neurons release dopamine (a neurotransmitter) into the nucleus accumbens, individuals feel pleasure. In non-addicted individuals, dopamine is released into synapses, crosses to other neurons, binds to receptors, and causes pleasure. Normally, excess dopamine is removed from these receptors, and nerve cells release a neurotransmitter called GABA (gamma-aminobutyric acid) to prevent receptors from becoming over stimulated. Addictive substances produce exaggerated amounts of dopamine in the synapses, which induces heightened feelings of

[a] Despite providing this definition of addiction, the National Institute on Drug Abuse uses the DSM-IV criteria to assess the prevalence of substance dependence and abuse in their National Survey on Drug Use and Health.

pleasure: amphetamines cause excess release of dopamine, cocaine blocks the reuptake of dopamine to the pre-synaptic neuron, and heroin and morphine block the release of GABA. Repeated drug use disrupts the balance of brain circuits that control reward, memory and cognition.[37] This is the biological process that is hypothesized to underlie compulsive drug use and ultimately addiction.[38]

There is some evidence that sweet-tasting substances (both caloric and non-caloric sweeteners) stimulate sweet taste receptors on the surface of the tongue that activate the l-opioid receptors on GABA interneurons in the ventral tegmental area of the brain which in turn cause an exaggerated frequency of dopamine firing in the nucleus accumbens.[15, 39] This neurological pathway is similar to that which is activated when humans consume drugs of abuse. However, one distinction is that the dorsal striatum, a part of the brain contributing to decision making,[40] may influence food reward, while the ventral striatum, associated with emotional and motivational aspects of behavior,[40] may influence the processing of drugs of abuse.[15]

Neurological Evidence from Animal Studies

There is preliminary evidence that certain types of foods lead to neurological changes in animals, suggestive of addiction. Many studies have focused on the addictive quality of sugar or high fat diets, and have examined dopamine levels, both baseline and in response to eating palatable food. One study[33] found that rats that increased their sugar consumption over time (from 37 to 112 ml per day over 21 days) experienced dopamine increases—130% of baseline levels—in the nucleus accembens after eating sugar. Control groups did not have significant increases in dopamine levels. Another study[19] found that over time, rats eating a "cafeteria diet" consisting of high fat and sweet foods (bacon, sausage, cheesecake, pound cake, frosting and

chocolate) had lower baseline dopamine levels as well as lower chow or amphetamine-stimulated dopamine in the nucleus accumbens. The researchers hypothesized that low baseline dopamine was responsible for the rats' increased consumption of the palatable food.

Another group[18] found that the development of obesity in rats led to a worsening deficit in neural reward response as is observed in human drug-users. They found more compulsive feeding behaviors and fewer dopamine receptors in obese compared with lean rats. They also found that reduced expression of dopamine receptors sped up the development of addiction-like reward deficits and the onset of compulsive food seeking in rats with prolonged access to palatable, high-fat food.

A more recent study[34] provided evidence that a high-fat, but not high-sugar diet leads to neurological changes over time. These researchers examined the effects of four liquid diets (a sucrose solution, a nutritionally complete diet [Vanilla Ensure], a protein solution [i.e., peptone—a mixture of polypeptides and amino acids], and a corn oil emulsion) on activity in the small intestines and brains of rats. This study found that the fat-based and nutritionally complete diets prompted the release of cannabinoid chemicals in the gut, encouraging further fat intake as well as a surge of dopamine release in the brain. However, the carbohydrate diets and protein diets did not have a significant effect on activity in the small intestine or brain (these diets showed a non-significant decrease of dopamine release in the brain). The fatty diet findings support the theory that a positive feedback mechanism in the gut may drive the intake of fatty foods, and further suggest that strategies aimed at limiting small-intestine cannabinoid activity may reduce overeating of fatty foods.[25] However, the carbohydrate diet findings are contrary to evidence supporting a model of sugar addiction.

The animal studies explicated above suggest that over time, sugar and other highly palatable foods may lead to changes in the brain. Most studies have focused on dopamine responses, finding larger than normal dopamine releases and lower baseline dopamine levels in the brain in response to eating large amounts of sugar or fatty foods over time.[18, 19, 25, 33] More recent research suggests that leptin resistance may also play a role in excessive eating.[26-28] Despite the burgeoning evidence of an internal dysfunction at a neurological level, these food addiction findings are still inconclusive and may not necessarily be extrapolated to humans.

Neurological Evidence from Human Studies

To date, two studies[41, 42] have explicitly examined food addiction in relation to neurological activity in humans. The first study[41] (n = 39) used functional magnetic resonance imaging to examine whether food addiction scores were associated with increased neurological activity suggestive of addiction in response to exposure to palatable food. Food addiction scores were positively correlated with more activity in the reward center of the brain, (anterior cingulate cortex, r = 0.74, p <0.001, medial orbitofrontal cortex, r = 0.58, p = 0.004, and amygdala, r = 0.55, p = 0.007). In addition, participants with higher (≥3 symptoms, 57%) compared with lower food addiction scores (≤1 symptom, 43%) had significantly less activity in the inhibitory region of the brain in response to drinking a chocolate milkshake compared with a tasteless solution (lateral orbitofrontal cortex, r = -0.66, p = 0.009).

A second study[42] (n = 28) using electroencephalography found similar neural responses in food-addicted individuals to those we see in drug abusers. This study examined neurological activity under three conditions: 1) resting for five minutes, 2) tasting a chocolate milkshake and resting for five minutes, and 3) tasting a control neutral solution and resting for five minutes. As only four participants (14.3%) met criteria for food addiction, participants with ≥3 food addiction

symptoms (50%) were compared with those with ≤2. Results in the group that tasted the chocolate milkshake indicated significant increases (*p*-values, 0.01 to 0.05) in neural activity in the delta power in the right middle frontal gyrus, the right precetral gyrus, the theta power in the right insula, and the inferior frontal gyrus among people with more food addiction symptoms compared to fewer. In addition, food addiction symptoms were significantly positively correlated with activation of theta and alpha frequency bands ($0.47 \leq r \leq 0.74$, $p < 0.05$). There were no differences in neural activity in the other groups. Both of these studies support greater neurological activity in response to palatable food among people with higher food addiction scores compared with lower, and suggest that certain types of food may affect the brain similarly to how drugs of abuse affect brains of drug users.

Most human neurological food addiction-related studies have compared dopamine activity in the brains of obese and non-obese individuals, rather than in people with food addiction per se. Specifically, studies have examined dopamine changes in response to seeing and/or tasting palatable foods. In one study,[20] researchers measured dopamine changes in the brains of ten healthy individuals using positron emission tomography (PET) scans. They found that dopamine levels increased significantly in the dorsal ($p < 0.03$), but not ventral, striatum after showing the participants displays of their favorite foods. [21]Another study[23] using functional magnetic resonance imaging found that obese compared with lean adolescent girls showed greater activity in areas of the brain encoding sensory and pleasurable characteristics of food in response to being shown and then drinking chocolate milkshakes compared with a tasteless solution ($p < 0.001$). However, obese girls had lower activity in the caudate nucleus, possibly due to lower dopamine receptor activity. Similar results were found by another study[24] (n = 26), which showed that obese compared with non-obese subjects had higher stimulation in their

dorsal striatum in response to viewing high-calorie foods ($0.50 \leq r \leq 0.56$, $p < 0.009$). This type of brain activity in response to food may be a risk factor for overeating and obesity.[15]

Another research group[22] compared the number of dopamine receptors in the brains of obese and non-obese subjects. This study compared ten severely obese individuals (mean body mass index 51.2) with ten non-obese individuals (mean body mass index 24.7), and found that the obese compared with non-obese individuals had significantly fewer dopamine receptors ($p \leq 0.0075$). In addition, among obese individuals, body mass index was negatively correlated with dopamine levels ($r = -0.84$, $p \leq 0.002$); participants with the largest body mass indices had the lowest dopamine values. The researchers hypothesized that individuals may overeat to compensate for reduced dopamine activity. In fact, research has shown that drugs that block dopamine receptors increase appetite and weight gain. [15, 23, 24]

The above evidence suggests that obese compared with lean individuals may have fewer baseline dopamine receptors and greater dopamine activity in response to seeing and tasting palatable foods. This type of dopamine activity is similar to what is observed in the brains of people addicted to drugs.[20, 43] While not all obese individuals are necessarily addicted to food, preliminary research demonstrates a strong dose-response relationship between body mass index and food addiction,[44] suggesting that people with food addiction may have similar neurological patterns of dopamine activity.

Despite results suggesting that anticipation and consumption of palatable foods may affect dopamine responses, research on the internal dysfunction of neurological human food addiction is limited and indirect. The studies are small, only hint at associations, (not causation), and mainly focus on obese compared with non-obese subjects, rather than on people with and

without food addiction. Thus, currently, there is not enough evidence to conclude that food addiction is a biological brain disorder.

While neurological research on food addiction is sparse and inconclusive, there is theoretical and biological evidence from animal studies that food addiction could meet criteria for a mental disorder and substance-related disorder as defined by the Diagnostic and Statistical Manual of Mental Disorders. The evidence that it has characteristics of a mental disorder and substance-related disorder leads us to conclude that food addiction has face validity.

Part 2. Construct Validity: A Systematic Review

In Part 2, we conduct a systematic literature review of human food addiction studies to evaluate whether the operationalization of the construct can be measured in populations and is correlated with other constructs in hypothesized directions. We examine studies that estimated the prevalence, validated measures, and/or assessed correlates of food addiction in humans.

Methods

Search Criteria and Information Sources

To yield a comprehensive yet discriminating list of potentially relevant publications, we searched the following combination of medical subject heading keywords in Pubmed, PsychINFO and Social Sciences Citation Index databases: ("Substance-related disorders" OR “behavior, addictive”) AND (eating OR "Eating disorders" OR food OR obesity OR nutrition disorders OR diet) OR "food addiction." The keyword, “Substance-related disorders” includes the sub-categories “drug addiction” and “substance addiction.” We aimed for keywords broad enough to identify the majority of published papers on food addiction. In addition to searching electronic databases, we consulted experts and authors as needed and hand-searched reference lists.

Eligibility and Study Selection

We accepted for initial review peer-reviewed articles and dissertations published by December 31, 2014 (when we completed the search) about human food addiction from all countries with an English abstract (n = 8,485) (See Figure 1 in the Appendix). A study title was potentially relevant if it included a combination of the terms (or term variants): *binge, body mass index, craving, drinking, eating, food, obesity, overeating, sugar,* or *weight* with *abuse, addiction, alcohol, depression, drug, nicotine, smoking*, or *substance* (n = 671). Abstracts that included the term "food addiction" or a combination of terms related to eating or food and addiction or substance dependence, and were not animal studies or case studies, pooled analyses, meta-analyses, or other reviews were eligible for full publication review (n = 52). Full publications were included (n = 34) if they employed a validated, standardized measure of food addiction to examine prevalence, scale psychometric properties, or correlates of the disorder. Papers were excluded if they used the same sample as another study, and only reported redundant information (n = 1). We located an additional two articles[45, 46] through searching reference lists. Our final sample included 36 studies[41, 42, 44, 46-78] for review.

Data Collection Process

We extracted data from each study into Excel tables. We collected data on demographic and study characteristics (e.g., sample size, study design, source/sampling population, age, ethnicity, sex, mean body mass index), food addiction (e.g., type of scale used, reliability of scale, prevalence, mean symptom count), and potential correlates (e.g., food, age, binge eating disorder, body mass index, depression, and substance-use disorders), expectation about the association, and type of association (positive, none, or negative). We calculated frequencies and

percentages of each extracted variable. For details see Table 3 and Appendix 1, Tables A1.5 and A1.6.

Hypotheses about Correlates

We gathered information on all potential correlates of food addiction, (see Appendix 1, Table A1.6 for more details), but focused on a few in particular based on what is known about disordered eating, psychiatric disorders, and other substance-related disorders (see Table 3). We had hypotheses about the following variables:

Food

Core to the internal dysfunction of addictive disorders, and therefore food addiction, is the compulsive relationship between an individual's behavior and a substance. It has yet to be determined whether and to what degree certain types of foods are or become addictive "substances." Highly palatable food that is full of salt, fat, and sugar—nutrients believed to make certain types of food difficult to resist, and which could ultimately lead to addictive eating—are abundantly available.[15, 79] The animal evidence reviewed above suggests that consumption of foods high in sugar and/or fat could lead to compulsive eating behaviors, neurological changes, and food addiction.[15, 18-28, 41] We therefore expected positive relationships between consumption of fatty and/or sugary foods and cravings for these foods.

Age

We expected an inverse relationship between age and food addiction, as there is evidence of inverse relationships between age and alcohol dependence,[80, 81] current or lifetime substance-use disorders,[82] marijuana dependence,[80] and nicotine dependence among daily smokers.[83]

Binge eating disorder

We expected a positive relationship between food addiction and binge eating, as both are characterized by overeating. However, we expected that the disorders would not overlap entirely—theoretically or empirically—as we expected food addiction to be distinct from binge eating disorder.

Body mass index

Individuals who eat compulsively would likely gain weight and have a higher body mass index compared with those who do not. We therefore expected a positive relationship between body mass index and food addiction.

Depression

As prior evidence[84-90] supports a positive relationship between depression and other substance-use disorders, we expected a positive relationship between depression and food addiction.

Substance Use

Substance-related disorders involving alcohol, illicit drugs, and nicotine are often comorbid. For example, one study[91] found that the odds of lifetime drug dependence were 15.75 times higher (95% CI 9.59-25.86) among women with lifetime alcohol dependence compared with women without. However, researchers have hypothesized an inverse relationship between current food addiction and current substance-related disorders.[92-94] For certain types of people, food and alcohol or food and cigarettes may compete for the same neurotransmitters (e.g., dopamine) effect in the brain; people who have this susceptibility may not abuse more than one of these substances concurrently. Thus, while we expected lifetime comorbidity, we expected inverse relationships between current food addiction and current other substance-related disorders.

If evidence supports our hypotheses, our belief in food addiction as a valid substance-related disorder will be strengthened.

Results

Study Characteristics

As detailed in Table 1, most food addiction studies used small samples with fewer than 200 subjects (64%),[41, 42, 46, 49-56, 59-62, 64, 66, 67, 70, 72, 74, 75, 78] cross-sectional designs (78%),[41, 42, 46-49, 51, 52, 54-66, 70, 71, 73-77] or samples restricted to overweight or obese populations (58%).[30, 41, 42, 46, 47, 49-53, 55, 56, 60-62, 64, 65, 67, 70, 75, 78] Thirty-nine percent[41, 42, 46, 47, 51, 56, 61, 62, 64, 65, 67, 70, 75, 78] of studies specifically sampled obese, treatment-seeking individuals, 33%[47, 49, 50, 58, 65, 66, 71-74, 76] university populations, and 8% [44, 68, 69] used large cohorts of female nurses. The majority of each study was younger than 50 years of age, female, and/or Caucasian; a quarter[41, 44, 46, 59, 63, 68, 69, 72, 74] of studies exclusively sampled women. Approximately half of the studies were conducted in the United States;[41, 44, 47, 49-51, 56-62, 66-69, 75, 76, 78] the other half in Europe[42, 48, 63-65, 70-74] or Canada.[46, 52-55, 77] The majority of studies focused on food addiction prevalence and relationships with potential covariates. However, 30%[48, 51, 52, 58, 60, 62, 63, 65, 70, 73] focused on psychometric properties of food addiction scales. Only two studies[41, 42] (described in Part 1) examined neurological effects of food, comparing people with and without food addiction.

Standardized Measures of Food Addiction

Yale Food Addiction Scale

The vast majority of food addiction studies (Table 2) used the Yale Food Addiction Scale. Gearhardt and colleagues[58] developed this scale to identify people who show symptoms of substance dependence through consumption of high fat and/or high sugar foods.[58] They adapted the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition Revised criteria for

substance dependence so that each item addresses addictive-like eating in the past twelve months with food as the substance of abuse. Each of the 25 items taps into one of the seven criteria for substance dependence. For example, items 1-3 tap into the criterion "substance taken in larger amount and for longer period than intended," and items 4, 22, 24, and 25 tap into the criterion, "Persistent desire or repeated unsuccessful attempt to quit." The scale assesses clinical significance through two questions about whether eating behavior causes significant impairment or distress in the individual. Experts in addiction and binge eating as well as clinical patients in treatment for binge eating disorder reviewed the items proposed for the scale. (For details on this measure see Appendix 1, Tables A1.1 and A1.3).

Sixteen items are coded with a Likert scale (never to four or more times per week or daily), eight items have yes or no responses, and one item has options ranging from "one or fewer times a week" to "five or more times a day" (for details see Appendix 1, Table A1.4). The scale developers intended for the items with frequency scoring to assess behaviors that could occur occasionally in non-problem eaters and the dichotomous items to indicate more severe eating problems.[58] A diagnosis of food addiction is met if a person endorses three or more of the seven substance-use dependence criteria and meets the criterion for clinical significance.

In the first validation study,[58] Gearhardt and colleagues randomly selected 1,440 students from the roster of all students enrolled at Yale University to test the reliability and validity of the Yale Food Addiction Scale. Three hundred and fifty-three students (24.5%) initiated the survey. Students answered questions about food addiction, eating behaviors, alcohol consumption, gambling, and smoking. In this validation study, the scale evidenced good internal reliability (Cronbach's $\alpha = .86$), good convergent validity ($r = .46$ to $.61$, $p = 0.01$) with measures of similar constructs (emotional eating and eating troubles scores, respectively), and good discriminant

validity (low correlations between diagnostic and food addiction symptom scores and alcohol problems, r = .16 and .17).[58] While this study provided some indication of the scale's reliability and validity, it had a low response rate, which could have resulted in low generalizability. In addition, it did not evaluate the reliability of the scale over time.

Since its publication in 2009, eight[48, 51, 52, 62, 63, 65, 70, 73] additional studies that specifically assessed the reliability and validity of the Yale Food Addiction Scale have been conducted in different populations and languages (e.g., among the overweight and obese and weight-loss treatment seeking,[51, 52, 62, 65, 70] and in German,[73] French,[48] Spanish,[63] and Italian[65]). A total of 32[41, 42, 46-52, 54-59, 61-67, 70-78] studies have employed the Yale Food Addiction Scale, and approximately 60%[42, 46, 48, 50, 52, 54-58, 63-65, 70-74, 76] reported the scale's internal reliability, which ranged from α = 0.76 to 0.95 (good to excellent). The evidence thus far suggests that the scale has good internal reliability.

Modified Yale Food Addiction Scale

Three studies[44, 68, 69] (8%) (Table 2) used the Modified Yale Food Addiction Scale. Harvard Medical Center piloted a modified version of the Yale Food Addiction Scale in the 2008 and 2009 follow-up studies of the Nurses' Health Study and Nurses' Health Study II. The modified scale includes nine of the 25 items in the original scale. Researchers chose one item for each of the seven diagnostic criteria for substance dependence and included two items to assess clinical significance. In addition, they slightly modified and shortened the wording of each item. If a person endorses three or more of the seven substance-use dependence criteria and meets criterion for clinical significance, the person meets criteria for food addiction (same as the original Yale Food Addiction Scale). (For details on this scale see Appendix, Table A1.2).

Harvard researchers tested the reliability and validity of a proxy version of the modified scale (including the same items, but with the wording of the original scale) in the same sample of 353 Yale college students described above.[44] They found that the (proxy) modified scale estimated a food addiction prevalence of 9.0% compared with the original 11.4%.[44] The internal reliability of the scale was $\alpha = 0.75$, convergent validity with similar constructs (emotional eating and difficulty eating) ranged from $r = 0.40$ to 0.50, and correlations with discriminant measures were similar to those of the original Yale Food Addiction Scale (-0.04 to 0.27).[44] The psychometric properties of the (proxy) modified scale are similar to those of the original Yale Food Addiction Scale, although it estimated a slighted lower prevalence of food addiction. The two other studies using the modified Yale Food Addiction Scale did not report estimates of reliability or validity.[68, 69]

Yale Food Addiction Scale-Children's Version

One study[60] used the Yale Food Addiction Scale, Children's Version. Gearhardt and colleagues altered the wording of the original Yale Food Addiction Scale to make it appropriate for children. In their sample of 75 children, the scale had adequate internal reliability ($\alpha = 0.78$), and good convergent validity with relevant measures (positive associations with body mass index and emotional eating and inverse association with satiety responsiveness).

Food Addiction Prevalence

While most studies reported the prevalence of food addiction, estimates varied widely. Approximately 30%[44, 48, 60, 68, 69, 71, 73, 77] of studies found prevalence estimates between 5 and 10%, suggesting that food addiction may not be a common disorder; however, almost 30%[51, 61-65, 70, 78] of studies reported estimates between 30 and 60%. These high prevalence estimates are not surprising as the majority of studies sampled overweight or obese populations, and 75%[41, 42,

[46, 47, 49, 50, 52, 53, 55-57, 59, 61, 62, 64, 65, 67, 70, 75, 77, 78] of studies reporting body mass index reported means higher than 25 (Table 1). The largest epidemiologic study[44] included in this review (n = 134,175) that did not sample among overweight or obese participants found a prevalence of 5.8%. Although the participants in this study were all female, this estimate is likely much more representative of the general population than those from the all-overweight or obese samples.

Construct Validity

If food addiction has construct validity, evidence should suggest that it behaves as expected, i.e., that the operationalized measure is associated with other constructs in hypothesized directions. The studies included in this review investigated many potential correlates of food addiction—more than 115—including demographic and lifestyle factors; weight, weight loss, and weight attitudes; food cravings and liking; and eating disorder psychopathology, psychiatric disorders, personality characteristics, brain mechanisms, and physical disorders (for details see Appendix 1, Table A1.6). Of all the potential food addiction correlates, studies most often examined age (47%), body mass index (61%), binge eating (47%), and depression (36%). Emotional eating (31%) and food cravings (22%) were also popular variables.

In this review, we focused on certain potential food addiction correlates about which we had specific hypotheses (Table 3).

Food

Many food-related variables—including liking and cravings—were positively associated with food addiction, as expected. Twenty-two percent[42, 52, 53, 55, 59, 71, 72, 78] of studies examined overall food cravings or specific cravings for fatty, sugary, starchy, or fast foods. Positive associations were found between food addiction and starchy,[78] fatty,[59] processed,[59] and fast

food[78] cravings. Studies also found positive associations with fatty food liking,[59] processed food liking,[59] percent of diet from fat,[77] and sweet snacking.[52, 55]

However, some food-related findings were unexpected. Contrary to our hypothesis, 75%[41, 42, 59, 77, 78] of studies reporting on food variables found no association between sugar-related variables and food addiction. Specifically, no association was found between food addiction and percent of diet from carbohydrates,[77] sugar cravings,[59, 78] pleasantness ratings of a milkshake,[41, 42], and sugar liking.[59]

While these studies generally reported using valid and reliable measures for food addiction (as well as for the other food-related measures), misclassification could have biased these findings. It is possible that people with food addiction responded to questions about food cravings or food liking differently from people without food addiction. For example, if subjects with food addiction were more likely to under-report sweet cravings compared with people without food addiction, the association between food addiction and sweet cravings may have been deflated, and thus appeared consistent with our null hypotheses.

Age

Almost 50%[41, 42, 44, 46, 50, 52, 53, 55-57, 61-63, 71, 72, 74, 78] of studies reported on the relationship between age and food addiction. As expected, two studies (age ranges 19-32[72] and 45-88[44]) found inverse associations; however, 82%[41, 42, 46, 50, 52, 53, 55-57, 61, 62, 71, 74, 78] of studies found no association. It is possible that small samples contributed to these results. Approximately 86%[41, 42, 46, 50, 52, 53, 55, 56, 61, 62, 74, 78] of the studies finding no association had fewer than 200 participants, and half[42, 46, 50, 52, 53, 55, 78] found food addiction prevalence estimates resulting in 4 to 22 food addiction participants. These small numbers result in low power, which reduces the chances of finding a true main effect. However, one of the studies[44] finding an inverse relationship had a

large sample (n = 134,175) and 7,782 cases of food addiction, which provides ample power to detect a main effect. Restricted age range (i.e., 20 years compared with 40 or more years) did not differ between studies finding inverse versus no effect.

Body Mass Index

Approximately 66%[41, 42, 44, 46, 49, 50, 52, 53, 55-57, 60, 63, 65, 66, 68, 71-78] of studies reported on the relationship between body mass index and food addiction, however, only 44%[44, 46, 57, 60, 63, 65, 66, 68, 73, 76, 77] of associations were positive, 48%[41, 42, 49, 50, 52, 53, 55, 56, 71, 72, 75, 78] were compatible with our null hypotheses, and 8%[46, 74] were inverse. These inconsistent results may be due to restricted variance of the outcome variable, as all[41, 42, 49, 50, 52, 53, 55, 56, 72, 75, 78] but one[71] of the studies reporting no relationship used overweight or obese samples. None of the studies reporting positive associations were among overweight or obese samples. The risk of finding a positive relationship between body mass index and food addiction was therefore 12 times higher if the study sample was among the general population than among the overweight or obese (relative risk = 12, 95% confidence interval = (1.9, 78.4)). This suggests that above a certain threshold of body mass index, we may not be able to detect an association. Thus, in the general population, we are more likely to see a positive, dose-response relationship.

Depression

Thirty-six percent[42, 44, 46, 50, 52, 56, 61-64, 72, 74, 75] of studies examined depression and food addiction. As expected, the vast majority reported a positive association with depression. The three studies[42, 46, 72] reporting no association had extremely small samples ($n \leq 50$), which again, can result in low power, proving insufficient for detecting a main effect. For example, given their extremely small sample size of 28 subjects and 4 with food addiction, one study[42] had 15%

power to find a moderate effect size of d = 0.5. If we expected a large effect size of d = 0.9, this study would still only have 36% power to detect a significant difference between groups.[95]

Binge Eating

Almost 50%[46-48, 50-52, 55, 57, 59, 61-65, 73, 74, 92] of studies reported on food addiction's relationship with binge eating disorder or number of bingeing episodes. As expected, binge eating was positively correlated with food addiction in all studies. Below we discuss further whether the two disorders are distinct from one another.

Substance Use

Most of the findings related to substance use were consistent with our null hypotheses. For example, none of the studies[42, 58, 61, 62, 73] examining current alcohol use found inverse relationships with food addiction. Out of seven possible associations with current alcohol consumption, daily drinking, alcohol problems, or alcohol use disorder, five were consistent with our null hypothesis and two[58, 73] were positive. Three[42, 61, 62] of four[42, 61, 62, 73] studies reporting no association had small samples (n<100) and did not control for confounders. The other study[73] had a larger sample size (n = 752), but only controlled for emotional eating and eating attitudes. If an inverse relationship were the true relationship, not controlling for potential positive confounders such as depression could result in findings compatible with our null hypotheses. The one study[58] reporting positive associations found weak correlations (r < 0.2), and described their results as evidence of discriminant validity.

Similarly, none of the drug use findings supported our hypothesis. Rather, studies[51, 61, 62] found no association between food addiction and drug use, which could be due, in part, to small sample sizes, as all three studies had samples of fewer than 100 subjects.

Three studies[42, 44, 52] examined food addiction and current smoking. One[44] found an inverse relationship, while two found none. Supporting our hypothesis, the same study that found an inverse relationship with current smoking also found a positive one with past smoking. The two studies reporting no relationship with food addiction had very small samples with fewer than 100 subjects.

Overall we found that 50% of the possible 106 associations related to these potential food addiction correlates supported our hypotheses. However, only 4% of the unexpected associations were in the opposite direction.

Discriminant Validity

If food addiction is a valid mental disorder it should be conceptually and empirically distinct from other existing disorders, otherwise, it would be redundant. Researchers specifically question whether there is a meaningful difference between food addiction and other established eating disorders such as binge eating disorder.[62] A successful test of discriminant validity is one that demonstrates that an extant measure of a construct is not highly correlated with another extant measure designed to assess a theoretically different construct.[96, 97]

Eating disorders are a group of conditions defined by abnormal eating habits involving the consumption of too much or too little food, which negatively affects an individual's physical and mental health.[98] There are four main categories of eating disorders in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition: binge eating disorder, anorexia nervosa, bulimia nervosa, and eating disorders not otherwise specified. Anorexia nervosa is characterized by extreme emaciation, an intense desire to be thin and lose weight, refusal to maintain a healthy body weight, distortion of body image, and disturbed eating patterns. Approximately 1% of women and 0.3% of men report having anorexia at some time in their lives. Bulimia nervosa is

characterized by persistent and frequent episodes of eating large amounts of food during which a person feels a loss of control over his/her eating, followed by purging. One and a half percent of women and 0.5% of men report having bulimia. Binge eating disorder is characterized by persistent episodes of eating large amounts of food during which a person feels a loss of control over his/her eating. These episodes are not followed by purging.[99] Binge eating disorder is more common than the other eating disorders, affecting 3.5% of women and 2% of men.[100]

Of these eating disorders, binge eating disorder is most conceptually similar to the construct of food addiction. A binge eating episode is characterized as a) eating, in a discrete period of time, an amount of food that is definitely larger than most people would eat in a similar period of time under similar circumstances, and b) a sense of lack of control over eating during the episode. These characteristics are not accompanied by compensatory behaviors. Similarly, food addiction is characterized by a diminished sense of control over the substance (food), use despite negative consequences, and diminished ability to cut down on use (eating). Thus, both binge eating disorder and food addiction are characterized by a lack of control over eating.

Despite their similarities, there are arguably several core clinical differences between the two disorders. First, binge eating disorder specifies that consumption of food must occur during a discrete period of time, while food addiction is not marked by a specific time constraint. Thus individuals who suffer from disordered eating, but who do not meet the binge eating disorder criterion, may be captured under an addiction framework.[29] Second, food addiction is defined by withdrawal, tolerance, time spent on eating, and activities given up due to eating, while binge eating disorder is not. Third, in food addiction there is an emphasis on the role of the substance (i.e., food or components of food) and their potential to be addictive, while binge eating disorder focuses on the amount of food, rather than on specific types or components. Finally, behavioral

or psychological treatment for food addiction would likely be different from treatment for binge eating disorder, as treatment for substance dependence commonly focuses on reduction of or abstinence from a substance and/or identifying triggers for overuse of the substance, while binge eating disorder treatments focus on shape and weight concerns and dieting behaviors.[29]

Although theoretical considerations suggest conceptual distinctions between food addiction and binge eating disorder, the empirical evidence is more nuanced. Seventeen studies have evaluated the relationships between food addiction and binge eating disorder diagnosis, binge eating episodes, or binge eating scores, and all found positive associations. For example, among five studies reporting statistically significant correlations between the Binge Eating Scale and Yale Food Addiction Scale, correlations were 0.47 ($p < 0.05$),[51] 0.58 ($p < 0.001$),[47, 48] 0.69 ($p < 0.01$),[50] and 0.78 ($p = 0.001$).[64] These correlations suggest that the disorders are moderately to strongly statistically associated; however, they do not fully account for one another.

Two studies[61, 62] examined food addiction *specifically among individuals with binge eating disorder*, and found that although the disorders were associated, they were also empirically distinct. One study assessed food addiction in a clinical sample of 81 obese individuals, all of whom had a Diagnostic and Statistical Manual of Mental Disorder, Fourth Edition diagnosis of binge eating disorder.[62] Subjects were recruited via newspaper ads looking for obese individuals who 'want to lose weight' and 'eat out of control,' and who would be willing to come to an urban medical school clinic for a treatment study. Fifty-seven percent of the participants with binge eating disorder also had food addiction, which again, supports a strong association between the disorders, but also indicates that not everyone with binge eating disorder has food addiction. In addition, the correlation between food addiction scores and objective binge eating episodes was weak, but significant ($r = 0.28$, $p = 0.01$). Food addiction

symptom count was a significant predictor of binge eating episodes after controlling for eating disorder psychopathology and depressive mood, and accounted for 6.3% of the unique variance in binge eating episodes.[62]

Another study[61] examined food addiction in a racially diverse sample of 96 obese patients, all of whom had a Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition diagnosis of binge eating disorder. Participants were seeking treatment for obesity and binge eating at an urban primary care center. This study found that 42% of the binge eating disorder patients also had food addiction, again indicating that the disorders do not overlap entirely. In addition, the correlation between food addiction scores and objective binge eating episodes was weak, but significant ($r = 0.35$, $p = 0.01$). Hierarchical multiple regression analysis revealed that food addiction predicted 11.1% of the unique variance in binge eating scores after accounting for a global eating disorder psychopathology score.[61]

While the theoretical considerations above suggest that binge eating disorder and food addiction are separate disorders, the empirical evidence is not as straightforward. Correlations between the scales are generally high, which does not support discriminant validity. However, most correlations are below 0.70, suggesting that the disorders are not perfectly collinear. In addition, the two studies described above indicate that not all individuals with binge eating disorder have food addiction. Thus, while there appears to be statistical overlap between the two disorders, they do entirely account for one another. More research—particularly among individuals suffering from addictive eating without binge eating disorder—is needed to continue investigating the distinction between the disorders.

Discussion

To our knowledge, this is the first systematic literature review of human food addiction to focus on food-related variables, age, binge eating, body mass index, depression, and substance use. Specifically, it is the first to tabulate (through frequencies and percentages) different characteristics and correlates of food addiction across studies (Tables 1-3). Based on our review, can we conclude that food addiction is a valid substance-related disorder that deserves entry into the next version of the Diagnostic and Statistical Manual of Mental Disorders? Among other criteria, a disorder should have face validity, be detectable in populations, and have construct validity. In Part 1, we assessed whether food addiction could meet the Diagnostic and Statistical Manual of Mental Disorders definitions of a mental disorder and substance-related disorder, as well as the National Institute on Drug Addiction definition of addiction. Examination of the phenomenological criteria for a mental disorder and substance-related disorder, results from animal studies, and preliminary neurological evidence led us to conclude that food addiction has face validity.

In Part 2, we identified 36 papers that estimated the prevalence of food addiction, examined scale reliability and validity, and/or evaluated whether food addiction is associated with, or different from other constructs. All studies identified subjects with food addiction, and prevalence estimates ranged from 5% to almost 60%. Overall, 50% of reported associations met our hypotheses. While several studies reported positive relationships between food addiction and food-related variables as expected, some results were compatible with our null hypotheses. Surprisingly, three studies found no relationship between food addiction and sugar cravings, sugar liking, and percent of diet from carbohydrates. Also contrary to our hypotheses, the majority of studies did not find inverse relationships between food addiction and age, alcohol consumption, smoking, or drug use. However, as expected, the majority of studies found positive

associations between food addiction and binge eating and depression. In addition, some theoretical and empirical evidence suggests that food addiction and binge eating disorder are distinct from one another. Finally, while an unexpected 50% of studies reported no association with body mass index, all but one were among overweight and obese populations. Overall, although findings were mixed, many results supported food addiction having construct validity.

Despite the burgeoning evidence that food addiction may be a valid substance-related disorder, gaps in the literature remain. First, while researchers have examined the relationship between several different variables and food addiction, most variables have only been assessed in one or very few studies. Therefore, our understanding of the relationship between addictive eating and most potential covariates is limited. In particular, we need to better understand food addiction's relationship with the substance itself (i.e., food), obesity, and other substance-related disorders.

Second, several methodological issues threaten the internal validity of food addiction findings. For instance, the majority of studies were cross-sectional. Although cross-sectional research can be useful in the early stages of new exposure-disease relationships, they are not ideal for determining causality. In addition, small sample sizes can lead to unstable estimates and do not necessarily provide the statistical power to detect a main effect or control for multiple potential confounders. Unfortunately, control for confounders was rare even among those studies that used larger samples and/or measured a higher prevalence of food addiction.

It is also worth noting that the majority of studies sampled only Caucasian, female, or overweight or obese populations. Thirty percent of studies recruited university participants, three used large epidemiologic studies of female nurses, and only one used a representative sample. Thus, associations between food addiction and other constructs as well as prevalence estimates

are likely not representative of the general population. Although a lack of generalizability does not affect the internal validity of study results, it does suggest that food addiction should be examined in more representative populations, and in particular among men and other racial groups.

Limitations of this review

This review has several limitations. First, we only searched the published literature; within this domain, we may have overlooked certain papers on food addiction or the ones we found may have been biased towards positive results. We aimed to minimize this possibility by using comprehensive search terms, searching multiple databases, consulting with experts, and hand-searching reference lists. Second, due to the heterogeneity of study results, we were unable to conduct a meta- or pooled analysis. However, we were able to summarize food addiction findings by tabulating results across studies. In addition, having one reviewer extract data and interpret results increases the possibility for tabulation and/or categorization errors. We aimed to minimize this by reconfirming table contents multiple times. Finally, while it is possible that our hypotheses about potential food addiction correlates were incorrect, associations consistent with our null hypotheses—many of which could have resulted from low power due to small samples—comprised 96% of the unexpected findings.

Food addiction appears to have face validity as a mental disorder and substance-related disorder. Thirty-six studies provided evidence that the disorder exists in populations, can be measured reliably, and is often correlated as expected with other conditions and distinct from existing ones. To further validate the construct, we need more in-depth assessment of food addiction's relationship with variables such as food consumption and other substance-related disorders. In conclusion, larger, representative samples, prospective analyses and sound

epidemiologic methods are needed before food addiction is granted entry into the Diagnostic and Statistical Manual of Mental Disorders.

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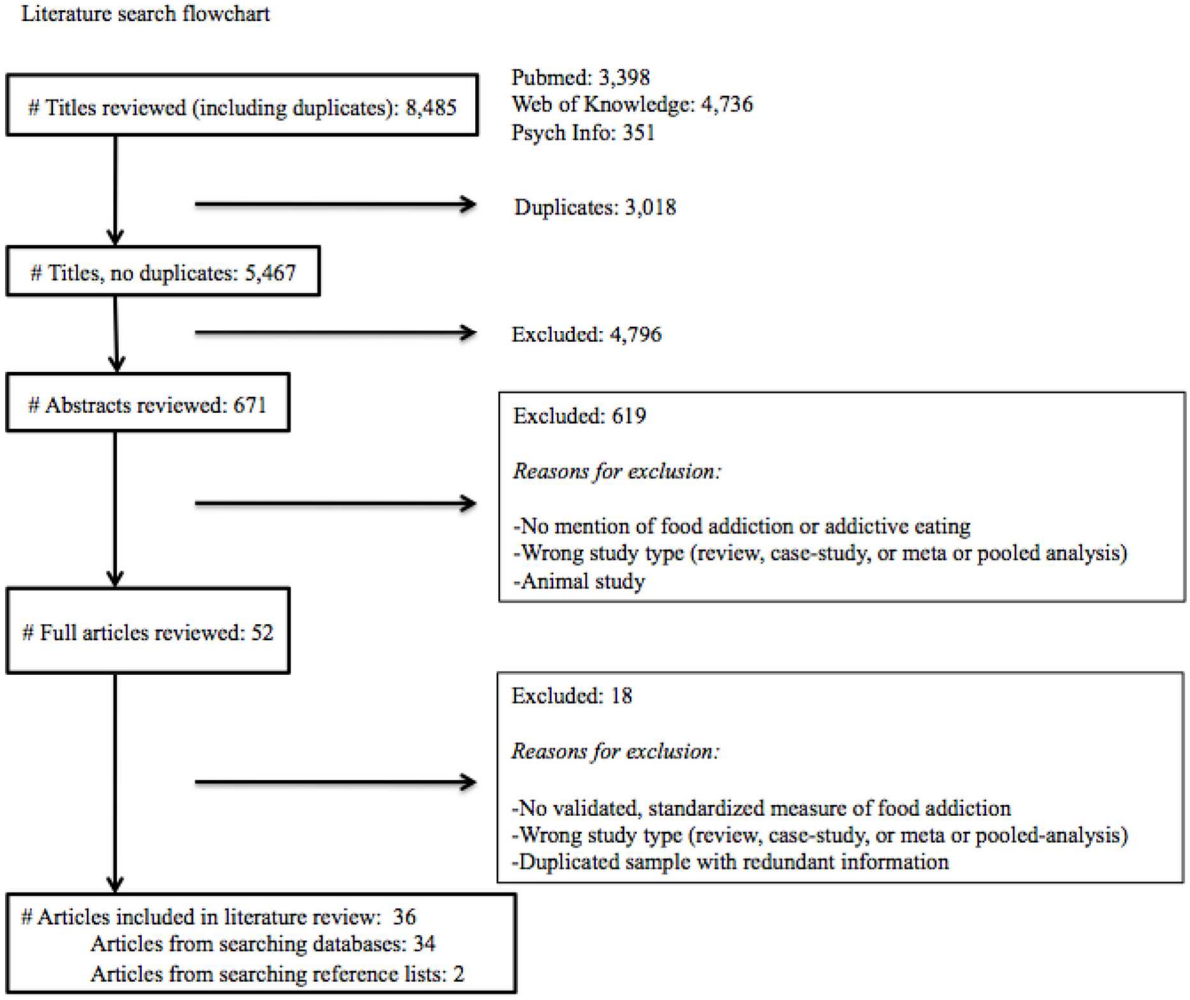
Figure

Figure 1. Literature search flowchart



Tables

Table 1. Study Characteristics (n = 36)

	n	%
Sample Size		
<100	12	33%
100-200	11	31%
201-1,000	10	28%
>1,000	3	8%
Study Design		
Cross-sectional	28	78%
Cross-over	1	3%
Cohort	3	8%
Intervention	2	6%
Randomized control trial	2	6%
Sampling/Source Population[a]		
Obese weight loss treatment seeking	14	39%
Obese/overweight[b]	5	14%
University	12	33%
Nurses	3	8%
Representative of USA	1	3%
Community	11	31%
Body Mass Index (mean)		
18.5-<=24.9 (Normal)	7	25%
25-29.9 (Overweight)	8	29%
30+ (Obese)	13	46%
Age (mean)		
<30	11	34%
30-40	6	19%
41-50	10	31%
>50	5	16%
Sex (female)		
<50%	1	3%
62-99%	25	69%
100%	9	25%
Ethnicity (Caucasian)		
<60%	6	23%
≥ 60%	20	77%
Study Location		
Europe	10	28%
Canada	6	17%
USA	17	47%
Validity/Reliability study		
Yes	10	28%
No	26	72%
Brain Study		
Yes	2	6%
No	34	94%

n's may not add to 36 due to non-reporting
[a] Does not add up to 36 as categories are not mutually exclusive
[b] Category does not overlap with weight loss treatment seeking

Table 2. Food Addiction Results (n = 36)

		n	%
Food Addiction Scale			
	YFAS	32	89%
	mYFAS	3	8%
	YFAS-C	1	3%
Food Addiction Scale Internal Reliability (α)			
YFAS[a]			
	0.76 to 0.78	3	16%
	0.81 to 0.89	10	53%
	0.90 to 0.95	6	32%
mYFAS[b]			
	0.75	1	100%
YFAS-C			
	0.78	1	100%
Food Addiction Prevalence[c]			
	5-10%	8	28%
	>10-20%*	8	28%
	>20-30%	5	17%
	>30-60%	8	28%
Scale type			
	Symptom count	8	23%
	Diagnosis	6	17%
	Both	21	60%
Food Addiction Symptom Count (mean)[d]			
	<2	5	28%
	≥2 to <3	6	33%
	≥ 3 to 6	7	39%

YFAS, Yale Food Addiction Scale; *mYFAS,* modified Yale Food Addiction Scale; *YFAS-C*, Yale Food Addiction Scale, Children's Version

[a] 32 studies used the Yale Food Addiction Scale, but only 19 calculated the internal reliability of the scale in their sample

[b] 3 studies used the modified Yale Food Addiction Scale, but only 1 calculated the internal reliability of the scale in their sample

[c] 7 studies (19%) did not report a prevalence of food addiction

[d] 19 studies (51%) did not report mean food addiction count

* Eichen et al. (2013) and Lent et al. (2013) used the same study sample so food addiction prevalence (15%) only counted once

Table 3. Construct Validity of Food Addiction: Correlates and Types of Association in 36 Studies

Variable	Studies[a] n (%[b])	Hypothesized Association	Association Found n (%[c]) Positive	None	Negative
Food					
Carbohydrate (% of diet)	1 (3)	Positive	-	1 (100)	-
Fat (% of diet)	1 (3)	Positive	**1 (100)**	-	-
Fatty food craving	2 (6)	Positive	**1 (50)**	1 (50)	-
Fast-food craving	1 (3)	Positive	**1 (100)**	-	-
Fatty food liking	1 (3)	Positive	**1 (100)**	-	-
Food cravings (non-specific)	6 (17)	Positive	**5 (71)**	1 (29)	-
Pleasantness of milkshake	2 (6)	Positive	-	2 (100)	-
Processed food craving	1 (3)	Positive	**1 (100)**	-	-
Processed food liking	1 (3)	Positive	**1 (100)**	-	-
Starchy food cravings	1 (3)	Positive	**1 (100)**		-
Sugary food cravings	2 (6)	Positive	-	2 (100)	-
Sugary food liking	1 (3)	Positive	-	1 (100)	-
Sweet snacking	2 (6)	Positive	**2 (100)**	-	-
Age	17 (47)	Negative	1 (6)	14 (82)	**2 (12)**
Body Mass Index[d]	24 (67)	Positive	**11 (44)**	12[e] (48)	2 (8)
Binge Eating	17 (47)	Positive	**17 (100)**	-	-
Depression	13 (36)	Positive	**10 (77)**	3 (23)	-
Substance Use					
Alcohol consumption (current)	2 (6)	Negative	1 (50)	1 (50)	-
Daily drinking	1 (3)	Negative		1 (100)	-
Alcohol problem	1 (3)	Negative	1 (100)	-	-
Alcohol use disorder	3 (8)	Negative	-	3 (100)	-
Drug use[f]	3 (8)	Negative	-	3 (100)	-
Smoking (current)	3 (6)	Negative	-	2 (67)	**1 (33)**
Smoking (past)	1 (3)	Positive	**1 (100)**	-	-

[a] n's refer to the number of studies examining the row variable

[b] The denominator of the percentages in this column is 36 (the total number of studies in this review)

[c] The denominator of the percentages in these columns is the n from the 2nd column (the total number of studies examining the row variable)

[d] One study (Begin et al., 2012) reported two different associations; thus, the denominator of the percentages in columns 4-6 is 25 instead of 24

[e] All but one of these studies sampled among overweight or obese populations

[f] Drug use disorder/Problematic substance use

bold, type of association met hypothesis

Out of 106 possible associations 53 (50%) met our hypotheses

Appendix 1

Table A1.1. The Yale Food Addiction Scale

This survey asks about your eating habits in the past year. People sometimes have difficulty controlling their intake of certain foods such as:

- Sweets like ice cream, chocolate, doughnuts, cookies, cake, candy, ice cream
- Starches like white bread, rolls, pasta, and rice
- Salty snacks like chips, pretzels, and crackers
- Fatty foods like steak, bacon, hamburgers, cheeseburgers, pizza, and French fries
- Sugary drinks like soda pop

When the following questions ask about "CERTAIN FOODS" please think of ANY food similar to those listed in the food group or ANY OTHER foods you have had a problem with in the past year

IN THE PAST 12 MONTHS:	Never	Once a month	2-4 times a month	2-3 times a week	4 or more times or daily
1. I find that when I start eating certain foods, I end up eating much more than planned	0	1	2	3	4
2. I find myself continuing to consume certain foods even though I am no longer hungry	0	1	2	3	4
3. I eat to the point where I feel physically ill	0	1	2	3	4
4. Not eating certain types of food or cutting down on certain types of food is something I worry about	0	1	2	3	4
5. I spend a lot of time feeling sluggish or fatigued from overeating	0	1	2	3	4
6. I find myself constantly eating certain foods throughout the day	0	1	2	3	4
7. I find that when certain foods are not available, I will go out of my way to obtain them. For example, I will drive to the store to purchase certain foods even though I have other options available to me at home.	0	1	2	3	4
8. There have been times when I consumed certain foods so often or in such large quantities that I started to eat food instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.	0	1	2	3	4
9. There have been times when I consumed certain foods so often or in such large quantities that I spent time dealing with negative feelings from overeating instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.	0	1	2	3	4

IN THE PAST 12 MONTHS:	Never	Once a month	2-4 times a month	2-3 times a week	4 or more times or daily
10. There have been times when I avoided professional or social situations where certain foods were available, because I was afraid I would overeat.	0	1	2	3	4
11. There have been times when I avoided professional or social situations because I was not able to consume certain foods there.	0	1	2	3	4
12. I have had withdrawal symptoms such as agitation, anxiety, or other physical symptoms when I cut down or stopped eating certain foods. (Please do NOT include withdrawal symptoms caused by cutting down on caffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)	0	1	2	3	4
13. I have consumed certain foods to prevent feelings of anxiety, agitation, or other physical symptoms that were developing. (Please do NOT include consumption of caffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)	0	1	2	3	4
14. I have found that I have elevated desire for or urges to consume certain foods when I cut down or stop eating them.	0	1	2	3	4
15. My behavior with respect to food and eating causes significant distress.	0	1	2	3	4
16. I experience significant problems in my ability to function effectively (daily routine, job/school, social activities, family activities, health difficulties) because of food and eating.	0	1	2	3	4

IN THE PAST 12 MONTHS:	NO	YES
17. My food consumption has caused significant psychological problems such as depression, anxiety, self-loathing, or guilt.	0	1
18. My food consumption has caused significant physical problems or made a physical problem worse.	0	1
19. I kept consuming the same types of food or the same amount of food even though I was having emotional and/or physical problems.	0	1
20. Over time, I have found that I need to eat more and more to get the feeling I want, such as reduced negative emotions or increased pleasure.	0	1
21. I have found that eating the same amount of food does not reduce my negative emotions or increase pleasurable feelings the way it used to.	0	1
22. I want to cut down or stop eating certain kinds of food.	0	1
23. I have tried to cut down or stop eating certain kinds of food.	0	1
24. I have been successful at cutting down or not eating these kinds of food	0	1

25. How many times in the past year did you try to cut down or stop eating certain foods altogether?	1 or fewer times	2 times	3 times	4 times	5 or more times

Gearhardt, AN., Corbin, W.R., & Brownell, K.D. (2009). Preliminary validation of the Yale Food Addiction Scale. *Appetite, 52,* 430-436

Table A1.2. The Modified Yale Food Addiction Scale used in the Nurses' Health Study Cohorts

Question 54. The following questions ask about your eating habits in the past year. People sometimes have difficulty controlling their intake of certain foods such as sweets, starches, salty snacks, fatty foods, sugary drinks, and others.					
In the past 12 MONTHS, how often were each of these statements true for you?	**Never**	**Once per Month**	**2-4 times per month**	**2-3 times per week**	**4+ times per week**
1. I find myself consuming certain foods even though I am no longer hungry.					
2. I worry about cutting down on certain foods.					
3. I feel sluggish or fatigued from overeating.					
4. I have spent time dealing with negative feelings from overeating certain foods, instead of spending time in important activities such as time with family, friends, work, or recreation.					
5. I have had physical withdrawal symptoms such as agitation and anxiety when I cut down on certain food. (Do NOT include caffeinated drinks: coffee, tea, cola, energy drinks, etc.)					
6. My behavior with respect to food and eating causes me significant distress.					
7. Issues related to food and eating decrease my ability to function effectively (daily routine, job/school, social or family activities, health difficulties).					
IN THE PAST 12 MONTHS…	No				Yes
8. I kept consuming the same types or amounts of food despite significant emotional and/or physical problems related to my eating.					
9. Eating the same amount of food does not reduce negative emotions or increase pleasurable feelings the way it used to.					

Table A1.3. Food Addiction Items in Yale Food Addiction Scale and Modified Yale Food Addiction Scale and Correspondence with DSM-IV Substance-use Dependence Criteria

DSM-IV Substance-Use Dependence Criteria	YFAS Items	YFAS Items used in mYFAS	mYFAS Item
1. Substance taken in larger amount and for longer period than intended	1, 2, and 3	2	1
2. Persistent desire or repeated unsuccessful attempt to quit	4, 22, 24, and 25	4	2
3. Much time/activity to obtain, use, recover	5, 6, and 7	5	3
4. Important social, occupational, or recreational activities given up or reduced	8, 9, 10, and 11	9	4
5. Characteristic withdrawal symptoms; substance taken to relieve withdrawal	12, 13, and 14	12	5
6. Use continues despite knowledge of adverse consequences	19	19	8
7. Tolerance (marked increase in amount; marked decrease in effect)	20, 21	21	9
Clinical impairment items	15	15	6
	16	16	7

DSM-IV: Diagnostic and Statistical Manuel of Mental Disorders, Version 4; YFAS: Yale Food Addiction Scale; mYFAS, Modified Yale Food Addiction Scale

Items 17, 18 and 23 in the YFAS are primer questions and are not scored
Items 15 and 16 of the YFAS and 6 and 7 of the Modified scale assess clinically significant impairment or distress
A diagnosis of food addiction is met if a person endorses 3 or more of the 7 substance-use dependence criteria and has clinical significance

Table A1.4. Scoring the Yale Food Addiction Scale

Item	Response option	Response needed for positive symptom
1, 2, 4, and 6	Never to 4 or more times per week or daily	4 or more times a week or daily
3, 5, 7, 9 and 12-16	Never to 4 or more times per week or daily	≥ 2-3 times a week
8, 10, and 11	Never to 4 or more times per week or daily	≥ 2-4 times a month
19-22	Yes/No	Yes
24	Yes/No	No
25	1 or fewer times to 5 or more times	≥ 4 times

Questions 17, 18 and 23 are primer items and are not scored

Questions 15 and 16 assess clinically significant impairment or distress

A diagnosis of food addiction is met if a person endorses 3 or more of the 7 substance-use dependence criteria and has clinical significance

Table A1.5. Details of Studies Selected for Review

Author, Year	Sample size	Study design	Country	Age range	Mean age	BMI	Caucasian	Female	Food Addiction prevalence	Scale Internal reliability	Controlled for confounders?
Begin, 2012[46]	50	Cross-sectional	Canada	19-65	41.58 (SD 13.35)	28.47 (SD 5.8)	100%	100%	22% (Sampled on FA)	0.90	NR
Boggiano, 2014[47]	496	Cross-sectional	USA	15-80	20.6 (4.6) and 48.3 (13.6)	25.7 (6.2) and 38.9 (8.9)	50%	>62%	NR	NR	Yes (age, sex, ethnicity, BMI)
Brunault, 2014[48]	553	Cross-sectional	France	NR	28.9	22.5 kg (SD 4.5)	NR	NR	8.70%	0.84 (KR-20)	No
Burgess, 2014[49]	150	Cross-sectional	USA	17-60	24.4 (SD NR)	26.3 (range 16.4–51.0)	46.70%	70.10%	NR	NR	Yes (ethnicity, sex, age)
Burmeister, 2013[50]	57	RCT	USA	NR	47.4 (SD = 13.7))	38.2 (SD 8.1)	84.20%	68.40%	19.60%	0.90	Yes, RCT, but not in analysis; (checked for differences between demographic variables)
Clark, 2013[51]	67	Cross-sectional	USA	25-73	42.72 (SD NR)	NR	86.60%	62.70%	53.70%	NR	Yes (eating pathology)
Davis, 2011[52]	72	Cross-sectional	Canada	25-46	33.6 (SD NR)	38.5 (SD NR)	80% or higher	68%	25%	0.92	Yes (personality factors and eating behaviors)
Davis, 2013[55]	120	Cross-sectional	Canada	25-47	32.6 (SD 6.43)	33.24 (SD 8.55)	NR	68.30%	17.50%	0.92	Yes (gender)
Davis, 2014[53]	136	Randomized, Cross-over, double-bind	Canada	25-50	32.7 (SD 6.7)	33.9 (SD 8.1)	NR	67.60%	16.90%	NR	Yes (BMI)
Davis, 2014[54]	145	Cross-sectional	Canada	24-47	NR	NR	80%	69%	17.90%	0.78	Yes (BMI, sex)
Eichen, 2013[56]	178	Cross-sectional	USA	NR	51.2 (SD 11.7)	36.1 (SD 4.8)	NR (30.9% not AA)	74.70%	15%	0.76	No

Author, Year	Sample size	Study design	Country	Age range	Mean age	BMI	Caucasian	Female	Food Addiction prevalence	Scale Internal reliability	Controlled for confounders?
Flint, 2014[44]	134,175	Cohort	USA	45-88	NR	Strong, positive association between FA and BMI	1	100%	5.8%	0.75	Yes (age, living status, relationship status, depression, diabetes, hypercholesterolemia, hypertension, physical activity, smoking, BMI, geographic region, ancestry)
Gearhardt, 2009[58]	353	Cross-sectional	USA	NR	20.11 (SD = 1.38)	22.58 (SD = 3.18)	72.5%	64.2%	11.40%	0.86 (KR)	Yes (problem eating attitudes (EAT-26) and emotional eating (EES))
Gearhardt, 2011[41]	48	Cross-sectional	USA	NR	20.8 [SD = 1.31]	28.0 [3.0]	NR	100%	NR	NR	No
Gearhardt, 2012[62]	81	Cross-sectional	USA	28-64	47.47 years, SD 5 8.43	40.58 kg/m2 (SD 5 6.63	79.30%	70.10%	56.80%	NR	No
Gearhardt, 2013[61]	96	Cross-sectional	USA	19-65	44.88 (SD 12.82)	38.30 kg/m^2 (SD=5.73)	45.30%	75.8%	41.50%	NR	No
Gearhardt, 2013[60]	75	Cross-sectional	USA	4–16	8.32 (SD = 2.78)	70.07%tile (SD = 32.45)	65.10%	42.70%	7.20%	0.78	Yes (emotional overeating and satiety)
Gearhardt, 2014[59]	105	Cross-sectional	USA	18-50	31.27 (SD = 9.70)	35.07 (SD = 8.05	42%	100%	NR	NR	Yes (BMI, food addiction, eating disorders)
Gearhardt, 2014[57]	815	Cross-sectional	USA	18-73	33 (SD NR)	28.70, SD= 8.77	79.1%	88.1%	25.7%	0.77	No

Author, Year	Sample size	Study design	Country	Age range	Mean age	BMI	Caucasian	Female	Food Addiction prevalence	Scale Internal reliability	Controlled for confounders?
Granero, 2014[63]	207	Cross-sectional	Spain	NR	27 (SD 8.7)	22.4 (SD 5.7)	NR	100%	44.9% (72.8% in ED group and 2.4% in non-ED group)	0.95	No
Imperatori, 2014[42]	28	Cross-sectional	Italy	29-58	43.64	28.46	NR	78.60%	14.29%	0.83	No
Imperatori, 2014[64]	112	Cross-sectional	Italy	18-73	43.46 years (SD = 12.91	32.09 (SD = 6.76: range: 25.04–53.40	NR	71.40%	33.90%	0.87	Yes (sex, BMI)
Innamorati, 2014[65]	600	Cross-sectional	Italy	18-81	42.65 (SD 12.23)	27.64 (SD 6.46)	NR	79.50%	31.65%	0.83 for YFAS and 0.85 for YFAS-16	No
Jin, 2012[66]	154	Cross-sectional	USA	18-65	NR	NR	64.30%	86.40%	21.40%	NR	Yes (age, race, stress, and gender)
Lent, 2014[67]	178	RCT	USA	NR	51.26 + or - 11.7	36.16 + or - 4.8	25.80%	74.70%	15.20%	NR	Yes (treatment arm, gender, and baseline weight)
Mason, 2013[68]	57,321	Cohort	USA	45-62	NR	NR	>90%	100%	8.2%	NR	Yes (age, race, mom and dad education, mom and dad in professional job, parental home owner, recalled body size at age 5, and parent history of depression)

Author, Year	Sample size	Study design	Country	Age range	Mean age	BMI	Caucasian	Female	Food Addiction prevalence	Scale Internal reliability	Controlled for confounders?
Mason, 2014[69]	49,408	Cohort	USA	45-62	NR	NR	>93%	100%	8.0%	NR	Yes (age, race/ethnicity, mom and dad education, mom and dad in professional occupation, parental homeownership, recalled body size at age 5 years, and parental lifetime history of depression)
Meule, 2012[72]	50	Experiment	Germany	19-32	22.3 years (SD=3.0;	21.5 kg/m2 (SD=2.7)	Most	100%	NR	0.83	No
Meule, 2012[70]	96	Cross-sectional	Germany	NR	39.92 years (SD= 11.51)	50.64kg/m² (SD= 8.99	Most	65.60%	41.70%	0.82	No
Meule, 2012[71]	616	Cross-sectional	Germany	NR	24.5 years (SD±4.0)	22.3 kg/m2 (SD±3.3)	Most	75.80%	7.80%	0.83	Yes (positive reinforcement, food craving without positive reinforcement, and the interaction positive reinforcement×food craving without positive reinforcement and BMI)

Author, Year	Sample size	Study design	Country	Age range	Mean age	BMI	Caucasian	Female	Food Addiction prevalence	Scale Internal reliability	Controlled for confounders?
Meule, 2012[73]	752	Cross-sectional	Germany	16-45	23.1	In German	Most	77%	8.8%	0.81	Yes (emotional eating and the Eating Attitudes Test)
Meule, 2014[74]	109	Cross-sectional	Germany	NR	24.3	21.7	Most	100%	NR	0.93	No
Miller-Matero, 2014[75]	142	Cross-sectional	USA	NR	46.26 ± 11.70	49.05 ± 9.56	53.50%	81%	16.90%	NR	NR
Murphy, 2014[76]	233	Cross-sectional	USA	18-32	19.65 (2.15)	22.78 (4.00)	84%	77%	24%	0.89	Yes (negative urgency (Lack of) Premeditation (Lack of) Perseverance Positive urgency)
Pedram, 2014[77]	652	Cross-sectional	Canada	20-90	44.3 (SD 12.9)	27.4 (SD 5.4)	NR	63.70%	5.40%	NR	Yes (age, sex, smoking status, medication use and physical activity)
Pepino, 2014[78]	44	Intervention	USA	NR	42.8 (SD 11)	48 + or -8	79.90%	88.60%	32%	NR	No

NR, Not reported; RCT, Randomized controlled trial; USA, United States of American; SD, Standard deviation; FA, food addiction; AA, African American; YFAS, Yale Food Addiction Scale; ED, eating disorders; BMI, body mass index; KR, Kuder–Richardson

Table A1.6. Food Addiction Correlates and Type of Association in 36 Studies

				Association Found[a]					
Variable	Number of study results (n)	%[b]	Hypothesized Association	Positive (n)	%	None (n)	%	Negative (n)	%
Demographics and Lifestyle Factors									
African American (ref white or other)	8	22%	NE	0	0%	7	88%	1	13%
Age	17	47%	Negative	1	6%	14	82%	2	12%
Child abuse	1	3%	Positive	1	100%		0%		
Education	5	14%	NE			4	80%	1	20%
Employment	1	3%				1	100%		
Income	1	3%				1	100%		
Living alone	1	3%	Positive	1	100%				
Living in western USA (ref northeast)	1	3%	NE	1	100%				
Menopause	1	3%				1			
Physical activity	1	3%	Negative					1	100%
Sex (female)	10	28%	Positive	3	30%	7	70%		
Marital status (ref married)	3	8%	NE			2	67%	1	33%
Weight, Weight Loss, and Attitudes									
Age of dieting onset	2	6%	NE	1	50%	1	50%		
Body mass index[d]	24	67%	Positive	11	44%	12[e]	48%	2	8%
Body dissatisfaction	2	6%	Positive	2	100%				

				Association Found[a]					
Variable	Number of study results (n)	%[b]	Hypothesized Association	Positive (n)	%	None (n)	%	Negative (n)	%
Body fat (%)	1	3%		1					
Body shame	1	3%	Positive	1	100%				
Current dieting	1	3%	Positive	1	100%				
Dietary restraint	1	3%	NE			1	100%		
Drive for thinness	1	3%		1	100%				
Earlier age being overweight	3	8%	Positive	1	33%	2	67%		
Eating/Weight/Shape concern (many subscales)	4	11%	Positive	4	100%				
Height	1	3%		1	100%				
Hip circumference	1	3%		1	100%				
Hours since last meal	1	3%	NE			1	100%		
Highest body mass index	1	3%	Positive	1	100%				
Internalized weight bias/fear of fat	1	3%	NE	1	100%				
Objective overeating	1	3%	Positive	1	100%				
Time spent dieting	1	3%	Positive	1	100%				
Truck fat (%)	1	3%		1	100%				
Waist circumference	1	3%		1	100%				
Waist to hip ratio	1	3%		1	100%				
Weight cycling	1	3%	Positive	1	100%				
Weight before surgery	1	3%				1	100%		
Weight after surgery	1	3%				1	100%		
Weight	1	3%		1	100%				
Weight loss	4	11%	Negative			1	25%	3	75%

			Association Found[a]						
Variable	Number of study results (n)	%[b]	Hypothesized Association	Positive (n)	%	None (n)	%	Negative (n)	%
Cravings and Food									
Appetite ratings	1	3%	NE	1	100%				
Carbohydrate intake (% of diet)	1	3%	Positive			1	100%		
Fat intake (% of diet)	1	3%	Positive	1	100%				
Pleasantness of milkshake	2	6%				2	100%		
Sweet snacking	2	6%	Positive	2	100%				
Cravings									
Fatty food craving	2	6%	Positive	1	50%	1	50%		
Fast food craving	1	3%		1	100%				
Food cravings (non-specific)	6	17%	Positive	5	71%	1	29%		
Processed food craving	1	3%	Positive	1	100%				
Starchy food cravings	1	3%	Positive	1	100%				
Sugary food cravings	2	6%	Positive			2	100%		
Liking		0%							
Fatty food liking	1	3%	Positive	1	100%				
Processed food liking	1	3%	Positive	1	100%				
Sugary food liking	1	3%	Positive			1	100%		
Eating Disorder Psychopathology									
Binge eating disorder/Binge episodes	17	47%	Positive	17	100%				
Bulimia	4	11%	Positive	4	100%				
Eating disorder severity	1	3%	Positive	1	100%				

			Association Found[a]					
Variable	Number of study results (n)	%[b]	Hypothesized Association	Positive (n)	%	None (n)	%	Negative (n)	%
Eating troubles	1	3%	Positive	1	100%				
Emotional eating	11	31%	Positive	11	100%				
External eating	5	14%	NE	4	80%	1	20%		
Hedonic eating/hedonic responsiveness	3	8%	Positive	3	100%				
Palatable eating	1	3%	Positive	1	100%				
Problematic eating behavior	1	3%	Positive	1	100%				
Restrictive eating	1	3%	NE	1	100%				
Psychiatric and Substance Use									
Alcohol consumption (current)	2	6%		1	50%	1	50%		
Alcohol consumption (daily drinking)	1	3%				1	100%		
Alcohol problem	1	3%		1	100%				
Alcohol use disorder	3	8%				3	100%		
Anxiety	6	17%	Positive	3	50%	3	50%		
Attention deficit hyperactivity disorder (childhood)	1	3%	NE	1	100%				
Depression	13	36%	Positive	10	77%	3	23%		
Drug use disorder/Problematic substance use	3	8%	Negative			3	100%		
All mood disorders	2	6%	Positive			2	100%		
Post-traumatic stress disorder	1	3%	Positive	1	100%				

			Association Found[a]						
Variable	Number of study results (n)	%[b]	Hypothesized Association	Positive (n)	%	None (n)	%	Negative (n)	%
Smoking (current)	3	8%	Negative			2	67%	1	33%
Smoking (past)	1	3%	Positive	1	100%				
Personality									
Addictive personality traits	1	3%	Positive	1	100%				
Asceticism		3%		1	100%				
Behavioral inhibition	3	8%	NE	2	67%	1	33%		
Behavioral activitation	3	8%	NE	1	33%	2	67%		
Delay discounting	1	6%	NE	1				1	50%
Delay gratification	1	6%	NE	1				1	50%
80 Distress[c]	1	3%	Positive	1	100%				
Emotional dysregulation (many subscales)	3	8%	Positive	2	67%	1	33%		0%
Global severity index	1	3%		1					
Harm avoidance	1	3%				1	100%		
Hyperactivity	1	3%	NE	1	100%				
Hostility	2	6%		2					
Impulse regulation		3%		1					
Impulsivity (attentional)	1	3%	Positive	1	100%				
Impulsivity (motor)	1	3%	NE			1	100%		
Impulsivity (non-planning)	1	3%	NE			1	100%		
Impulsivity (non-specific)	3	8%	Positive	3	100%				
Ineffectiveness	1	3%	NE	1	100%				
Interoceptive awareness	1	3%	NE	1	100%				
Interpersonal distrust	1	3%	NE	1	100%				

			Association Found[a]							
Variable	Number of study results (n)	%[b]	Hypothesized Association	Positive (n)	%	None (n)	%	Negative (n)	%
Interpersonal sensitivity	2	6%	NE	2	100%				
Lack of perseverance	1	3%	NE	1	100%				
Lack of premeditation	1	3%	NE	1	100%				
Maturity fears	1	3%	NE	1	100%				
Negative affect	3	8%	Positive	3	100%				
Negative urgency	1	3%	NE	1	100%				
Novelty seeking	1	3%	NE	1	100%				
Obsessive/compulsive	2	6%	NE	2	100%				
Paranoid ideation	2	6%	NE	2	100%				
Perfectionism	1	3%	NE	1	100%				
Positive urgency	1	3%	NE	1	100%				
Phobic anxiety	2	6%		2	100%				
Psychotic	2	6%		2	100%				
Self-esteem	2	6%	Negative					2	100%
Sensation seeking	1	3%				1	100%		
Sensitivity to reward	1	3%				1	100%		
Social insecurity	1	3%				1	100%		
Somatisation	2	6%		2	100%				
Brain Mechanisms and Genes									
Brain activation in response to food cues	2	6%	Positive	2	100%				
Reward-based genetic profile	1	3%	Positive	1	100%				

			Association Found[a]							
Variable	Number of study results (n)	%[b]	Hypothesized Association	Positive (n)	%	None (n)	%	Negative (n)	%
Physical Disorders									
Diabetes	1	3%	NE			1	100%		
Hypercholesterolemia	1	3%	Positive	1	100%				
Hypertension	1	3%	NE			1	100%		

n, number; *ref,* reference; *NE*, no expectation

[a] Percentages in this column refer to the column to the left divided by 36 (total number of studies in this review), multiplied by 100

[b] n's refer to the number of studies examining the row variable; the denominators of the percentages refer to the total number of studies examining the row variable

[c] Distress includes subscales interpersonal sensitivity, obsessive-compulsive, hostility, paranoid ideation, psychoticism, somatization, and global severity index

[d] One study (Begin et al., 2012) reported two different associations; the denominator of the percentages in columns 4-6 is 25 instead of 24

Chapter 3. Assessing the Psychometric Properties of Two Food Addiction Scales

Introduction

In recent years, the concept of food addiction has pervaded popular culture. Groups such as Food Addicts Anonymous, Overeaters Anonymous, and Food Addicts in Recovery Anonymous were created by individuals who identify as food addicts and compulsive eaters. There is currently a plethora of self-help books on food addiction, such as *A Substance Called Food* (1989) and *Breaking the Bonds of Food Addiction* (2004), and many television networks offer shows featuring obese individuals who identify as food addicts. While food addiction has a prominent presence in popular culture, it is not currently included in the Diagnostic Statistical Manual of Mental Disorders. Its scientific validity as a mental disorder in general and substance-use disorder in particular is still under investigation. To empirically examine the prevalence of food addiction and whether certain eating behaviors are indicative of addiction, consistent and accurate operationalized measures (e.g., scales) of the construct are needed.

If food addiction is a valid substance-use disorder, it should manifest as the compulsive relationship between eating (a behavior) and addictive foods (a substance) and associated neurological manifestations.[1, 2] Burgeoning research suggests that animals and humans consume certain types of foods in an addictive manner. Several studies[3-15] have found that animals eating large quantities of sugary and/or fatty foods over time show symptoms of addictive-like eating. One research group[16, 17] found that sucrose-bingeing rats showed signs of opiate-like withdrawal such as chattering teeth, forepaw tremor, and head shakes when deprived of sugar. Another[3] found that rats continued to eat palatable foods despite awareness of adverse consequences (e.g., an electric shock). To date, almost forty studies have examined food addiction in humans.

According to these studies, the prevalence of food addiction ranges from 5%[18, 19] in the general population to over 40%[20-23] among obese groups. Findings indicate that the disorder is positively associated with binge eating behaviors,[20, 24-27] depression,[24, 26-28] food cravings,[25, 26, 29] and impulsivity.[26] Many of these studies suggest that food addiction is associated with other theoretically- related constructs, which contributes to its validity as a psychiatric disorder.

Researchers have generally used two scales to measure food addiction adults—the Yale Food Addiction Scale and the Modified Yale Food Addiction Scale. Several studies[26, 30-32] suggest that the Yale Food Addiction Scale has good psychometric properties—including internal reliability, convergent validity and discriminant validity—however, important aspects of its reliability and validity have not yet been evaluated. Specifically, there are no test-retest analyses of the scale. Researchers piloted and continue to use the Modified Yale Food Addiction Scale, a shorter version of the longer one, in the Nurses' Health Study cohorts. To date, there are no psychometric tests of the Modified Yale Food Addiction Scale per se, although researchers have begun to examine a proxy version of this shorter scale[18] —referred to here as the Modified Yale Food Addiction Scale proxy. In the current paper, we assess the psychometric properties of the Modified Yale Food Addiction Scale proxy as well as the longer, original Yale Food Addiction Scale itself.

Using data from two community-based convenience samples, we assessed the a) internal and test-retest reliability of the Yale Food Addiction Scale, b) internal and test-retest reliability of the Modified Yale Food Addiction Scale proxy, and c) sensitivity and negative predictive value of the Modified scale proxy using the original Yale Food Addiction Scale as the standard. We considered Cronbach's alpha $\geq .70$,[33] Kappa $\geq .61$,[34] and sensitivity and negative predictive values >0.70[35] to indicate good internal reliability, test retest reliability, and sensitivity and

negative predictive value, respectively. In addition, we used both versions of the scale to examine the prevalence of food addiction.

Methods

Samples

Yale Health Behaviors Survey 2008 and 2010

Researchers at Yale University created the 2008 and 2010 Yale Health Behaviors Surveys to examine alcohol, smoking, and obesity-related behaviors.[36, 37] The research team recruited participants using flyers posted around the Yale University campus and other locations throughout New Haven, Connecticut. The team also recruited through online Craigslist postings for the 2010 survey. The 2008 survey (n = 235) recruited participants 18 years and older, while the 2010 survey (n = 51) recruited 18-25 year olds.

For the 2008 survey, after providing consent, participants came to a lab in the Department of Psychology at Yale to complete an hour-long online questionnaire and be measured for height and weight. Participants answered questions about their health behaviors (e.g., nicotine and illicit drug use, alcohol consumption, eating, and gambling), family history of problems with alcohol and drug use, and demographic information. The research team compensated participants $10.[37]

The 2010 survey was designed as a test-retest reliability study. Participants were informed that the purpose of the study was to better understand whether several health-related behaviors stay the same or change over time.[36] At the first session, subjects provided consent for completing a series of computerized self-report questions about alcohol use, cigarette smoking and eating, and having their height and weight measured on two separate occasions in the same lab, two weeks apart. To ensure their data would be linked over time, participants answered the

same series of identifying questions at each visit. Their answers had to match for their data to be linked. After linking the data, the research team destroyed the answers to the identifying questions and assigned each participant a random number. Participants earned $5 at the first visit and $15 at the second.

The research team stored the data for the 2008 and 2010 surveys at Yale in a password-protected computer file, and the Human Subjects Committee of Yale University approved both studies.[36]

Measures

The Yale Food Addiction Scale

Gearhardt and colleagues[30] developed the Yale Food Addiction Scale to identify people who show symptoms of substance dependence based on food as the substance of abuse (see Appendix 2, Table A2.1).[30] They adapted the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition-Revised criteria for substance dependence (Table 1) with items assessing addictive-like eating in the past 12 months.

Table 1. DSM-IV Substance-Use Dependence Criteria

1. Substance taken in larger amount and for longer period than intended
2. Persistent desire or repeated unsuccessful attempt to quit
3. Much time/activity to obtain, use, recover
4. Important social, occupational, or recreational activities given up or reduced
5. Characteristic withdrawal symptoms; substance taken to relieve withdrawal
6. Use continues despite knowledge of adverse consequences
7. Tolerance (marked increase in amount; marked decrease in effect)

Each of the 25 items taps into one of the seven criteria for substance dependence. For example, items 1-3 assess "substance taken in larger amount and for longer period than intended," and items 4, 22, 24, and 25 assess "Persistent desire or repeated unsuccessful attempt to quit." The

scale assesses clinical significance through two questions about whether eating behavior causes significant impairment or distress in the individual. Experts in addiction and binge eating as well as clinical patients in treatment for binge eating disorder reviewed and approved the items proposed for the scale.

Sixteen items are coded with a Likert scale (never to four or more times per week or daily), eight items have yes or no responses, and one item has options ranging from one or fewer times a week to five or more times a day. The items with frequency scoring are intended to assess behaviors that could occur occasionally in non-problem eaters and the dichotomous items to indicate more severe eating problems.[30] A diagnosis of food addiction is met if a person endorses three or more of the seven substance-use dependence symptoms and meets the criterion for clinical significance. For more details, see Appendix 2, Tables A2.2 and A2.3.

To test the reliability and validity of the Yale Food Addiction Scale, researchers randomly selected 1,440 students from the roster of all students enrolled at Yale University in 2007. Three hundred and fifty-three students (24.5%) initiated the survey. Students answered questions about food addiction, eating behaviors, alcohol consumption, gambling, and smoking. In this validation study, the scale evidenced good internal reliability (Cronbach's $\alpha = .86$), moderate to good convergent validity ($r = .46$ to $.61$, $p = 0.01$) with measures of similar constructs (emotional eating and eating troubles scores, respectively), and good discriminant validity (low correlations between diagnostic and food addiction symptom scores and alcohol problems, $r = .16$ and $.17$).[30] While this study provided some indication of the scale's reliability and validity, it had a low response rate, which could have resulted in non-representative findings. In addition, it did not evaluate the test-retest reliability of the scale.

The Modified Yale Food Addiction Scale Used in Nurses' Health Study Cohorts

Harvard Medical Center piloted a modified version of the Yale Food Addiction Scale (Appendix 2, Table A2.4) in the 2008 and 2009 follow-up studies of the Nurses' Health Study and Nurses' Health Study II. The Modified Yale Food Addiction Scale includes nine of the 25 items in the original scale. Researchers chose one item for each of the seven diagnostic criteria for substance dependence and included two items to assess clinical significance. In addition, they slightly modified and shortened the wording of each item. If a person endorses three or more of the seven substance-use dependence symptoms and meets criterion for clinical significance, the person meets criteria for food addiction (same as the original Yale Food Addiction Scale). The reliability and validity of this version of the scale have not yet been tested. In the current analysis, we test the reliability and validity of a proxy version of this scale (see description below).

The Modified Yale Food Addiction Scale Proxy Used in Current Analyses

Participants in the current analyses filled out the original Yale Food Addiction Scale. They did not fill out a separate shorter scale. We tested the reliability and validity of a shortened, nine-item version of the original 25-item scale. This shortened scale includes the same items as the Modified Yale Food Addiction Scale used in the Nurses' Health Study cohorts; however, its wording is identical to that of the original scale rather than to the slightly modified wording used in the Nurses' Health Study cohorts. In this paper, we refer to this shortened scale as the Modified Yale Food Addiction Scale proxy, or simply the modified scale proxy.

Harvard researchers tested the reliability and validity the Modified Yale Food Addiction Scale proxy in the same sample of 353 Yale college students described above.[18] The students did not fill out a shortened version of the scale. Rather, just as we did for the current analyses, the researchers created a shortened scale by including nine items from the original scale that

correspond to the items in the modified scale used in the Nurses' Health Study. They found that the Modified Yale Food Addiction Scale proxy estimated a food addiction prevalence of 9.0% compared with the original 11.4%.[18] The internal reliability of the scale was $\alpha = 0.75$, convergent validity with similar constructs (emotional eating and difficulty eating) ranged from r = 0.40 to 0.50, and correlations with discriminant measures were similar to those of the original Yale Food Addiction Scale (-0.04 to 0.27).[18] The psychometric properties of the Modified Yale Food Addiction Scale proxy are similar to those of the original Yale Food Addiction Scale, although it estimated a slightly lower prevalence of food addiction. See Table A2.4 in Appendix 2 for a comparison of the items used in the Modified Yale Food Addiction Scale proxy with the Modified Yale Food Addiction Scale used in the Nurses' Health Study.

Table 2. Differentiating the Studies

Sample	Year	Sample size	Scale Used	Test-retest Study?
Yale Health Behaviors Survey	2008	235	Yale Food Addiction Scale	No
Nurses' Health Study I and II	2008, 2009	134,175	Modified Yale Food Addiction Scale	No
Yale Health Behaviors Survey	2010	51	Yale Food Addiction Scale	Yes

Data Analysis

Using the 2008 and 2010 Yale Health Behavior Surveys, we calculated the prevalence of food addiction and the internal and test-retest reliability of the original Yale Food Addiction Scale and the Modified Yale Food Addiction Scale proxy, for men and women, separately. We evaluated additional psychometric properties of the Modified Yale Food Addiction Scale proxy using the original scale as the standard.

We assessed the scales' internal reliability for the seven substance dependence symptoms by calculating Cronbach's alphas and 95% confidence intervals. We also assessed each item's influence on the internal reliability of the scale by examining 1) each item's correlation with the overall scale and 2) the reliability of the scale after removing each item, one at a time.

Using the 2010 survey, we evaluated the test-retest reliability of both scales by calculating Cohen's Kappa coefficients and 95% confidence intervals for food addiction diagnosis between Times 1 and 2. We also calculated test-retest Kappas for the seven substance dependence symptom clusters in the Yale Food Addiction Scale.

Finally, we estimated the sensitivity, specificity and negative and positive predictive values and 95% confidence intervals[38] of the Modified Yale Food Addiction Scale proxy in the 2008 and 2010 surveys by comparing its diagnosis of food addiction to that made by the original Yale Food Addiction Scale (the benchmark). Table A2.6 in Appendix 2 shows the raw data used for this analysis.

We conducted all analyses in Stata/MP 11.0 for Mac.

Results

Descriptive statistics

A total of 235 and 51 people participated in the 2008 and 2010 surveys, respectively. Three individuals did not fill out the food addiction items in 2008 and were excluded from analyses (Table 3). The majority of both samples was female, 18 to 25 years of age, and college-educated. Fifty percent of the participants in both surveys were Caucasian, and about 30% were Asian or African American. Fewer were Hispanic or mixed.

Food Addiction Prevalence and Scale Reliability and Validity

Prevalence

Prevalence estimates for both versions of the scale were similar in the 2008 survey (Table 4); 5.6% (95% confidence interval, 2.6% - 8.6%) for the original scale and 5.2% (95% confidence interval, 2.3% - 8.0%) for the Modified Yale Food Addiction Scale proxy. The prevalence was twice as high for women as men for both versions of the scale. See Table A2.5 in Appendix 2 for food addiction counts by scale, year of survey and gender.

In the 2010 test-retest survey, the scales' prevalence estimates were not as consistent with each other. The overall prevalence was 11.8% (95% confidence interval, 2.6% - 20.9%) for the original scale and 5.9% (95% confidence interval, 0% - 12.6%) for the Modified Yale Food Addiction Scale proxy. While both versions of the scale estimated a 4.2% prevalence of food addiction among men (one participant), the original scale estimated a much higher prevalence among women (13%) than did the modified scale proxy (8.7%). Wide confidence intervals indicate that the prevalence estimates in this sample are not precise.

Reliability

In the 2008 and 2010 surveys, both versions of the scale had good internal and test-retest reliability (Table 5). The internal reliability of the seven dependence symptoms of the Yale Food Addiction Scale was excellent, with $\alpha > 0.80$ in both surveys. The internal reliability of the Modified Yale Food Addiction Scale proxy was lower in both surveys, ranging from $\alpha = 0.59$ to 0.72, but still reasonable. When stratified by gender, the reliability was somewhat higher for women than men; the confidence intervals overlapped appreciably.

No individual item had a strong influence on the internal reliability of the Yale Food Addiction Scale, although a few items were weakly correlated with the scale. Specifically, "How many times in the past year did you try to cut down or stop eating certain foods altogether," "I

have been successful at cutting down or not eating these kinds of food," and "Over time, I have found that I need to eat more and more to get the feeling I want, such as reduced negative emotions or increased pleasure" had the lowest correlations with the scale (r = 0.22, 0.34, and 0.39, respectively). None of these items are in the shortened version of the scale.

Both scales had good test-retest reliability for food addiction diagnosis in the 2010 survey. The test-retest reliability of the original Yale Food Addiction Scale for food addiction diagnosis between Times 1 and 2 was Kappa = 0.73 (95% confidence interval, 0.56 - 0.84), indicating substantial agreement over time.[34] This scale found six individuals with food addiction at Time 1 (n = 51) and three at Time 2 (n = 45). The test-retest reliability of the Modified Yale Food Addiction Scale proxy was Kappa = 0.79 (95% confidence interval, 0.48 - 1.00), also indicating substantial agreement over time. This scale found three individuals with food addiction at Time 1, and two at Time 2. However, small samples and wide confidence intervals indicate that these estimates are not precise and should be interpreted with caution.

The test-retest reliability Kappas for the seven addiction dependence symptoms ranged from 0.40 to 0.76 (Table 6). The symptoms, "Much time/activity to obtain, use, recover" and "Substance taken in larger amount and for longer period than intended" had the highest reliabilities (0.76 and 0.67, respectively), and "Important social, occupational, or recreational activities given up or reduced" and "Tolerance, marked increase in amount; marked decrease in effect" had the lowest reliabilities (0.40 and 0.44, respectively). According to benchmarks proposed by Landis and Koch,[34] Symptom 4 had fair agreement, Symptoms 2, 5, 6, and 7 had moderate agreement, and Symptoms 1, 3, and 6 had substantial agreement over time.

Validity: Comparison of the Modified Yale Food Addiction Scale proxy to the Original Yale Food Addiction Scale

Using the original Yale Food Addiction Scale as the standard, the Modified Yale Food Addiction Scale proxy had excellent sensitivity and negative predictive value in the 2008 survey (Table 7). Of the 13 people identified with food addiction by the Yale Food Addiction Scale, the modified scale proxy correctly identified 12. The modified scale proxy's sensitivity was 92.3% (95% confidence interval, 64% - 99.8%), and the negative predictive value was 99.5% (95% confidence interval, 97.5% - 100%). Among men, the scale's sensitivity and negative predictive values were 100%. Among women, the sensitivity was 90% (95% confidence interval, 55.5% - 99.7%), and the negative predictive value was 99.2% (95% confidence interval, 95.7% - 100%). The sensitivity of the shorter scale was not as high in the 2010 test-retest survey (50%, 95% confidence interval, 11.8% - 88.2%); however, due to an extremely small number of cases at Time 2 and as indicated by wide confidence intervals, this estimate was not precise.

Discussion

Overall, the original Yale Food Addiction Scale and Modified Yale Food Addiction Scale proxy had good psychometric properties in the 2008 and 2010 Yale Health Behavior Surveys. The modified scale proxy performed well as a substitute for the original, particularly in the 2008 survey. In 2008, estimations of food addiction prevalence were consistent for both versions of the scales. The scales' prevalence estimates were not consistent in the substantially smaller 2010 test re-test survey, except among men. Both scales had reasonable to excellent internal reliability for the seven symptoms of substance dependence ($0.52 < \alpha < 0.90$), although Cronbach's alphas were consistently higher for the longer version of the scale. This is not surprising as the number of items in a scale influences internal consistency; scales with more items are typically more

reliable.[39] Test-retest reliability estimates were good for both scales, with Cohen's Kappas >0.73. However, these estimates were imprecise. In the 2008 survey, the modified scale proxy had excellent sensitivity and negative predictive value using the original scale as the benchmark.

The validity of the Modified Yale Food Addiction Scale proxy as a substitute for the original version necessarily depends on the assumption that the original version is a tool that can validly assess food addiction. Use of the original scale as a benchmark for examining the psychometric properties of the modified version seemed appropriate, as preliminary evidence from other study samples suggested that the original version had good psychometric properties. The majority of these studies found that the internal reliability was good to excellent (α>0.80). This has been replicated among university students,[30] the general community,[25] the overweight and obese,[24, 40] and in German,[32] Italian,[41] French,[42] and Spanish[31] populations. The current analyses corroborated this early evidence.

In this study, the specificity and positive predictive value were not useful psychometric measures. Because the items in the Modified Yale Food Addiction Scale proxy (the test) were from a subset of the original Yale Food Addiction Scale (the benchmark), participants could not meet the criteria for food addiction using the modified scale proxy unless they also met criteria using the original scale. The modified scale proxy could therefore not identify false positives, indicating that the specificity and positive predictive value would always be 100%.

Our paper found that the original Yale Food Addiction Scale and the Modified Yale Food Addiction Scale proxy had good test-retest reliability (Kappa > 0.73). This test-retest score is comparable to those found in other datasets for other substance use and eating disorders (alcohol use disorder (κ = .69)[43] and binge eating disorder (κ = 0.75)).[44] However, test-retest studies have limitations. For example, the time interval between tests influences reliability estimates.

Typically, the shorter the time gap, the higher the correlation between tests.[14] Test-retest investigators typically try to choose a time period that provides a reasonable balance between potential memory bias and actual (unwanted) clinical change.[45] In our study, despite the rather short time interval of two weeks, the prevalence of food addiction fell. This drop in prevalence is unlikely to reflect real behavior change. Rather, participants may have believed the second questionnaire was intended to amplify the first and did not feel the need to repeat their answers,[46] or participants answered "no" to move quickly through the questionnaires. It is also possible that factors unrelated to food addiction (e.g., the participants' moods, fatigue levels, health) affected test-taking, and thus test scores.[39] However, these factors would not necessarily lead to a systematic change in food addiction endorsement. Finally, test-retest methods are only suitable for characteristics that are stable over time. This particular potential limitation likely would not affect our results, as addiction diagnoses do not fluctuate day to day (unlike moods such as anger or anxiety).[47] These potential limitations are unlikely to negate our high Kappa coefficients (>0.73). However, wide confidence intervals, in part due to small sample sizes, indicate that our estimates are not precise.

As previously mentioned, the Modified Yale Food Addiction Scale proxy used in the current analyses is not identical to the version used in the Nurses' Health Study cohorts. There are several wording differences between the corresponding items in each scale (see Table A2.4 in Appendix 2). Previous evidence[48, 49] suggests that under some circumstances, even minor changes to diagnostic criteria can have major effects on prevalence estimates, which could ultimately complicate scientific theory as well as public health efforts.[49] This potential limitation is particularly relevant if one intends to extrapolate the reliability and validity findings of the modified scale proxy used in the current analyses to the version used in the Nurses' Health Study

cohorts. While we believe that the meaning of the items in both versions of the scales is similar, we were unable to evaluate what effect, if any, these word modifications had on estimates of reliability and validity. Nonetheless, three papers[18, 50, 51] have examined correlates of food addiction using the Nurses' Health Study cohorts' version. All of these studies found strong associations between food addiction and variables expected to be associated with food addiction such as body mass index,[18] child abuse,[50] and post-traumatic stress disorder.[51] Therefore, in practice, the Modified Yale Food Addiction Scale has begun to help us better understand the food addiction construct.

This paper evaluated the prevalence of food addiction and several psychometric properties of two measures of food addiction using two community-based convenience samples. The seven substance dependence symptoms in both versions of the scale had good internal reliability, the scales had good test re-test reliability, and the Modified Yale Food Addiction Scale proxy had excellent sensitivity and negative predictive value using the original scale as the benchmark. Our analyses suggest that the shortened version of the scale may be an appropriate substitute for the original Yale Food Addiction Scale, although we were unable to test whether the context of being asked only nine versus the full array of items influenced people's answers. Our findings support the continued use of the original Yale Food Addiction Scale and the modified version to investigate whether the construct of food addiction is a valid mental illness and substance-related disorder.

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Tables

Table 3. Characteristics of 2008 and 2010 Yale Health Behavior Surveys

	2008		2010	
	(n = 232)		(n = 51)	
	n	%	n	%
Age				
18-25	174	76.0	37	72.5
26-35	42	18.3	14	27.5
36+	13	5.7		
Gender				
Male	96	41.6	24	47.1
Female	135	58.4	27	52.9
Education				
<=High School/Vocational	32	13.8	10	19.6
Some or all of College	157	67.7	27	52.9
>=Graduate School	43	18.5	14	27.5
Race/ethnicity				
Other/Unknown	5	2.2		
Mixed	18	7.8	6	11.8
African American	23	10.0	7	13.7
Hispanic	14	6.0	2	3.9
Asian	56	24.2	8	15.7
Caucasian	115	49.8	28	54.9
Body Mass Index				
19.7-<=24.9 (Normal)	178	78.5	22	43.1
25-29.9 (Overweight)	36	15.8	17	33.3
30+ (Obese)	14	6.1	12	23.5

Table 4. Food Addiction Prevalence in the 2008 and 2010 Yale Health Behavior Surveys

	Yale Food Addiction Scale	Modified Yale Food Addiction Scale proxy[a]
	% (95% CI)	% (95% CI)
2008 (n = 232)	5.6 (2.6 - 8.6)	5.2 (2.3 - 8.0)
Men	3.1 (0 - 6.6)	3.1 (0 - 6.6)
Women	7.4 (2.9 - 11.9)	6.6 (2.4 - 10.9)
2010 Time 1 (n = 51)	11.8 (2.6 - 20.9)	5.9 (0 - 12.6)
Men	4.2 (0 - 12.5)	4.2 (0 - 12.5)
Women	18.5 (3.2 - 33.8)	7.4 (0 - 17.7)
2010 Time 2 (n = 45)	6.7 (0 - 14.2)	4.4 (0 - 10.7)
Men	0	0
Women	13.0 (0 - 27.5)	8.7 (0 - 20.8)

[a] This scale has 9 of the 25 items in the Yale Food Addiction Scale

Table 5. Food Addiction Scale Reliability in the 2008 and 2010 Yale Health Behavior Surveys

	Yale Food Addiction Scale	Modified Yale Food Addiction Scale proxy[a]
2008[b]		
Internal Reliability	0.84 (0.76 - 0.91)	0.67 (0.54 - 0.79)
Men	0.81 (0.45 - 1.17)	0.63 (0.35 - 0.91)
Women	0.84 (0.77 -0.92)	0.68 (0.54- 0.82)
2010 Time 1 (n = 51)[b]		
Internal Reliability	0.80 (0.68 - 0.93)	0.59 (0.40 - 0.79)
Men	0.59 (0.45 - 0.73)	0.52 (0.25 - 0.80)
Women	0.84 (0.73 - 0.94)	0.60 (0.38 - 0.82)
2010 Time 2 (n = 45)[b]		
Internal Reliability	0.85 (0.71 - 0.99)	0.72 (0.47 - 0.96)
Men	0.66 (0.46 - 0.85)	0.67 (0.33 - 1.02)
Women	0.90 (0.75 - 1.05)	0.76 (0.50 - 1.01)
2010 Test Re-Test Reliability (n = 45)[c]	0.73 (0.56 - 0.84)	0.79 (0.48 - 1.00)

[a] This scale has 9 of the 25 items in the Yale Food Addiction Scale

[b] Cronbach's alpha and 95% confidence intervals

[c] Cohen's Kappa coefficients and 95% confidence intervals

Table 6. Test Re-Test Reliability Estimates for Food Addiction Dependence Symptoms in 2010 Yale Health Behavior Survey (n = 45)

	Cohen's Kappa	95% CI	Items included in YFAS symptom cluster
Food Addiction Dependence Symptoms			
Substance taken in larger amount and for longer period than intended	0.67	0.36 - 0.92	1, 2, and 3
Persistent desire or repeated unsuccessful attempt to quit	0.59	0.32 - 0.72	4, 22, 24, and 25
Much time/activity to obtain, use, recover	0.76	0.66 - 0.93	5, 6, and 7
Important social, occupational, or recreational activities given up or reduced	0.40	0.23 - 0.73	8, 9, 10, and 11
Characteristic withdrawal symptoms; substance taken to relieve withdrawal	0.48	0.18 - 0.73	12, 13, and 14
Use continues despite knowledge of adverse consequences	0.63	0.54 - 0.78	19
Tolerance (marked increase in amount; marked decrease in effect)	0.44	0.28 - 0.58	20, 21

CI, Confidence Interval; YFAS, Yale Food Addiction Scale

Questions 17, 18 and 23 in the YFAS are primer questions and are not scored

Landis and Koch interpretation of Kappa: <0.00 = poor agreement; 0.00-0.20 = slight agreement; 0.21-0.40 = fair agreement; 0.41-0.60 = moderate agreement; 0.61-0.80 = substantial agreement; and 0.81-1.00 = almost perfect agreement

Table 7. Validity of Food Addiction Diagnosis Measured by the Modified Yale Food Addiction Scale Proxy Compared with the Original Yale Food Addiction Scale in the 2008 and 2010 Yale Health Behavior Surveys

	Modified Yale Food Addiction Scale Proxy Compared with Yale Food Addiction Scale
2008 (n = 232)	
Sensitivity	92.3% (64%, 99.8%)
Specificity	100% (98.3%, 100%)
Positive Predictive Value	100% (73.5%, 100%)
Negative Predictive Value	99.5% (97.5%, 100%)
2010 Time 1 (n = 51)	
Sensitivity	50% (11.8%, 88.2%)
Specificity	100% (92.1%, 100%)
Positive Predictive Value	100% (29.2%, 100%)
Negative Predictive Value	93.8% (82.8%, 98.7%)
2010 Time 2 (n = 45)	
Sensitivity	66.7% (9.43% - 99.2%)
Specificity	100% (91.6% - 100%)
Positive Predictive Value	100% (15.8% - 100%)
Negative Predictive Value	97.7% (87.7% - 99.9%)

Appendix 2

Table A2.1. The Yale Food Addiction Scale

This survey asks about your eating habits in the past year. People sometimes have difficulty controlling their intake of certain foods such as:

- Sweets like ice cream, chocolate, doughnuts, cookies, cake, candy, ice cream
- Starches like white bread, rolls, pasta, and rice
- Salty snacks like chips, pretzels, and crackers
- Fatty foods like steak, bacon, hamburgers, cheeseburgers, pizza, and French fries
- Sugary drinks like soda pop

When the following questions ask about "CERTAIN FOODS" please think of ANY food similar to those listed in the food group or ANY OTHER foods you have had a problem with in the past year

IN THE PAST 12 MONTHS:	Never	Once a month	2-4 times a month	2-3 times a week	4 or more times or daily
1. I find that when I start eating certain foods, I end up eating much more than planned	0	1	2	3	4
2. I find myself continuing to consume certain foods even though I am no longer hungry	0	1	2	3	4
3. I eat to the point where I feel physically ill	0	1	2	3	4
4. Not eating certain types of food or cutting down on certain types of food is something I worry about	0	1	2	3	4
5. I spend a lot of time feeling sluggish or fatigued from overeating	0	1	2	3	4
6. I find myself constantly eating certain foods throughout the day	0	1	2	3	4
7. I find that when certain foods are not available, I will go out of my way to obtain them. For example, I will drive to the store to purchase certain foods even though I have other options available to me at home.	0	1	2	3	4
8. There have been times when I consumed certain foods so often or in such large quantities that I started to eat food instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.	0	1	2	3	4
9. There have been times when I consumed certain foods so often or in such large quantities that I spent time dealing with negative feelings from overeating instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.	0	1	2	3	4

IN THE PAST 12 MONTHS:	Never	Once a month	2-4 times a month	2-3 times a week	4 or more times or daily
10. There have been times when I avoided professional or social situations where certain foods were available, because I was afraid I would overeat.	0	1	2	3	4
11. There have been times when I avoided professional or social situations because I was not able to consume certain foods there.	0	1	2	3	4
12. I have had withdrawal symptoms such as agitation, anxiety, or other physical symptoms when I cut down or stopped eating certain foods. (Please do NOT include withdrawal symptoms caused by cutting down on caffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)	0	1	2	3	4
13. I have consumed certain foods to prevent feelings of anxiety, agitation, or other physical symptoms that were developing. (Please do NOT include consumption of caffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)	0	1	2	3	4
14. I have found that I have elevated desire for or urges to consume certain foods when I cut down or stop eating them.	0	1	2	3	4
15. My behavior with respect to food and eating causes significant distress.	0	1	2	3	4
16. I experience significant problems in my ability to function effectively (daily routine, job/school, social activities, family activities, health difficulties) because of food and eating.	0	1	2	3	4

IN THE PAST 12 MONTHS:	NO	YES
17. My food consumption has caused significant psychological problems such as depression, anxiety, self-loathing, or guilt.	0	1
18. My food consumption has caused significant physical problems or made a physical problem worse.	0	1
19. I kept consuming the same types of food or the same amount of food even though I was having emotional and/or physical problems.	0	1
20. Over time, I have found that I need to eat more and more to get the feeling I want, such as reduced negative emotions or increased pleasure.	0	1
21. I have found that eating the same amount of food does not reduce my negative emotions or increase pleasurable feelings the way it used to.	0	1
22. I want to cut down or stop eating certain kinds of food.	0	1
23. I have tried to cut down or stop eating certain kinds of food.	0	1
24. I have been successful at cutting down or not eating these kinds of food	0	1

25. How many times in the past year did you try to cut down or stop eating certain foods altogether?	1 or fewer times	2 times	3 times	4 times	5 or more times

Gearhart, AN., Corbin, W.R., & Brownell, K.D. (2009). Preliminary validation of the Yale Food Addiction Scale. *Appetite, 52,* 430-436

Table A2.2. Food Addiction Items in Yale Food Addiction Scale and Modified Yale Food Addiction Scale and Correspondence with Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition Substance-use Dependence Criteria

DSM-IV Substance-Use Dependence Criteria	YFAS Items	YFAS items used in Modified Yale Food Scale
1. Substance taken in larger amount and for longer period than intended	1, 2, and 3	2
2. Persistent desire or repeated unsuccessful attempt to quit	4, 22, 24, and 25	4
3. Much time/activity to obtain, use, recover	5, 6, and 7	5
4. Important social, occupational, or recreational activities given up or reduced	8, 9, 10, and 11	9
5. Characteristic withdrawal symptoms; substance taken to relieve withdrawal	12, 13, and 14	12
6. Use continues despite knowledge of adverse consequences	19	19
7. Tolerance (marked increase in amount; marked decrease in effect)	20, 21	21
Clinical impairment items	15	15
	16	16

DSM-IV, Diagnostic and Statistical Manuel of Mental Disorders, Fourth Edition; *YFAS*: Yale Food Addiction Scale

Items 17, 18 and 23 in the YFAS are primer questions and are not scored

Items 15 and 16 of the YFAS and 6 and 7 of the modified version of the scale assess clinically significant impairment or distress

A diagnosis of food addiction is met if a person endorses 3 or more of the 7 substance-use dependence criteria and has clinical significance

Table A2.3. Scoring the Yale Food Addiction Scale

Item	Response option	Response needed for positive symptom
1, 2, 4, and 6	Never to 4 or more times per week or daily	4 or more times a week or daily
3, 5, 7, 9 and 12-16	Never to 4 or more times per week or daily	≥ 2-3 times a week
8, 10, and 11	Never to 4 or more times per week or daily	≥ 2-4 times a month
19-22	Yes/No	Yes
24	Yes/No	No
25	1 or fewer times to 5 or more times	≥ 4 times

Questions 17, 18 and 23 are primer items and are not scored

Questions 15 and 16 assess clinically significant impairment or distress

A diagnosis of food addiction is met if a person endorses 3 or more of the 7 substance-use dependence criteria and has clinical significance

Table A2.4. A Comparison of Items in the Modified Yale Food Addiction Scale Proxy and the Modified Yale Food Addiction Scale

	Modified Yale Food Addiction Scale Proxy used in Current Analyses	**Modified Yale Food Addiction Scale used in Nurses' Health Study Cohorts**
1	I find myself continuing to consume certain foods even though I am no longer hungry.	I find myself consuming certain foods even though I am no longer hungry.
2	Not eating certain types of food or cutting down on certain types of food is something I worry about.	I worry about cutting down on certain foods.
3	I spend a lot of time feeling sluggish or fatigued from overeating	I feel sluggish or fatigued from overeating.
4	There have been times when I consumed certain foods so often or in such large quantities that I spent time dealing with negative feelings from overeating instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.	I have spent time dealing with negative feelings from overeating certain foods, instead of spending time in important activities such as time with family, friends, work, or recreation.
5	I have had withdrawal symptoms such as agitation, anxiety, or other physical symptoms when I cut down or stopped eating certain foods. (Please do NOT include withdrawal symptoms caused by cutting down on caffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)	I have had physical withdrawal symptoms such as agitation and anxiety when I cut down on certain food. (Do NOT include caffeinated drinks: coffee, tea, cola, energy drinks, etc.)
6	My behavior with respect to food and eating causes significant distress.	My behavior with respect to food and eating causes me significant distress.
7	I experience significant problems in my ability to function effectively (daily routine, job/school, social activities, family activities, health difficulties) because of food and eating.	Issues related to food and eating decrease my ability to function effectively (daily routine, job/school, social or family activities, health difficulties).
8	I kept consuming the same types of food or the same amount of food even though I was having emotional and/or physical problems.	I kept consuming the same types or amounts of food despite significant emotional and/or physical problems related to my eating.
9	I have found that eating the same amount of food does not reduce my negative emotions or increase pleasurable feelings the way it used to.	Eating the same amount of food does not reduce negative emotions or increase pleasurable feelings the way it used to.

Scale prompt: "The following questions ask about your eating habits in the past year. People sometimes have difficulty controlling their intake of certain foods such as sweets, starches, salty snacks, fatty foods, sugary drinks, and others. In the past 12 MONTHS, how often were each of these statements true for you?"

Table A2.5. Food Addiction Diagnosis by Scale, Year of Survey, and Gender

	Food Addiction			
	Yale Food Addiction Scale		Modified Yale Food Addiction Scale proxy[a]	
	Yes	No	Yes	No
2008 (n = 232)	13	219	12	220
Male	3	93	3	93
Female	10	125	9	126
2010 Time 1 (n = 51)	6	45	3	48
Male	1	23	1	23
Female	5	22	2	25
2010 Time 2 (n = 45)	3	42	2	43
Male	0	22	0	22
Female	3	20	2	21

[a] This scale has 9 of the 25 items in the Yale Food Addiction Scale

Table A2.6. Raw Data for Measures of Validity of the Modified Yale Food Addiction Scale Proxy Using the original Yale Food Addiction Scale as the Benchmark in the 2008 and 2010 Health Behavior Surveys

		Modified Yale Food Addiction Scale proxy (Test)	
2008	Food Addiction	Yes	No
Yale Food Addiction Scale	Yes	12	1
	No	0	219
2010 Time 1	Food Addiction	Yes	No
Yale Food Addiction Scale	Yes	3	3
	No	0	45
2010 Time 2	Food Addiction	Yes	No
Yale Food Addiction Scale	Yes	2	1
	No	0	42

Chapter 4. Food Consumption and Food Addiction in the Nurses' Health Study Cohorts

Introduction

Beginning in the early 1980s, the concept of food addiction has gained currency in popular culture. Groups such as Food Addicts Anonymous, Overeaters Anonymous, and Food Addicts in Recovery Anonymous were created for and by individuals who identify as food addicts and compulsive eaters. A variety of self-help books have been published on the subject of food addiction, ranging from *A Substance Called Food* (1989) to *Breaking the Bonds of Food Addiction* (2004), and many television networks offer programs featuring obese individuals who identify as food addicts. While food addiction has been prominent in popular culture for decades, it has had little presence in the scientific literature until recently. It remains unclear whether there is enough evidence for food addiction to meet the criteria for a mental disorder in general and be categorized as a substance-use disorder in particular. Whether it belongs in a future version of the Diagnostic Statistical Manual of Mental Disorders remains to be determined.

Psychologist, Jerome Wakefield, defines dysfunction, (which may be psychological, behavioral, and/or neurological), as an internal mechanism that fails to perform one of its natural functions.[1] The compulsive relationship between an individual's behavior (eating) and a substance (food) is core to the internal dysfunction of addictive disorders, and therefore food addiction. It is unclear whether certain types of foods or nutrients are positively reinforcing "substances," and therefore core to the internal dysfunction of food addiction. Highly palatable foods that are full of fat, salt, and sugar are difficult for some individuals to resist and might be linked to addictive eating.[2, 3] Preliminary evidence suggests that consumption of sugar and foods

high in sugar and/or fat could lead to compulsive eating behaviors, neurological changes, and food addiction.[2, 4-15] However, this has not been investigated using epidemiologic data.

The operationalized measures of food addiction (discussed below) are based on the Diagnostic Statistical Manual of Mental Disorders, Fourth Edition criteria*, which defined maladaptive substance use as meeting three or more of the following criteria in a 12-month period:

1. Tolerance (marked increase in amount; marked decrease in effect)
2. Characteristic withdrawal symptoms; substance taken to relieve withdrawal
3. Substance taken in larger amount and for longer period than intended
4. Persistent desire or repeated unsuccessful attempt to quit
5. Much time/activity to obtain, use, recover
6. Important social, occupational, or recreational activities given up or reduced
7. Use continues despite knowledge of adverse consequences

Preliminary research[2, 4-15] suggests that animals that eat large quantities of sugar and foods high in sugar and/or fat over time show some of these dependency symptoms. Several studies[16-22] have found evidence of tolerance in animals, i.e., a need for markedly increased amounts of food to achieve a desired effect or markedly diminished effect with continued consumption of the same amount of food. Studies demonstrate that rats consuming palatable (i.e., savory, tasty, or agreeable in flavor) food over time increase their consumption, suggesting that rats need more of these foods over time to achieve a desired effect. One research group[16, 23] found that sucrose-binging rats show signs of opiate-like withdrawal such as chattering teeth, forepaw tremor, and head shakes when deprived of sugar. Another study found[4] that animals continue to eat palatable foods despite awareness of adverse consequences (e.g., an electric shock).

Research on food addiction in humans is beginning to accumulate. In 2009, Gearhardt and colleagues[24] developed and validated the Yale Food Addiction Scale to estimate the prevalence of food addiction in populations. The scale was developed to identify people most likely to exhibit substance dependence symptoms through consumption of high fat and/or high sugar foods. Experts in addictive behaviors and binge eating as well as patients in treatment for binge-eating disorder reviewed the questions proposed for the scale. The Yale Food Addiction Scale has 25 questions about consumption of food in the past 12 months. Each question falls under one of the seven criteria for substance dependence as defined by the Diagnostic Statistical Manual of Mental Disorders, Fourth Edition (see above). The scale assesses clinical significance with two questions about whether eating behavior causes significant impairment or distress in the individual. The Yale Food Addiction Scale was first tested in a stratified random sample of Yale college students (n = 353), and was found to have good internal reliability (α = .86), good convergent validity (r = .46 to .61, p = 0.01) with measures of similar constructs (emotional eating and eating troubles scores, respectively), and good discriminant validity (r = .16 and .17 for diagnostic and count food addiction scores) from a related, but different construct (alcohol problems).[24]

The Yale Food Addiction Scale has since been used in almost 40 studies. Findings so far suggest that food addiction is positively associated with body mass index,[22, 25-27] binge eating behaviors,[28-32] depression,[28, 31-33] food cravings,[30, 31, 34] child abuse,[27] and impulsivity.[31] This early research suggests that the operationalized construct of food addiction behaves as we would expect it to. However, the majority of these studies used small samples (n<200)[22, 28-33, 35-37], were in overweight or obese populations,[28, 29, 31-33, 35-37] and did not control for potential confounders such as age, gender, smoking status, alcohol consumption, depression, or eating disorders.

This preliminary research does not address what is fundamental to the internal dysfunction of addiction, i.e., the compulsive relationship between an individual's behavior and a specific substance. Assessment of the validity of food addiction as a substance-related disorder necessarily relies on an individual's relationship to food. There is no research to date on whether and to what degree certain potentially positively reinforcing nutrients (e.g., fat, sodium, or sugar), foods, (e.g., pizza, popcorn, or ice cream), or food groups (e.g., fatty foods, salty foods, or dessert) are associated with food addiction. Furthermore, research conducted on food addiction in large epidemiologic studies remains scarce.

The aim of this study is to test the hypothesis that there is a positive relationship between consumption of a selection of potentially positively reinforcing nutrients, foods, and food groups and food addiction. Based on the existing research to date, we expect a positive relationship between consumption of fat, salt, sugar, and starch, and fatty, salty, sugary and starchy foods, and food addiction.

Methods

Sample

Data to test these hypotheses come from the Nurses' Health Study and Nurses' Health Study II, two large prospective cohort studies conducted in the United States. The Nurses' Health Study began in 1976 with the enrollment of 121,700 female registered nurses from the 11 most populous states.[38] At the start of the study, nurses were married and 30 to 55 years old. The Nurses' Health Study II began in 1989 with the enrollment of 116,686 women who were 25 to 42 years old at baseline. The objective of both studies was to examine the long-term health consequences of oral contraceptive use, diet, and lifestyle. Participants receive questionnaires about their medical history and lifestyle every two years. Response rates for each two-year cycle

of questionnaires for both cohorts have been 90%. The Human Research Committees of Brigham and Women's Hospital and Massachusetts Eye and Ear Infirmary approved the studies.[38, 39]

The current analyses use data collected in 2006 and 2008 for the Nurses' Health Study and 2007 and 2009 for the Nurses' Health Study II (n = 160,946), as diet was assessed in 2006 and 2007 and food addiction was assessed in 2008 and 2009. We excluded women from our sample if they did not have data on date of birth (n = 130), weighed less than 50 pounds (n = 1), or were never married and in the Nurses' Health Study (n = 19; eligibility required being married at enrollment). In addition, we excluded women who did not provide sufficient information to determine a food addiction diagnosis (n = 25,741) (see Appendix 3, Table A3.1). Of the 25,741 women who were dropped, 18,603 filled out short versions of the questionnaire that did not include questions on food addiction. Thus, 7,138 women filled out questionnaires that had questions on food addiction, but did not provide sufficient information to make a food addiction diagnosis. Women who were dropped from the analysis were not significantly different from women who were kept in the analysis in terms of age, average daily consumption of food groups, calories, cigarette smoking, alcohol consumption, or body mass index. After making these exclusions, our final sample included 135,055 women—61,460 (45.5%) from the Nurses' Health Study and 73,595 (54.5%) from the Nurses' Health Study II.

Variables and Variable Definitions

Exposures

The Nurses' Health Study first collected dietary information in the 1980, 1984, and 1986 follow-up questionnaires, and every four years since. The Nurses' Health Study II first collected diet information in 1991, and every four years since.[39] We used average consumption of specific nutrients, food items and food groups from the 2006 Nurses' Health Study and 2007 Nurses'

Health Study II 131-item food frequency questionnaires. Epidemiologic studies use food frequency questionnaires as the primary tool for measuring nutrient and food intake.[40] Most validation studies comparing diet records and food frequency questionnaires find correlation coefficients between 0.5 and 0.7, which are similar to validity measures of other epidemiologic measurements (e.g., physical activity) that have well-known relationships with disease.[40]

We used three approaches to examine the relationship between potentially positively reinforcing foods and food addiction. Our first approach was decompositional, and focused on specific components of foods (additives (salt and sugar) and nutrients (lipids)). This approach is advantageous because a) specific components of foods may be most biologically relevant to food addiction; and b) identification of specific compounds may be important for dietary supplementation or elimination (which may become relevant for treatment). Solely relying on food items or food groups may result in overlooking an important relationship between a nutrient or additive and food addiction, as nutrients and additives are distributed over many foods.[40] Our second and third approaches were integrative, focusing on the consumption of food items and food groups. These approaches are advantageous because a) if the correct nutrient or food is not measured or identified, its effect on food addiction is less likely to be missed by examining the whole food or food group; b) analyses of food or food groups, as opposed to additives or nutrients, are most relevant for dietary recommendations since individuals change their nutrient intake through food choices; and c) we could miss an interaction between several components of foods or between several foods and food addiction if we focused only on single nutrients, additives, or foods.[40] An examination of foods and food groups helps capture the potential complexity of how chemicals, additives, nutrients, and foods interact with each other to produce a biological effect.

We identified potentially positively reinforcing nutrients, food items and food groups through previously published animal and human research on food addiction, discussions with researchers investigating food addiction, and individuals who identify as food addicts and compulsive overeaters.[3, 4, 16, 17, 19, 21, 24, 41-43]

Nutrients

We evaluated the relationships between grams of fat (total, saturated and *trans)*, milligrams of sodium, and grams of sugar (total, added, fructose, glucose, sucrose, starch and artificial sugar), and food addiction. Nutrient intake was derived using the raw data from the food frequency questionnaire. All relevant information was used to create the nutrient variables, including frequency of food consumption, vitamin and mineral intake, type of fat used for baking and frying, and specific food brands.[44] For example, for *trans* fat, we summed the amount of *trans* fat across all food items containing *trans* fat based on answers to the 2006 and 2007 food frequency questionnaires. We created the artificial sugar variable by summing intake of saccharine, aspartame, and sucralose. We examined quintiles of average daily consumption for each nutrient. Reproducibility studies of food frequency questionnaires among nurses have found moderate to good correlations ranging from 0.40 for *trans* fatty acids[45] to 0.71 for sucrose.[46] Validity studies comparing food frequency questionnaires to diet records have found Pearson correlation coefficients of 0.53 for total fat, 0.59 for saturated fat, 0.45 for total carbohydrates, and 0.54 for sucrose.[46]

Food items

We assessed the relationships between average consumption per day of 54 different food and beverage items and food addiction. In published work, Pearson correlation coefficients

comparing food frequency questionnaires at two time points range from 0.31 for pie to 0.71 for doughnuts.[47]

The food frequency questionnaire asks about the average amount consumed over the past year for a specified serving size of food and beverages using nine possible responses: Never or less than once per month, 1-3 per month, 1 per week, 2-4 per week, 5-6 per week, 1 per day, 2-3 per day, 4-5 per day, and 6+ per day. We examined frequencies of each food item to create new food variables with three categories as follows: a) Rarely consumed the food item over the past year (less than three times per month or never); b) Consumed the food item sometimes to regularly; and c) Consumed the food item in a seemingly excessive or abnormal way. The latter two categories varied for each food item and were determined by a) examining the frequencies of women falling into each category of consumption, and b) determining what could be considered excessive consumption based on the frequencies and the type of food. We created these three categories of consumption to simplify analyses and results. The second column of each food table lists the three categories of consumption. See Appendix 3, Table A3.2 for a list of foods and portion sizes as listed on the Food Frequency Questionnaire.

Food Groups

We created food groups (non-sweet "Fatty Foods," "Salty Foods," "Desserts," "Starchy Foods" and "Fruits and Vegetables") by merging consumption of individual food items. Previous epidemiologic studies have used these food groups to study nutrition and disease.[48-50] We created quartiles of average daily consumption of each food group to evaluate the relationship between each food group and food addiction and to evaluate the presence of linear trends.[51] The food items contained in the food groups were mutually exclusive, except for regular fat popcorn, corn/potato chips, and salami/bologna, which we included in the non-sweet fatty food group and

in the salty food group. See Table 12 and/or Appendix 3, Table A3.2 for a list of food groups and food items included in the food groups.

Outcome

Food Addiction

We assessed food addiction using a modified version of the Yale Food Addiction Scale in the Nurses' Health Study 2008 and Nurses' Health Study II 2009 questionnaires. The modified Yale Food Addiction Scale retained nine of the original 25 items in the Yale Food Addiction Scale. There was one item for each of the seven diagnostic symptoms for substance dependence as defined by the Diagnostic Statistical Manual of Mental Disorders, Fourth Edition, and two additional items to assess clinical impairment (i.e., impairment and distress). A participant met the criteria for food addiction if she had three or more of the seven substance-use dependence symptoms, and had clinical significance in the past year.[27, 52] Researchers tested the validity and reliability of the Modified scale in the same sample of 353 Yale college students in which the Yale group tested the original Yale Food Addiction Scale. They estimated a 9.0% prevalence of food addiction using the modified Yale Food Addiction Scale, compared with a prevalence of 11.4% using the Yale Food Addiction Scale.[24, 52] The internal reliability of the scale was α = 0.75, and convergent validity with similar constructs (emotional eating and difficulty eating) ranged from r = 0.40 to 0.50.[52]

The modified Yale Food Addiction Scale as well as a list of Diagnostic Statistical Manual of Mental Disorders Version, Fourth Edition substance dependence symptoms and corresponding items asked in the scale are listed in Appendix 3, Tables A3.4 and A3.5.

Potential Confounders

To assess confounding, we began by constructing a directed acyclic graph based on the extant literature (Appendix 3, Figure 1). As we only had one assessment of food addiction, we could not know for certain whether consumption of potentially positively reinforcing foods preceded food addiction. However, we hypothesized that our exposure preceded our outcome and that our potential confounders preceded both our exposure and our outcome. Our assumptions about potential confounders were conservative; if we were incorrect about their timing, we would not have wanted to control for them in our analyses. We operationalized a confounder as a variable that was associated with both the exposure (consumption of potentially positively reinforcing food) and the outcome (food addiction). We examined age, alcohol consumption, smoking, depression, and total energy intake (i.e., calories in kcal) as potential confounders of the relationship between food and food addiction.

Age

As people age, their diets could change; they may eat more of certain types of foods, and less of others. Aging could also decrease the risk of food addiction, as people tend to become less addicted to substances in general as they age. We calculated age based on date of birth and included it as a continuous variable as it met linearity assumptions.

Alcohol consumption

Heavy alcohol consumption could cause less consumption of potentially positively reinforcing foods for two reasons: a) people may require less food if they receive significant calories from alcohol and/or b) people may seek fewer potentially positively reinforcing nutrients, foods, or food groups if they are currently benefiting from the pleasure-inducing effects of alcohol.[53, 54] With regards to food addiction, heavy alcohol consumption does not cause

food addiction per se. However, having a susceptibility to addictive behavior in general could create an association between heavy alcohol consumption and food addiction.[55-58]

According to standards proposed by the Centers for Disease Control and Prevention, heavy alcohol consumption for women is drinking, on average, more than one drink per day. As one drink typically has between 12 and 15 grams of alcohol, we created a three-category variable for alcohol consumption: a) non-drinkers (coded 0, reference); b) >0 to 15 grams of alcohol per day (coded 1); and c) more than 15 grams of alcohol per day (coded 2). The 2006 and 2007 food frequency questionnaires assessed number of drinks per day, including "Beer, regular (1 glass, bottle, can)," "Light beer, e.g., Bud Light (1 glass, bottle, can)," "Red wine (5 oz glass)," "White wine (5 oz. glass)," and "Liquor, e.g., vodka, gin, etc. (1 drink or shot)." Participants were asked to indicate, on average, how often they drank each type of alcoholic beverage in the past year. We calculated grams of alcohol consumed per day as the sum of average drinks per day multiplied by the average amount of alcohol in each type of drink (12.8 g of alcohol for a 12-oz bottle or can of beer, 11.0 g for a 5-oz glass of wine, and 14.0 g for liquor).[59] A study found that alcohol consumption measured by food frequency questionnaire is reliable and valid.[60]

Cigarette smoking

Cigarette smoking may cause less consumption of potentially positively reinforcing foods because smoking could suppress appetite and/or, as with alcohol consumption, people may need less palatable foods if they are currently benefiting from the pleasure-inducing effects of nicotine.[61, 62] Cigarette smoking likely does not cause food addiction. However, having susceptibility to this type of addictive behavior could create an association between cigarette smoking and food addiction.[63, 64] The Nurses' Health Study 2008 and Nurses' Health Study II 2009 ask the following two smoking questions: "Do you currently smoke cigarettes" (n/y), and

"If yes, how many/day?" with response categories 1-4, 5-14, 15-24, 25-34, 35-44, and 45+. We defined smoking as never smoking, (coded 0, reference) currently smoking 1 to 14 cigarettes per day (coded 1), and smoking ≥15 cigarettes per day (coded 2).[65]

Depression

Depression could cause both increased consumption of specific potentially positively reinforcing foods and an increased risk of food addiction, as there is evidence of a positive association between depression and substance-use disorders in general.[66-72] In the 2008 and 2009 Nurses' Health Study questionnaires, nurses were asked whether they have received a physician diagnosis of depression. We categorized nurses as having depression if they marked "yes" (coded 1), and "no" (coded 0, reference) if they left the item blank.

Total energy intake

A high calorie diet would lead to greater consumption of food in general and likely positively reinforcing foods as well. With regards to our outcome, consuming large quantities of food in general could result in addictive eating; for example, high calorie consumption could lead to leptin signaling dysfunction, which could result in overeating.

Derived nutrient variables were additionally adjusted for total energy intake using the residual method.[40] The residual method is advantageous because nutrient residuals offer a measure of nutrient consumption that is not correlated with total energy intake, and this method isolates the variation in nutrient intake caused by the nutrient composition of the diet. Total energy intake is held constant while the amount of the nutrient varies between exposure groups.[73]

We additionally included total energy intake in each model, as caloric intake could have important independent effects on consumption of positively reinforcing foods and food addiction. However, it is possible that consumption of positively reinforcing foods leads to

higher calorie consumption rather than the other way around. If this is the case, then calorie consumption is not a confounder, but rather a mediator; it would be part of the legitimate effect of consumption of food on food addiction, and we would not (necessarily) want to control for it. Our approach of controlling for caloric intake was conservative. However, we conducted sensitivity analyses to examine models with and without control for calorie intake (see Appendix 3, Tables A3.13 and A3.14).

Data analysis

We used logistic regression to determine whether average consumption of potentially positively reinforcing nutrients, foods, and food groups was associated with food addiction. We performed statistical analyses using SAS version 9.3 (SAS Institute Inc, Cary, North Carolina). We used logistic regression because our outcome was dichotomous and reasonably rare. We excluded nurses from analyses if a) they did not fill out the long version of the questionnaire in 2006 or 2007 and therefore did not fill out the food frequency questionnaire in those years or b) they were missing data on any confounder included in the model. We also excluded nurses from food item analyses if they were missing dietary information on that particular food item. We conducted sensitivity analyses examining missing and non-missing nurses. See Appendix 3, Tables A3.7-9 for more details. We evaluated potential confounders by examining the relationships between each potential confounder and food variable (the exposure) and between each potential confounder and food addiction (the outcome) using linear, logistic, and polychotomous regression. If *p*-values were ≤ 0.1, we assumed that these variables could cause confounding. To test whether the potential confounders variables were indeed confounders in our data, we placed each into a model with food and food addiction using multivariable logistic regression. If the adjusted exposure variable beta (log odds ratio) was appreciably different from

the crude (i.e., > 10%), we concluded that these variables were confounders. We indicate which confounders we controlled for in our analyses in the footnotes for each table. We also present odds ratios adjusted for all identified confounders. As food addiction was only measured once in each cohort of nurses, our analyses are cross-sectional.

Results

Descriptive statistics

The analytic sample included 135,055 nurses with complete food addiction data (see Table 1). When stratified by cohort, 1,675 (2.7%) of the earlier and 6,218 (8.5%) of the later cohort met the criteria for food addiction. The nurses were 64 years old and younger in the later cohort and 60 years old and older in the earlier cohort. The majority of women in both cohorts were married, Caucasian, non-smokers, and non-drinkers. Approximately 21% of nurses in the earlier, and 29% of nurses in the later cohort were obese (body mass index $\geq$ 30).

Table 2 shows frequencies and percentages of food addiction diagnosis within potential confounder categories. Food addiction was associated with all of the potential confounders. There were positive relationships between depression and food addiction and between calories and food addiction and inverse relationships between age, smoking, and drinking and food addiction. For example, 8.6% of women aged 45 to 59 had food addiction compared with 1.4% of women aged 75 to 87, and 15.2% of women with depression had food addiction compared with 4.4% of women without.

Potential confounders, age, calories, and alcohol consumption were associated with all nutrient, food item, and food group exposures. Smoking was not associated with consumption of cake, store-bought cookies, cheese, pie, string beans, no/low fat sweet rolls, or the salty foods group. Depression was not associated with bacon, store-bought cookies, fried food at home,

white potatoes, or home baked sweet roll. See Appendix 3, Table A3.6 for more details about the relationships between the potential confounders and exposures.

Hypotheses testing

Nutrients and food addiction

Tables 3a and 3b show crude odds ratios, odds ratios adjusted for variables that met the criteria for confounders, and odds ratios adjusted for all potential confounders, of the associations between nutrients and food addiction. We hypothesized that there would be positive dose response relationships between fat, sodium, and sugar and food addiction. The data supported our hypotheses for total fat, saturated fat, *trans* fat, and sodium and food addiction. For example, after adjusting for confounders, compared with the lowest quintile of consumption (0.11 to 1.26 grams), nurses consuming the highest amount of *trans* fat per day (2.15 to 7.04 grams) had a 59% increased odds of food addiction (95% confidence interval, 1.46, 1.73). Likewise, nurses consuming 2358 to 6817 milligrams of sodium per day had 2.04 times the odds of food addiction compared with nurses consuming 323 to 1680 milligrams of sodium per day (95% confidence interval, 1.86, 2.24).

In contrast, our data did not support our hypothesis regarding sugar intake. Contrary to our hypothesis, we found strong, inverse, dose-response relationships between consumption of grams of total sugar, added sugar, fructose, glucose, sucrose, and food addiction. For example, compared with the lowest quintile of consumption of sucrose per day (0.53 to 24.83 grams), nurses in the highest quintile of consumption (46.81 to 189.92 grams) had a 34% decreased odds of food addiction (95% confidence interval, 0.61, 0.72). We found no relationship between consumption of starch and food addiction. We also found a strong, positive relationship between consumption of artificial sugar and food addiction.

Foods and food addiction

Tables 4 - 11 show crude and adjusted odds ratios for the relationship between foods items and food addiction. We hypothesized that the odds of food addiction would be higher with increased consumption of non-sweet fatty, salty, sweet and starchy foods and lower with increased consumption of fruits and vegetables.

Of the non-sweet fatty foods examined, high compared with low consumption of bacon, French fries, hamburgers, and pizza had the highest odds of food addiction. In particular, high compared with low consumption of French fries and pizza had more than twice the odds of food addiction. The odds ratio of food addiction among nurses who ate fried food outside the home four or more times per week compared with less than once per week was 2.89 (95% CI 1.76-4.73). We did not observe a notable relationship between consumption of peanut butter and food addiction.

Of the salty foods examined, high compared with low consumption of popcorn (full fat and fat free) had the highest odds ratio of food addiction, with fat free popcorn having the highest odds ratio (OR 2.23, 95% CI 1.77-2.80). Consumption of chips and salami were positively associated with food addiction, though only statistically significant in the middle compared with lowest consumption groups.

Of the sweet foods examined, only a subgroup of the foods examined were associated with food addiction. High compared with low consumption of low fat/fat free and store-bought sweet rolls/coffee cakes, candy bars, milk chocolate, and frozen yogurt/sherbet had the strongest associations with food addiction. For example, nurses who consumed two or more bars or packets of milk chocolate per day compared with those who consumed milk chocolate less than three times per month had a 93% higher odds of food addiction (95% CI 1.32-2.82). High

compared with low consumption of pie, muffins, ice cream and homemade sweet rolls/coffee cake were not associated with food addiction, while high compared with low consumption of dark chocolate, homemade cookies, and sugar (teaspoons per day) were inversely associated with food addiction.

Of the starchy foods examined, only white rice had a notable inverse relationship with food addiction. The other starchy foods had no relationship or an inverse relationship with food addiction. All fruits and vegetables examined, with the exception of string beans, were associated with lower odds of food addiction with greater consumption. Contrary to our hypothesis, of the beverages examined, high compared with low consumption of sugary beverages had inverse relationships with food addiction, while high compared with low consumption of sugar-free beverages were associated with higher odds of food addiction.

Based on our observation that consumption of sugary beverages and teaspoons of sugar were inversely associated with food addiction, while consumption of diet drinks, Splenda, and other artificial sugar were positively associated with food addiction, we organized all of the diet foods into Table 11. In this table we included sugar-free drinks, artificial sugar, no/low fat cookies, no/low fat sweet rolls/coffee cake, fat-free popcorn, and sherbet/frozen yogurt. With the exception of no or low fat cookies, high compared with low consumption of all diet, no or low fat food items in this table were associated with greater odds of food addiction.

Food groups and food addiction

Table 12 shows crude and adjusted odds ratios for associations between food groups (non-sweet fatty foods, salty foods, desserts, starchy foods and fruits and vegetables) and food addiction. We hypothesized that consumption of non-sweet fatty foods, salty foods, desserts, and starchy foods would be positively associated with food addiction and that consumption of fruits

and vegetables would be inversely associated with food addiction. We observed positive, (though not strong) dose-response relationships between the consumption of non-sweet fatty and salty foods and food addiction. Compared with the lowest quartile of consumption, nurses who were in the highest quartile of consumption of non-sweet fatty foods had a 40% increased odds of food addiction (95% confidence interval, 1.30, 1.52). However, only the highest compared with the lowest quartile of dessert consumption was associated with higher odds of food addiction (OR 1.17, 95% CI 1.08-1.26). The lowest compared with the referent quartile of dessert consumption was associated with a lower odds of food addiction, while the other quartiles of dessert consumption were not associated with food addiction. In addition, high compared with low consumption of starchy foods was inversely associated with food addiction, as was consumption of fruits and vegetables.

Discussion

Based on previous research, we hypothesized that nutrients, foods, and food groups high in fat, salt, and sugar would be associated with food addiction. While some of our hypotheses were supported, others were not. In support of our hypotheses, we found strong, positive associations between high versus low consumption of fat as a nutrient, several specific non-sweet fatty foods, and the fatty foods group and food addiction. Sodium, certain (though not all) salty foods, and two of the highest quartiles of consumption of the salty food group were also positively associated with food addiction, and fruits and vegetables were inversely associated with food addiction. However, we found that the nutrient sugar, sugary beverages, several sweet foods, and the dessert food group were inversely or not associated with food addiction. These findings did not support our hypotheses or previous existing literature. In post-hoc analyses, we found that grams of artificial sugar, diet beverages, and most diet foods were positively associated with food addiction.

Consistent with prior animal studies, we found that high versus low consumption of fat as a nutrient and certain fatty foods were positively associated with food addiction. Wojnicki et al. (2008)[21] found that rats given intermittent access to shortening induced binge-like eating behaviors. Another study found that a corn oil emulsion diet (a fatty diet) prompted the release of cannabinoid chemicals in the gut of rats that encouraged further fat intake as well as a surge of dopamine release in the brain.[11] Another study found that mice that ate a high fat diet for six months experienced leptin resistance (known to induce obesity) in the brain.[12] Similarly, a study found that after four months of eating a high fat diet, mice experienced leptin resistance.[13] One recent study by Gearhardt et al. (2014)[74] among overweight adults found that higher food addiction scores were associated with higher cravings for fatty foods.

Some of our findings, however, were unexpected. We found inverse relationships between consumption of sugary beverages and grams of sugar consumed per day and food addiction. These results contradict previous animal research, most of which have supported a model of "sugar addiction."[16, 18, 19, 23, 42, 75, 76] We only found three studies in support of our findings, one by Wojnicki et al. (2008) (cited above).[21] In addition to their finding that the fatty diets prompted the release of cannabinoid chemicals in the gut of rats that encouraged further fat intake as well as a surge of dopamine release in the brain, they found that a sucrose solution diet did not have a significant effect on activity in the small intestine or brain; rather, this diet showed a non-significant decrease of dopamine release in the brain. Another study published by Pedram et al. (2013)[25] found that people who met criteria for food addiction consumed more calories from fat and protein than controls. This study also examined carbohydrate consumption, but found no significant differences in consumption between food addicts and controls. More recently, Gearhardt et al (2014)[74] reported that as "liking" ratings for sugary foods increased,

participants reported decreased cravings. Beyond these three studies, which suggest that sugar may not be positively associated with food addiction and/or craving, no other studies support our findings.

There are a few possible explanations for our results. First, people who met the criteria for food addiction may not be addicted to sugar 'in the raw,' as has been observed in rat studies; rather, it may be the combination of sugar, fat and/or salt that creates the positively reinforcing quality of foods and that leads to the most addictive eating. Some of our findings support this 'combination' theory: high versus low consumption of certain sweet fatty desserts had a strong association with food addiction (e.g., candy bars and milk chocolate), but sweet foods that were mostly sugar (i.e., candy without chocolate, sugary beverages, sugar in teaspoons per day) had no association or an inverse association with food addiction. Second, it is possible that people who suffer from food addiction make efforts to replace their consumption of sugary beverages and raw sugar with diet beverages, artificial sweeteners, and low-fat products. We could not test this potential reverse causation in our data, as our analyses were cross-sectional.

As will be reiterated again below, while our analyses generally supported an inverse or no relationship between sugar consumption and food addiction, they do not allow us to conclude that eating large quantities of sugar lowers one's food addiction risk. Nor do they allow us to conclude that eating large amounts of diet food increases our food addiction risk. These analyses are cross-sectional and should be interpreted with caution; future research should carefully examine whether this observed inverse relationship is a reflection of obesity leading to consumption of sugar-free foods and/or whether this relationship manifests differently among weight-stable or diet-stable people.

Limitations and strengths

Our study also has a number of limitations including potential information bias, reverse causation, confounding, and limited generalizability. As the assessments of consumption of potentially positively reinforcing foods and food addiction rely on recall by the study participants, it is possible that there was misclassification of the exposure and/or outcome. In particular, the assessment of diet using the food frequency questionnaire could have led to exposure misclassification.[77, 78] Nurses with unusual diets or who eat foods that are not assessed on the food frequency questionnaire (e.g., cheese puff snacks, macaroni and cheese, fried chicken) may appear to eat fewer potentially positively reinforcing foods than the questionnaire was able to assess. In addition, quantification of intake may not be accurate since participants are asked to recall their usual diet over the past year, which can be a difficult task. As these types of measurement error are likely unrelated to food addiction, our effect estimates may be biased towards the null.

However, it also is possible that current food intake may influence reporting about diet in the past year. If women with food addiction over-report (or exaggerate) and women without food addiction underreport consumption of certain potentially positively reinforcing foods, our effect estimates could be biased away from the null. More likely, however, women with food addiction may under-report consumption of these types of food (e.g., due to cognitive dissonance), which would bias our estimates towards the null.

While there are several potential sources of error in using food frequency questionnaires—including fixed lists of foods, reliance on participants' memories, and the perception of portion size— they have become the standard method for assessing dietary intake in epidemiologic studies. They are appropriate for assessing average intake over an extended period of time, easy for subjects to complete, and readily computerized and inexpensive.[40]

Reproducibility studies of food frequency questionnaires among nurses have found moderate to good correlations ranging from 0.40 for *trans* fatty acids[45] to 0.71 for sucrose.[46] Validity studies comparing food frequency questionnaires to diet records have found Pearson correlation coefficients of 0.53 for total fat, 0.59 for saturated fat and 0.54 for sucrose.[46]

In addition to possible information bias, our effect estimates may be biased due to residual confounding. Our measure of depression may be inaccurate, as we classified a non-response to the physician diagnosis of depression item as a "no." If these non-responders were more likely to be depressed and more likely to have food addiction, our adjusted estimates of the relationship between food consumption and food addiction may appear stronger than they truly are. Although it is unlikely that these non-responders were more likely to be depressed, this type of non-differential misclassification of a confounder could have biased our results away from the null. It is also possible that we incorrectly defined depression, as we did not include depression treatment in our definition. To examine this potential bias, we conducted a sensitivity analysis to examine whether controlling for different definitions of depression had significant effects on our effect estimates. As can be seen in Appendix 3, Table A3.12, different definitions did not significantly change our results.

It is also possible that unknown or unmeasured factors may confound the relationship between food consumption and food addiction. However, we accounted for a wide variety of potential confounders in our analyses, which should minimize this potential bias. Our findings of strong dose-response relationships between several nutrients, food items and food groups and food addiction are unlikely to be explained away by potential misclassification.

Although the Nurses' Health Study cohorts provide an extremely rich source of data, the generalizability of our findings may be limited due to the narrow definition of the population: the

cohorts are comprised of middle-aged to elderly female nurses, most of whom are Caucasian. Thus, the findings may not be generalizable to younger individuals, people with a different socioeconomic status, men or non-white populations. However, as most previous studies on food addiction have been conducted in small, overweight samples, our study should be more generalizable to the general public.

While our data were sourced from two large prospective studies, our analyses were cross-sectional. We do not know whether the consumption of potentially positively reinforcing foods preceded food addiction since we did not begin with a cohort free of food addiction. Some of our results (e.g., the inverse relationships between sugar and food addiction) may be a manifestation of reverse causation or prevalence-incidence bias (also known as Neyman's bias). Our hypothesis that consuming certain types of potentially positively reinforcing food causes food addiction may be inaccurate. Rather, having food addiction may cause nurses to consume certain types of food or change their eating habits (reverse causation). For example, people with food addiction may develop diabetes or another illness, which might lead them to limit consumption of certain foods (e.g., sugar) and replace it with others (e.g., artificial sugar). Or, it is possible that nurses with food addiction who consumed the most positively reinforcing foods died due to secondary illnesses such as cardiovascular disease or diabetes. If this occurred, these individuals would no longer be in our study sample. The individuals remaining would be those with food addiction who have lower levels of consumption of certain foods (prevalence-incidence bias). Some of our exposures (e.g., sugar consumption) may appear protective in our analyses due to these potential biases.[79]

Another possible limitation of our cross-sectional analyses is that because the nurses in the Nurses' Health Study cohorts are well aware that they should not be overweight, they may

make conscientious efforts to maintain a normal weight. As such, the food addiction scale may classify them as having food addiction if they are the "worried well" (e.g., they consume more of certain foods despite knowing that gaining weight will be bad for their health, their eating causes distress most of the time, etc.). In our cross-sectional analyses, we were not able to tease out whether these attitudes and behaviors precede or follow consumption of potentially positively reinforcing foods.

Although cross-sectional analyses are not ideal for determining causality, they are useful in the early stages of new exposure-disease research. As the epidemiology of food addiction is still in its infancy, our current study, which found many strong dose-responses between the consumption of different types of foods and food addiction, have helped illuminate factors that may eventually prove to be important predictors of food addiction.

Our study has a number of strengths. The Nurses' Health Study and Nurses' Health Study II are large cohort studies with biennial response rates of 90%, which limits potential selection bias from loss to follow-up. The large sample size provides ample power to detect main effects and control for many confounders simultaneously. In addition, the prospective design allows for continuous updating of exposures and outcomes, which limits potential misclassification and increases the validity of measures.

Conclusion

This paper is the first to examine which nutrients, foods, and food groups are associated with food addiction in a large epidemiologic study. We found that the consumption of fat—including total, saturated and *trans*— and non-sweet fatty foods (especially fried) are strongly associated with food addiction. While several dessert foods are strongly associated with food addiction, many dessert items, sugar as a nutrient, and the dessert food group are largely unassociated or inversely associated with food addiction. These results are contrary to most of

the literature that supports a "sugar addiction" model. Consumption of some salty foods and sodium appear to be positively associated with food addiction, while starchy foods and fruits and vegetables appear to be inversely associated with food addiction. Our analyses make fundamental contributions to assessing the relationship between a new, potentially important substance-related disorder and the substances at play. While our research lends support to the many previously suspected foods associated with food addiction (fried foods, pizza, etc.), it does not support a model of sugar addiction. Our sugar and artificial sweetener findings may be a result of reverse causation, but our cross-sectional analyses could not test this. Future research should examine whether the consumption of potentially positively reinforcing nutrients, foods, and food groups – especially sugar and sugary foods—predict the incidence of food addiction.

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Tables

Table 1. Characteristics of Nurses in Nurses' Health Studies I and II (n = 135,055)

	NHS I		NHS II	
	n	%	n	%
Food Addiction				
No	59,785	97.3	67,377	91.6
Yes	1,675	2.7	6,218	8.5
Age (years)				
45-59			59,829	81.3
60-74	35,550	57.8	13,766	18.7
75-87	25,910	42.2		
Martial Status				
Never married	0	0.0	3,767	5.2
Separated or divorced	4,703	7.7	9,358	13.0
Widowed	17,430	28.6	2,132	3.0
Married	38,808	63.7	56,678	78.8
Race/ethnicity				
Other/Unknown	4,041	6.6	2,241	3.1
African American	672	1.1	940	1.3
Hispanic	383	0.6	996	1.4
Asian	455	0.7	1,114	1.5
Caucasian	55,909	91.0	68,304	92.8
Smoking (cig/day)				
0	58,095	94.9	68,765	94.0
1 to 14	1,822	3.0	2,478	3.4
15+	1,304	2.1	1,948	2.7
Alcohol Consumption (g/day)				
0	23,148	43.8	21,218	33.7
> 0 to 15	22,277	42.1	33,518	53.2
> 15	7,479	14.1	8,251	13.1
Depression				
No	57,067	92.9	60,260	81.9
Yes	4,393	7.2	13,335	18.1
Body Mass Index				
<=24.9	27,846	45.4	29,978	41.0
25-29.9	20,405	33.2	22,061	30.2
30+	13,146	21.4	21,126	28.9

NHS, Nurses' Health Study; *cig*, cig; *g*, grams

Table 2. The Relationship between Potential Confounders and Food Addiction Among Nurses in 2008 and 2009

		No Food Addiction (n=127,162) n (%)	Food Addiction (n=7,893) n (%)
Age (years)			
	45-59	54,693 (91.4)	5,136 (8.6)
	60-74	46,927 (95.2)	2,389 (4.8)
	75-87	25,542 (98.6)	368 (1.4)
Depression			
	No	112,125 (95.6)	5,202 (4.4)
	Yes	15,037 (84.8)	2,691 (15.2)
Smoking (cig/day)			
	0	119,348 (94.1)	7,512 (5.9)
	1-14	4,105 (95.5)	195 (4.5)
	15+	3,115 (95.8)	137 (4.2)
Alcohol (g/day)			
	0	41,550 (93.7)	2,816 (6.3)
	>0-15	52,662 (94.4)	3,133 (5.6)
	>15	15,179 (96.5)	551 (3.5)
Calories (average kcal/day)		1730 (548)	1864 (595)

yrs, years; *SD,* standard deviation; *cig,* cigarettes; *g,* grams

Table 3a. Association between Consumption of Grams of Fat and Sodium per Day (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

		Crude			**Adjusted for confounders**[a]			**Adjusted for all variables**[b]		
	Cases	OR	95% CI		OR	95% CI		OR	95% CI	
Total fat: 9.6 - 49.95	741	1.00			1.00			1.00		
Total fat: 49.96 - 57.3	993	**1.36**	**1.24**	**1.50**	**1.11**	**1.00**	**1.22**	**1.11**	**1.00**	**1.22**
Total fat: 57.31 - 63.66	1251	**1.73**	**1.58**	**1.90**	**1.22**	**1.11**	**1.35**	**1.23**	**1.11**	**1.35**
Total fat: 63.67 - 71.44	1519	**2.12**	**1.94**	**2.32**	**1.34**	**1.22**	**1.47**	**1.34**	**1.22**	**1.47**
Total fat: 71.45 - 147	1996	**2.85**	**2.62**	**3.11**	**1.72**	**1.57**	**1.89**	**1.74**	**1.59**	**1.91**
Saturated fat: 2.31 - 14.93	772	1.00			1.00			1.00		
Saturated fat: 14.94 - 17.83	1023	**1.34**	**1.22**	**1.48**	**1.09**	**0.99**	**1.20**	**1.10**	**1.00**	**1.21**
Saturated fat: 17.84 - 20.42	1290	**1.72**	**1.57**	**1.88**	**1.25**	**1.14**	**1.38**	**1.26**	**1.15**	**1.38**
Saturated fat: 20.43 - 23.66	1475	**1.99**	**1.82**	**2.18**	**1.32**	**1.20**	**1.45**	**1.34**	**1.22**	**1.47**
Saturated fat: 23.67 - 65.86	1940	**2.67**	**2.45**	**2.91**	**1.59**	**1.46**	**1.74**	**1.63**	**1.49**	**1.78**
Trans fat: 0.11 - 1.26	859	1.00			1.00			1.00		
Trans fat: 1.27 - 1.55	1039	**1.19**	**1.08**	**1.30**	1.05	0.96	1.16	1.06	0.96	1.16
Trans fat: 1.56 - 1.81	1218	**1.46**	**1.34**	**1.60**	**1.16**	**1.06**	**1.27**	**1.17**	**1.07**	**1.28**
Trans fat: 1.82 - 2.14	1425	**1.70**	**1.56**	**1.85**	**1.24**	**1.14**	**1.36**	**1.26**	**1.15**	**1.38**
Trans fat: 2.15 - 7.04	1959	**2.46**	**2.27**	**2.68**	**1.59**	**1.46**	**1.73**	**1.62**	**1.49**	**1.77**
Sodium*: 323 - 1680	681	1.00			1.00			1.00		
Sodium: 1681 - 1908	971	**1.44**	**1.30**	**1.59**	**1.25**	**1.13**	**1.38**	**1.26**	**1.14**	**1.39**
Sodium: 1909 - 2111	1147	**1.72**	**1.56**	**1.89**	**1.32**	**1.20**	**1.46**	**1.33**	**1.20**	**1.46**
Sodium: 2112 - 2357	1580	**2.40**	**2.19**	**2.63**	**1.66**	**1.51**	**1.82**	**1.66**	**1.51**	**1.82**
Sodium: 2358 - 6817	2121	**3.32**	**3.04**	**3.63**	**2.04**	**1.86**	**2.24**	**2.06**	**1.87**	**2.26**

NHS, Nurses' Health Study; *OR*, Odds Ratio; *CI*, Confidence Interval

P-value, test for trend was <0.0001 for all nutrients

[a] Adjusted for calories, age, alcohol and depression (not smoking)

[b] Adjusted for calories, age, alcohol, smoking and depression

* Milligrams

Bold p <0.05

Table 3b. Association between Consumption of Grams of Sugar per Day (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

		Crude			**Adjusted for confounders**			**Adjusted for all variables[c]**		
	Cases	OR	95% CI		OR	95% CI		OR	95% CI	
Total sugar[c]: 8.7 - 72.8	1599	1.00			1.00			1.00		
Total sugar: 72.9 - 87.5	1454	**0.90**	**0.84**	**0.97**	**0.82**	**0.76**	**0.88**	**0.82**	**0.76**	**0.88**
Total sugar: 87.6 - 100.8	1352	**0.84**	**0.78**	**0.90**	**0.72**	**0.67**	**0.78**	**0.72**	**0.67**	**0.78**
Total sugar: 100.9 - 117.5	1106	**0.68**	**0.63**	**0.73**	**0.58**	**0.53**	**0.63**	**0.58**	**0.53**	**0.63**
Total sugar: 117.6 - 370.4	989	**0.60**	**0.56**	**0.66**	**0.48**	**0.44**	**0.52**	**0.48**	**0.44**	**0.52**
Added sugar[c]: 0.01 - 24.02	1228	1.00			1.00			1.00		
Added sugar: 24.03 - 32.76	1348	**1.10**	**1.02**	**1.19**	0.95	0.88	1.04	0.95	0.88	1.04
Added sugar: 32.77 - 41.58	1322	**1.09**	**1.00**	**1.18**	**0.87**	**0.80**	**0.94**	**0.87**	**0.80**	**0.94**
Added sugar: 41.59 - 54.67	1358	**1.11**	**1.03**	**1.20**	**0.87**	**0.80**	**0.94**	**0.87**	**0.80**	**0.94**
Added sugar: 54.68 - 334.92	1244	1.02	0.94	1.11	**0.72**	**0.66**	**0.79**	**0.72**	**0.66**	**0.79**
Fructose[b]: 0.71 - 13.7	1808	1.00			1.00			1.00		
Fructose: 13.71 - 17.67	1512	**0.82**	**0.77**	**0.88**	**0.80**	**0.75**	**0.86**	**0.82**	**0.76**	**0.88**
Fructose: 17.68 - 21.57	1232	**0.66**	**0.61**	**0.71**	**0.65**	**0.60**	**0.70**	**0.66**	**0.61**	**0.71**
Fructose: 21.58 - 26.95	1016	**0.54**	**0.50**	**0.59**	**0.53**	**0.49**	**0.58**	**0.55**	**0.50**	**0.59**
Fructose: 26.96 - 144.6	932	**0.50**	**0.46**	**0.54**	**0.48**	**0.44**	**0.52**	**0.48**	**0.44**	**0.52**
Glucose[b]: 1.08 - 13.45	1775	1.00			1.00			1.00		
Glucose: 13.46 - 16.85	1536	**0.85**	**0.80**	**0.92**	**0.83**	**0.77**	**0.89**	**0.84**	**0.78**	**0.91**
Glucose: 16.86 - 20.28	1259	**0.69**	**0.64**	**0.74**	**0.67**	**0.62**	**0.73**	**0.69**	**0.64**	**0.74**
Glucose: 20.29 - 25.19	1035	**0.57**	**0.52**	**0.61**	**0.55**	**0.51**	**0.60**	**0.56**	**0.52**	**0.61**
Glucose: 25.2 - 150.27	895	**0.49**	**0.45**	**0.53**	**0.48**	**0.44**	**0.52**	**0.48**	**0.44**	**0.52**

		Crude			Adjusted for confounders			Adjusted for all variables[c]		
	Cases	OR	95% CI		OR	95% CI		OR	95% CI	
Sucrose[c]: 0.53 - 24.83	1416	1.00			1.00			1.00		
Sucrose: 24.84 - 31.47	1429	1.01	0.93	1.09	**0.90**	**0.83**	**0.97**	**0.90**	**0.83**	**0.97**
Sucrose: 31.48 - 37.96	1278	**0.89**	**0.83**	**0.97**	**0.76**	**0.70**	**0.83**	**0.76**	**0.70**	**0.83**
Sucrose: 37.97 - 46.8	1220	**0.86**	**0.79**	**0.93**	**0.72**	**0.66**	**0.78**	**0.72**	**0.66**	**0.78**
Sucrose: 46.81 - 189.92	1157	**0.81**	**0.75**	**0.88**	**0.66**	**0.61**	**0.72**	**0.66**	**0.61**	**0.72**
Starch[c]: 0.9 - 60.4	1054	1.00			1.00			1.00		
Starch: 60.5 - 71.8	1113	1.05	0.96	1.14	0.97	0.89	1.06	0.97	0.89	1.06
Starch: 71.9 - 81.8	1262	**1.21**	**1.11**	**1.32**	1.01	0.92	1.10	1.01	0.92	1.10
Starch: 81.9 - 94.2	1405	**1.36**	**1.25**	**1.47**	1.01	0.92	1.10	1.01	0.92	1.10
Starch: 94.3 - 251.7	1666	**1.62**	**1.49**	**1.75**	1.06	0.98	1.15	1.06	0.98	1.15
Artificial sugar[a]: 0.02	761	1.00			1.00			1.00		
Artificial sugar: 0.03 - 0.26	651	**1.39**	**1.25**	**1.54**	**1.47**	**1.32**	**1.63**	**1.43**	**1.29**	**1.60**
Artificial sugar: 0.27 - 2.39	1285	**2.15**	**1.96**	**2.35**	**1.92**	**1.75**	**2.11**	**1.91**	**1.74**	**2.10**
Artificial sugar: 2.40 - 12.02	1691	**2.88**	**2.64**	**3.15**	**2.46**	**2.25**	**2.69**	**2.39**	**2.18**	**2.61**
Artificial sugar: 12.03 - 147.63	2112	**3.67**	**3.37**	**3.99**	**3.26**	**3.00**	**3.55**	**3.01**	**2.76**	**3.28**

NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

P-value, test for trend was <0.05 for all nutrients

[a] Adjusted for calories and age (not alcohol, smoking, or depression); artificial sugar includes intake of saccharine, aspartame, and sucralose

[b] Adjusted for calories, age, alcohol and smoking (not depression)

[c] Adjusted for calories, age, alcohol, smoking, and depression

* Milligrams

Bold p <0.05

Table 4. Association Between Fatty Foods (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

Fatty foods	Level of Consumption	Cases	Crude OR	95% CI	Adjusted for confounders OR	95% CI	Adjusted for all variables OR	95% CI
Bacon[c]	<3/month	5287	1.00		1.00		1.00	
	1-4/week	1368	**1.13**	**1.06, 1.20**	**1.07**	**1.00, 1.14**	**1.08**	**1.02, 1.16**
	5+/week	79	**1.81**	**1.43, 2.29**	**1.39**	**1.07, 1.82**	**1.50**	**1.14, 1.96**
Butter[b]	<3/month	3508	1.00		1.00		1.00	
	1/week to 2-3/day	2766	**1.07**	**1.01, 1.12**	1.04	0.99, 1.10	1.05	0.99, 1.11
	4+/day	47	**1.98**	**1.46, 2.68**	**1.96**	**1.40, 2.77**	**2.01**	**1.42, 2.82**
Cheese[e]	<3/month	1125	1.00		1.00		1.00	
	1/week to 2-3/day	5538	**1.28**	**1.20, 1.36**	0.98	0.91, 1.05	1.01	0.95, 1.09
	4+/day	37	**3.31**	**2.33, 4.71**	**1.53**	**0.99, 2.37**	1.50	0.96, 2.34
Fries[e]	<3/month	5184	1.00		1.00		1.00	
	1-4/week	1484	**1.90**	**1.79, 2.02**	**1.30**	**1.22, 1.39**	**1.26**	**1.18, 1.35**
	5+/week	46	**4.87**	**3.51, 6.74**	**2.48**	**1.68, 3.67**	**2.30**	**1.55, 3.42**
Hamburgers (full fat)[e]	<3/month	4683	1.00		1.00		1.00	
	1/week	1197	**1.71**	**1.60, 1.83**	**1.39**	**1.30, 1.50**	**1.38**	**1.28, 1.48**
	2+/week	387	**2.80**	**2.51, 3.13**	**1.95**	**1.72, 2.20**	**1.82**	**1.60, 2.06**
Hamburgers (lean)[b]	<3/month	3730	1.00		1.00		1.00	
	1-4/week	2700	**1.39**	**1.32, 1.47**	**1.19**	**1.12, 1.25**	**1.19**	**1.13, 1.26**
	5+/week	46	**3.35**	**2.44, 4.59**	**1.78**	**1.18, 2.70**	**1.79**	**1.18, 2.71**
Fried food at home[g]	<1/week	4381	1.00		1.00		1.00	
	4-6/week	2311	**1.16**	**1.10, 1.23**	**1.13**	**1.07, 1.19**	**1.15**	**1.09, 1.21**
	daily	39	**2.90**	**2.06, 4.07**	**2.60**	**1.80, 3.75**	**2.56**	**1.76, 3.72**
Fried food away from home[e]	<1/week	6072	1.00		1.00		1.00	
	1-3/week	587	**2.29**	**2.09, 2.50**	**1.74**	**1.58, 1.92**	**1.69**	**1.53, 1.86**
	4+/week	25	**4.89**	**3.14, 7.63**	**2.89**	**1.76, 4.73**	**2.68**	**1.63, 4.40**

Fatty foods	Level of Consumption	Cases	Crude OR	95% CI	Adjusted for confounders OR	95% CI	Adjusted for all variables OR	95% CI
Peanut butter[d]	<3/month	2977	1.00		1.00		1.00	
	1/week to 2-3/day	3700	**1.13**	**1.07, 1.19**	**1.08**	**1.03, 1.14**	0.99	0.94, 1.05
	4+/day	16	1.48	0.89, 2.47	1.52	0.88, 2.61	1.33	0.77, 2.30
Pizza[c]	<3/month	4090	1.00		1.00		1.00	
	1-4/week	2598	**1.80**	**1.71, 1.89**	**1.18**	**1.12, 1.25**	**1.17**	**1.10, 1.24**
	5+/week	51	**5.47**	**4.00, 7.46**	**2.72**	**1.85, 4.00**	**2.37**	**1.59, 3.53**
Steak[c]	<3/month	3229	1.00		1.00		1.00	
	1-4/week	3373	**1.31**	**1.24, 1.37**	1.04	0.99, 1.10	**1.06**	**1.01, 1.12**
	5+/week	78	**2.74**	**2.15, 3.48**	**1.49**	**1.12, 1.98**	**1.56**	**1.17, 2.08**

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**

[d] Adjusted for alcohol and depression **(not age, calories, or smoking)**

[e] Adjusted for age, calories, and depression **(not smoking or alcohol)**

[g] Adjusted for age and calories **(not alcohol, smoking, or depression)**

Bold $p < 0.05$

Table 5. Association Between Salty Foods (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

			Crude		Adjusted for confounders		Adjusted for all variables	
Salty foods	**Level of Consumption**	**Cases**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Crackers[b]	<3/month	3141	1.00		1.00		1.00	
	1/week to 2-3/day	3502	**1.08**	**1.03, 1.14**	1.00	0.95, 1.06	1.00	0.95, 1.06
	4+/day	36	**1.84**	**1.30, 2.60**	1.16	0.77, 1.74	1.18	0.78, 1.77
Peanuts[a]	<3/month	4946	1.00		1.00		1.00	
	1/week to 1/day	1692	1.03	0.98, 1.09	**0.94**	**0.88, 1.00**	**0.94**	**0.88, 1.00**
	2+/day	44	**1.48**	**1.09, 2.02**	1.22	0.84, 1.78	1.22	0.84, 1.78
Popcorn (full fat)[b]	<3/month	5546	1.00		1.00		1.00	
	1-6/week	966	**1.62**	**1.51, 1.74**	**1.21**	**1.12, 1.31**	**1.22**	**1.13, 1.31**
	1+/day	35	**2.69**	**1.89, 3.85**	**1.56**	**1.02, 2.38**	**1.59**	**1.04, 2.42**
Popcorn (fat free)[g]	<3/month	4957	1.00		1.00		1.00	
	1-6/week	1507	**1.76**	**1.65, 1.86**	**1.42**	**1.33, 1.51**	**1.40**	**1.32, 1.50**
	1+/day	105	**3.00**	**2.43, 3.69**	**2.23**	**1.77, 2.80**	**2.20**	**1.74, 2.78**
Potato/corn chips[c]	<3/month	3993	1.00		1.00		1.00	
	1-6/week	2644	**1.46**	**1.39, 1.54**	**1.08**	**1.02, 1.14**	**1.11**	**1.05, 1.17**
	1+/day	94	**1.87**	**1.51, 2.32**	1.21	0.95, 1.54	**1.29**	**1.01, 1.65**
Pretzels[g]	<3/month	4746	1.00		1.00		1.00	
	1/week to 1/day	1912	**1.29**	**1.23, 1.37**	1.04	0.99, 1.11	**1.10**	**1.03, 1.16**
	2+/day	36	**1.68**	**1.19, 2.36**	1.32	0.91, 1.92	1.31	0.90, 1.92
Salami/bologna[d]	<3/month	5575	1.00		1.00		1.00	
	1-4/week	1047	**1.33**	**1.24, 1.42**	**1.27**	**1.18, 1.37**	**1.18**	**1.10, 1.27**
	5+/week	57	**1.48**	**1.13, 1.95**	1.27	0.94, 1.72	1.17	0.86, 1.59

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for age, calories, alcohol, smoking, and depression

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**

[d] Adjusted for alcohol and depression **(not age, calories, or smoking)**

[g] Adjusted for age and calories **(not alcohol, smoking, or depression)**

Bold $p < 0.05$

Table 6. Association Between Sweet Foods (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

Sweet foods (1)	Level of Consumption	Cases	Crude		Adjusted for confounders		Adjusted for all variables	
			OR	95% CI	OR	95% CI	OR	95% CI
Cake[c]	<3/month	5759	1.00		1.00		1.00	
	1-4/week	915	**1.36**	**1.27, 1.46**	**1.16**	**1.07, 1.26**	**1.18**	**1.09, 1.28**
	5+/week	30	**1.51**	**1.04, 2.19**	1.05	0.64, 1.70	1.12	0.69, 1.82
Pie[b]	<3/month	6151	1.00		1.00		1.00	
	1/week	429	**1.19**	**1.07, 1.31**	1.08	0.96, 1.20	1.08	0.97, 1.21
	2+/week	95	**1.37**	**1.11, 1.69**	1.19	0.93, 1.53	1.19	0.92, 1.53
Cookies (homemade)[a]	<3/month	5186	1.00		1.00		1.00	
	1/week to 1/day	1373	0.97	0.91, 1.03	**0.89**	**0.84, 0.95**	**0.89**	**0.84, 0.95**
	2+/day	31	**0.64**	**0.45, 0.92**	0.73	0.49, 1.10	0.73	0.49, 1.10
Cookies (no/low fat)[b]	<3/month	5648	1.00		1.00		1.00	
	1/week to 1/day	734	**1.15**	**1.06, 1.24**	**1.23**	**1.13, 1.33**	**1.22**	**1.12, 1.33**
	2+/day	29	0.71	0.49, 1.02	1.00	0.67, 1.51	1.00	0.67, 1.51
Cookies (store)[c]	<3/month	4563	1.00		1.00		1.00	
	1/week to 1/day	1904	**1.11**	**1.05, 1.18**	**1.12**	**1.06, 1.19**	**1.11**	**1.05, 1.18**
	2+/day	99	0.81	0.66, 0.99	0.99	0.79, 1.25	0.96	0.76, 1.21
Donuts[b]	<3/month	6064	1.00		1.00		1.00	
	1-4/week	575	**1.46**	**1.34, 1.60**	**1.26**	**1.14, 1.38**	**1.27**	**1.15, 1.40**
	5+/week	32	**1.93**	**1.34, 2.79**	1.43	0.91, 2.26	1.49	0.95, 2.36
Muffins[b]	<3/month	5294	1.00		1.00		1.00	
	1-6/week	1337	**1.33**	**1.25, 1.41**	0.95	0.89, 1.02	0.96	0.90, 1.03
	1+/day	42	**1.77**	**1.29, 2.43**	0.94	0.62, 1.42	0.95	0.63, 1.45
Sweet roll/coffee cake (homemade)[f]	<3/month	6234	1.00		1.00		1.00	
	1/week	265	**1.14**	**1.01, 1.30**	0.88	0.77, 1.02	0.90	0.78, 1.04
	2+/week	61	1.05	0.81, 1.36	0.83	0.61, 1.13	0.87	0.64, 1.19

Sweet foods (1)	Level of Consumption	Cases	Crude OR	Crude 95% CI	Adjusted for confounders OR	Adjusted for confounders 95% CI	Adjusted for all variables OR	Adjusted for all variables 95% CI
Sweet roll/coffee cake (no/low fat)[b]	<3/month	6315	1.00		1.00		1.00	
	1/week	192	**1.46**	**1.26, 1.70**	**1.28**	**1.08, 1.51**	**1.29**	**1.09, 1.52**
	2+/week	71	**1.55**	**1.22, 1.98**	**1.42**	**1.08, 1.86**	**1.43**	**1.08, 1.88**
Sweet roll/coffee cake (store)[b]	<3/month	5835	1.00		1.00		1.00	
	1/week	577	**1.40**	**1.28, 1.53**	**1.25**	**1.13, 1.37**	**1.26**	**1.14, 1.39**
	2+/week	215	**1.49**	**1.29, 1.71**	**1.40**	**1.19, 1.64**	**1.40**	**1.19, 1.65**

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for age, calories, alcohol, smoking, and depression

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**

[f] Adjusted for age, calories, alcohol, and smoking **(not depression)**

Bold $p < 0.05$

Table 7. Association Between Sweet Foods (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

Sweet foods (2)	Level of Consumption	Cases	Crude OR	Crude 95% CI	Adjusted for confounders OR	Adjusted for confounders 95% CI	Adjusted for all variables OR	Adjusted for all variables 95% CI
Candy bar[c]	<3/month	5511	1.00		1.00		1.00	
	1-4/week	1052	**1.90**	**1.78, 2.04**	**1.51**	**1.40, 1.63**	**1.51**	**1.40, 1.63**
	5+/week	88	**2.49**	**1.99, 3.12**	**1.62**	**1.24, 2.11**	**1.73**	**1.32, 2.27**
Candy w/o chocolate[b]	<3/month	5293	1.00		1.00		1.00	
	1/week to 1/day	1265	1.31	1.23, 1.40	**1.19**	**1.11, 1.27**	**1.20**	**1.12, 1.28**
	2+/day	47	1.27	0.95, 1.72	1.20	0.86, 1.69	1.22	0.87, 1.72
Dark chocolate[b]	<3/month	5118	1.00		1.00		1.00	
	1/week to 1/day	1525	1.17	1.10, 1.24	**0.91**	**0.86, 0.97**	**0.91**	**0.86, 0.97**
	2+/day	32	1.28	0.89, 1.83	0.75	0.49, 1.14	0.74	0.49, 1.13
Milk chocolate[c]	<3/month	4247	1.00		1.00		1.00	
	1/week to 1/day	2431	**1.72**	**1.63, 1.81**	**1.35**	**1.28, 1.43**	**1.35**	**1.28, 1.43**
	2+/day	51	**3.38**	**2.51, 4.56**	**1.93**	**1.32, 2.82**	**2.05**	**1.39, 3.01**
Ice cream[a]	<3/month	4860	1.00		1.00		1.00	
	1-6/week	1554	1.07	1.01, 1.14	0.99	0.93, 1.06	0.99	0.93, 1.06
	1+/day	61	1.09	0.84, 1.41	0.96	0.71, 1.30	0.96	0.71, 1.30
Sherbet/frozen yogurt[b]	<3/month	4834	1.00		1.00		1.00	
	1-6/week	1417	**1.14**	**1.07, 1.21**	**1.10**	**1.03, 1.17**	**1.09**	**1.02, 1.16**
	1+/day	123	**1.51**	**1.26, 1.82**	**1.35**	**1.10, 1.66**	**1.34**	**1.09, 1.64**
Sugar (tsp)[a]	0 to 1/day	5741	1.00		1.00		1.00	
	2 to 4/day	535	**0.75**	**0.68, 0.82**	**0.66**	**0.60, 0.73**	**0.66**	**0.60, 0.73**
	5+/day	107	1.02	0.84, 1.24	0.85	0.69, 1.05	0.85	0.69, 1.05

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for age, calories, alcohol, smoking, and depression

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**

Bold $p < 0.05$

Table 8. Association Between Starchy Foods (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

Starchy foods	Level of Consumption	Cases	Crude OR	95% CI	Adjusted for confounders OR	95% CI	Adjusted for all variables OR	95% CI
White bread[a]	<3/month	3991	1.00		1.00		1.00	
	1/week to 2-3/day	2500	**1.11**	**1.05, 1.17**	1.03	0.97, 1.09	1.03	0.97, 1.09
	4+/day	29	**1.81**	**1.23, 2.66**	1.31	0.81, 2.11	1.31	0.81, 2.11
Pancakes/Waffles[b]	<3/month	5816	1.00		1.00		1.00	
	1-4/week	849	**1.11**	**1.03, 1.19**	**0.88**	**0.81, 0.95**	**0.87**	**0.80, 0.94**
	5+/week	31	**1.64**	**1.14, 2.38**	1.09	0.72, 1.66	1.09	0.72, 1.65
White potatoes[f]	<3/month	2645	1.00		1.00		1.00	
	1-6/week	4021	1.01	0.96, 1.07	**0.89**	**0.84, 0.94**	**0.90**	**0.86, 0.95**
	1+/day	70	1.19	0.93, 1.53	0.93	0.70, 1.25	0.97	0.72, 1.31
White rice[a]	<3/month	5054	1.00		1.00		1.00	
	1-4/week	1624	**1.15**	**1.09, 1.22**	**0.89**	**0.83, 0.94**	**0.89**	**0.83, 0.94**
	5+/week	39	0.93	0.67, 1.29	**0.50**	**0.33, 0.75**	**0.50**	**0.33, 0.75**
Pasta[b]	<3/month	2335	1.00		1.00		1.00	
	1-6/week	4358	**1.18**	**1.12, 1.24**	**0.86**	**0.81, 0.91**	**0.86**	**0.81, 0.91**
	1+/day	44	**2.39**	**1.74, 3.28**	1.10	0.73, 1.66	1.05	0.69, 1.59

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for age, calories, alcohol, smoking, and depression

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[f] Adjusted for age, calories, alcohol, and smoking **(not depression)**

Bold $p < 0.05$

Table 9. Association Between Fruits and Vegetables (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

			Crude		Adjusted for confounders		Adjusted for all variables	
Fruits and Vegetables	**Level of Consumption**	**Cases**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Apples[a]	<3/month	2684	1.00		1.00		1.00	
	1/week to 1/day	3962	0.99	0.94, 1.04	**0.87**	**0.83, 0.92**	**0.87**	**0.83, 0.92**
	2+/day	55	**1.44**	**1.09, 1.91**	0.91	0.67, 1.25	0.91	0.67, 1.25
Avocado[a]	<3/month	5869	1.00		1.00		1.00	
	1-4/week	735	0.96	0.89, 1.04	**0.83**	**0.76, 0.90**	**0.83**	**0.76, 0.90**
	5+/week	40	0.94	0.68, 1.29	0.74	0.51, 1.06	0.74	0.51, 1.06
Beans/lentils[a]	<3/month	4036	1.00		1.00		1.00	
	1-6/week	2614	**1.12**	**1.06, 1.18**	**0.88**	**0.83, 0.93**	**0.88**	**0.83, 0.93**
	1+/day	44	**1.36**	**1.00, 1.85**	**0.67**	**0.46, 1.00**	**0.67**	**0.46, 1.00**
Broccoli[b]	<3/month	2357	1.00		1.00		1.00	
	1/week to 1/day	4374	**1.11**	**1.06, 1.17**	0.98	0.93, 1.03	0.97	0.92, 1.02
	2+/day	19	**1.84**	**1.14, 2.95**	1.30	0.77, 2.21	1.28	0.75, 2.18
Grapes[f]	<3/month	4974	1.00		1.00		1.00	
	1/week to 1/day	1688	**0.76**	**0.71, 0.80**	**0.74**	**0.70, 0.78**	**0.75**	**0.71, 0.80**
	2+/day	25	1.29	0.86, 1.95	0.84	0.50, 1.39	0.87	0.52, 1.45
String beans[c]	<3/month	2947	1.00		1.00		1.00	
	1-4/week	3535	**1.07**	**1.02, 1.13**	**0.93**	**0.88, 0.98**	**0.94**	**0.89, 1.00**
	5+/week	216	**2.03**	**1.75, 2.34**	**1.33**	**1.13, 1.56**	**1.35**	**1.15, 1.59**

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for age, calories, alcohol, smoking, and depression

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**

[f] Adjusted for age, calories, alcohol, and smoking **(not depression)**

Bold $p < 0.05$

Table 10. Association Between Beverages (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

Beverages	Level of Consumption	Cases	Crude OR	Crude 95% CI	Adjusted for confounders OR	Adjusted for confounders 95% CI	Adjusted for all variables OR	Adjusted for all variables 95% CI
Carbonated beverage with caffeine and sugar[a]	<3/month	5990	1.00		1.00		1.00	
	1/week to 1/day	601	0.97	0.89, 1.06	**0.73**	**0.67, 0.81**	**0.73**	**0.67, 0.81**
	2+/day	59	1.08	0.83, 1.41	**0.57**	**0.42, 0.76**	**0.57**	**0.42, 0.76**
Carbonated beverage with sugar[a]	<3/month	6224	1.00		1.00		1.00	
	1-4/week	351	**0.89**	**0.79, 0.99**	**0.72**	**0.64, 0.81**	**0.72**	**0.64, 0.81**
	5+/week	72	1.19	0.94, 1.52	0.83	0.63, 1.07	0.83	0.63, 1.07
Other sugared beverages[a]	<3/month	5817	1.00		1.00		1.00	
	1/week to 1/day	784	**0.76**	**0.71, 0.83**	**0.63**	**0.58, 0.68**	**0.63**	**0.58, 0.68**
	2+/day	70	0.87	0.68, 1.11	**0.50**	**0.38, 0.66**	**0.50**	**0.38, 0.66**
Orange juice[c]	<3/month	5264	1.00		1.00		1.00	
	1/week to 1/day	935	**0.65**	**0.60, 0.69**	**0.66**	**0.62, 0.71**	**0.67**	**0.62, 0.73**
	2+/day	23	**0.60**	**0.40, 0.91**	**0.54**	**0.34, 0.85**	**0.49**	**0.30, 0.79**
Low-calorie beverage with caffeine[i]	<3/month	3052	1.00		1.00		1.00	
	1/week to 2-3/day	3392	**2.21**	**2.10, 2.32**	**1.75**	**1.66, 1.84**	**1.74**	**1.65, 1.84**
	4+/day	281	**4.73**	**4.14, 5.40**	**2.71**	**2.35, 3.13**	**2.83**	**2.45, 3.27**
Other low-calorie beverage without caffeine[i]	<3/month	4103	1.00		1.00		1.00	
	1/week to 2-3/day	2451	**1.78**	**1.69, 1.88**	**1.66**	**1.57, 1.75**	**1.63**	**1.55, 1.72**
	4+/day	84	**3.73**	**2.95, 4.72**	**2.34**	**1.82, 3.01**	**2.38**	**1.85, 3.07**
Water[b]	<3/month	633	1.00		1.00		1.00	
	1-6/week	1021	**0.87**	**0.79, 0.97**	**0.89**	**0.80, 0.99**	**0.88**	**0.79, 0.98**
	1+/day	5053	**0.81**	**0.75, 0.89**	**0.89**	**0.81, 0.98**	**0.87**	**0.80, 0.95**

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for age, calories, alcohol, smoking, and depression

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**

[i] Adjusted for age, depression, and alcohol **(not calories or smoking)**

Bold $p < 0.05$

Table 11. Association Between Diet Foods (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

			Crude		Adjusted for confounders		Adjusted for all variables	
Diet foods	**Level of Consumption**	**Cases**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Cookies (no/low fat)[b]	<3/month	5648	1.00		1.00		1.00	
	1/week to 1/day	734	**1.15**	**1.06, 1.24**	**1.23**	**1.13, 1.33**	**1.22**	**1.12, 1.33**
	2+/day	29	0.71	0.49, 1.02	1.00	0.67, 1.51	1.00	0.67, 1.51
Low-calorie beverage with caffeine[i]	<3/month	3052	1.00		1.00		1.00	
	1/week to 2-3/day	3392	**2.21**	**2.10, 2.32**	**1.75**	**1.66, 1.84**	**1.74**	**1.65, 1.84**
	4+/day	281	**4.73**	**4.14, 5.40**	**2.71**	**2.35, 3.13**	**2.83**	**2.45, 3.27**
Other low-calorie beverage without caffeine[i]	<3/month	4103	1.00		1.00		1.00	
	1/week to 2-3/day	2451	**1.78**	**1.69, 1.88**	**1.66**	**1.57, 1.75**	**1.63**	**1.55, 1.72**
	4+/day	84	**3.73**	**2.95, 4.72**	**2.34**	**1.82, 3.01**	**2.38**	**1.85, 3.07**
Popcorn (fat free)[g]	<3/month	4957	1.00		1.00		1.00	
	1-6/week	1507	**1.76**	**1.65, 1.86**	**1.42**	**1.33, 1.51**	**1.40**	**1.32, 1.50**
	1+/day	105	**3.00**	**2.43, 3.69**	**2.23**	**1.77, 2.80**	**2.20**	**1.74, 2.78**
Sherbet/frozen yogurt[b]	<3/month	4834	1.00		1.00		1.00	
	1-6/week	1417	**1.14**	**1.07, 1.21**	**1.10**	**1.03, 1.17**	**1.09**	**1.02, 1.16**
	1+/day	123	**1.51**	**1.26, 1.82**	**1.35**	**1.10, 1.66**	**1.34**	**1.09, 1.64**
Splenda[j]	<3/month	3856	1.00		1.00		1.00	
	1/week to 2-3/day	2374	**1.82**	**1.72, 1.91**	**1.67**	**1.58, 1.76**	**1.63**	**1.54, 1.72**
	4+/day	421	**2.65**	**2.38, 2.95**	**2.16**	**1.93, 2.41**	**2.04**	**1.82, 2.29**
Sweet roll, coffee cake (no/low fat)[b]	<3/month	6315	1.00		1.00		1.00	
	1/week	192	**1.46**	**1.26, 1.70**	**1.28**	**1.08, 1.51**	**1.29**	**1.09, 1.52**
	2+/week	71	**1.55**	**1.22, 1.98**	**1.42**	**1.08, 1.86**	**1.43**	**1.08, 1.88**
Artificial sweetener[h]	<3/month	4504	1.00		1.00		1.00	
	1/week to 2-3/day	1844	**1.56**	**1.47, 1.65**	**1.63**	**1.54, 1.73**	**1.55**	**1.46, 1.64**
	4+/day	292	**2.14**	**1.89, 2.43**	**2.18**	**1.92, 2.47**	**1.95**	**1.70, 2.23**

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**

[g] Adjusted for age and calories **(not alcohol, smoking, or depression)**

[h] Adjusted for age **(not calories, alcohol, smoking, or depression)**

[i] Adjusted for age, depression, and alcohol **(not calories or smoking)**

[j] Adjusted for age and depression **(not calories, smoking, or alcohol)**

Bold $p < 0.05$

Table 12. Association Between Quartiles of Food Group Consumption (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II

		Crude		Adjusted for confounders		Adjusted for all variables	
Level of consumption*	**Cases**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Fatty foods[c]							
0 to 2 (ref)	1337	1.00		1.00		1.00	
3	1025	**1.17**	**1.08, 1.27**	1.05	0.96, 1.15	1.06	0.97, 1.15
4 to 5	1922	**1.29**	**1.20, 1.39**	1.06	0.98, 1.14	1.06	0.99, 1.15
6 to 23	2533	**2.12**	**1.98, 2.27**	**1.40**	**1.30, 1.52**	**1.43**	**1.32, 1.55**
Salty foods[b]							
0 (ref)	1071	1.00		1.00		1.00	
1	1676	**1.15**	**1.06, 1.24**	1.06	0.97, 1.15	1.07	0.99, 1.16
2	1684	**1.39**	**1.28, 1.50**	**1.14**	**1.05, 1.24**	**1.17**	**1.08, 1.27**
3 to 10	2363	**1.81**	**1.68, 1.95**	**1.24**	**1.14, 1.34**	**1.31**	**1.20, 1.42**
Desserts[a]							
0 (ref)	1401	1.00		1.00		1.00	
1	1194	**0.91**	**0.84, 0.98**	**0.89**	**0.82, 0.97**	**0.89**	**0.82, 0.97**
2 to 3	1976	1.02	0.95, 1.10	0.96	0.89, 1.04	0.96	0.89, 1.04
4 to 21	2241	**1.41**	**1.32, 1.51**	**1.17**	**1.08, 1.26**	**1.17**	**1.08, 1.26**
Starchy foods[c]							
0 (ref)	1013	1.00		1.00		1.00	
1	1479	0.98	0.91, 1.07	**0.92**	**0.84, 1.00**	**0.92**	**0.84, 1.00**
2	1805	1.02	0.95, 1.11	**0.84**	**0.77, 0.91**	**0.84**	**0.78, 0.92**
3 to 9	2485	**1.17**	**1.08, 1.26**	**0.79**	**0.73, 0.86**	**0.80**	**0.74, 0.87**
Fruits and vegetables[a]							
0 to 1 (ref)	1773	1.00		1.00		1.00	
2	1476	1.02	0.95, 1.10	0.94	0.87, 1.01	0.94	0.87, 1.01
3	1537	1.03	0.96, 1.10	**0.88**	**0.81, 0.94**	**0.88**	**0.81, 0.94**
4 to 10	2015	1.05	0.99, 1.12	**0.78**	**0.72, 0.84**	**0.78**	**0.72, 0.84**

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval
* Food groups are a summation of food items. Each food item is a 3-level variable. Level 0 = little to no consumption, 1 = some normal consumption, and 2 = abnormal amount of consumption.

Fatty foods: Bacon, French fries, Hamburger, Other cheese, e.g., American, cheddar, etc., plain or as part of a dish, Peanut butter, Peanuts, Pizza, Popcorn (regular), Potato chips or corn/tortilla chips, Pure butter, Salami, bologna, or other processed meat sandwiches, Steak (beef or lamb as a main dish, e.g., steak, roast), How often do you eat fried or sautéed food at home? (Exclude "Pam"-type spray), How often do you eat deep fried chicken, fish, shrimp, clams or onion rings away from home?

Salty foods: Crackers, regular or low fat e.g., Triscuits, Ritz, Peanuts, Popcorn (fat free or light, regular), Potato chips or corn/tortilla chips, Pretzels, Salami, bologna, or other processed meat sandwiches

Desserts: Cake, homemade or ready made, Candy bars, e.g., Snickers, Milky Way, Reeses, Candy without chocolate, Cookies or brownies (fat free or reduced fat, other ready made, home baked), Dark chocolate, e.g., Hershey's Dark or Dove Dark, Doughnuts, Frozen yogurt, sherbet or low-fat ice cream, Milk chocolate (bar or pack), e.g., Hershey's, M&M's, Muffins or biscuits, Pie, homemade or ready made, Regular ice cream, Sweet roll, coffee cake, or other pastry (fat free or reduced fat, other ready made, home baked)

Starchy foods: Pancakes or waffles, Pasta, e.g., spaghetti, noodles, couscous, etc., White bread, including pita, White potatoes, White rice

Fruits and Vegetables: Fresh apples or pears, Avocado, Beans or lentils, baked, dried or soup, Broccoli, Raisins or grapes, String beans

[a] = Adjusted for calories, age, alcohol, smoking, and depression
[b] = Adjusted for calories, age and alcohol **(not smoking or depression)**
[c] = Adjusted for calories, age, alcohol, and depression **(not smoking)**

Bold $p < 0.05$

Appendix 3

Part 1. Exclusions, Food Group Decisions, Scales, Substance-Use Dependence Criteria, Directed Acyclic Graph, Determining Confounders

Table A3.1. Nurses with Insufficient Information to Make a Food Addiction Diagnosis

	n	%
Missing 7/7 symptoms: Answered 0/7 questions		
Not missing	139,148	86.54
Missing	21,648	13.46
Missing 6/7 symptoms: Answered 1/7		
Not missing	160,709	99.95
Missing	87	0.05
Missing 5/7 symptoms: Answered 2/7		
Not missing	160,677	99.93
Missing	119	0.07
Missing 4/7 symptoms: Answered 3/7, but don't have yeses or only have yeses to 1 or 2 out of 3 questions		
Not missing	160,752	99.97
Missing	44	0.03
Missing 3/7 symptoms: Answered 4/7, but don't have yeses or only have yeses to 1 or 2 out of 4 questions		
Not missing	160,727	99.96
Missing	69	0.04
Missing 2/7 symptoms: Answered 5/7, but only have yeses to 1 or 2 out of 5 questions		
Not missing	160,420	99.77
Missing	376	0.23
Missing 1/7 symptoms: Answered 6/7, but only have yeses to 1 or 2 out of 5 questions		
Not missing	160,796	98.5
Missing	2,416	1.5
Insufficient symptom information		
Not missing	136,037	84.6
Missing	24,759	15.4
Missing 1/2 clinical symptoms: Answered 1/2 questions but has a "no" to the answer		
Not missing	159,839	99.4
Missing	957	0.6
Missing 2/2 clinical symptoms: Answered 0/2 questions		
Not missing	138,795	86.32
Missing	22,001	13.68
Insufficient clinical impairment information		
No	137,838	85.72
Yes	22,958	14.28
Insufficient clinical impairment or symptom information such that a food addiction diagnosis could not be made		
No	135,055	83.99
Yes	25,741	16.01

Table A3.2. Foods and food groups examined in food addiction analyses

Food Group	Food as described in Nurses' Health Study Food Frequency Questionnaire (unless otherwise indicated, food was included in food group listed in left column)	Portion Size
Non-sweet fatty foods[a]	Bacon	2 slices
	French fries	6 oz. or 1 serving
	Hamburger	1 patty
	Hamburger (lean or extra lean)*	1 patty
	Other cheese, e.g., American, cheddar, etc., plain or as part of a dish	1 slice or 1 oz. serving
	Peanut butter	1 tbs
	Peanuts	Small packet or 1 oz
	Pizza	2 slices
	Popcorn (regular)	3 cups
	Potato chips or corn/tortilla chips	Small bag or 1 oz.
	Pure butter	ns
	Salami, bologna, or other processed meat sandwiches	ns
	Steak (beef or lamb as a main dish, e.g., steak, roast)	4-6 oz
	How often do you eat fried or sautéed food at home? (Exclude "Pam"-type spray)	
	How often do you eat deep fried chicken, fish, shrimp, clams or onion rings away from home?	
Salty foods	Crackers, regular or low fat e.g., Triscuits, Ritz	6
	Peanuts	Small packet or 1 oz
	Popcorn (fat free or light, regular)	3 cups
	Potato chips or corn/tortilla chips	Small bag or 1 oz.
	Pretzels	1 small bag or serving
	Salami, bologna, or other processed meat sandwiches	ns
Dessert	Cake, homemade or ready made	slice
	Candy bars, e.g., Snickers, Milky Way, Reeses	ns
	Candy without chocolate	1 oz
	Cookies or brownies (fat free or reduced fat, other ready made, home baked)	1
	Dark chocolate, e.g., Hershey's Dark or Dove Dark	ns

Food Group	Food as described in Nurses' Health Study Food Frequency Questionnaire (unless otherwise indicated, food was included in food group listed in left column)	Portion Size
Dessert	Doughnuts	1
	Frozen yogurt, sherbet or low-fat ice cream	1 cup
	Milk chocolate (bar or pack), e.g., Hershey's, M&M's	bar or pack
	Muffins or biscuits	1
	Pie, homemade or ready made	slice
	Regular ice cream	1 cup
	Sweet roll, coffee cake, or other pastry (fat free or reduced fat, other ready made, home baked)	serving
Starchy foods	Pancakes or waffles	2 small pieces
	Pasta, e.g., spaghetti, noodles, couscous, etc.	1 cup
	White bread, including pita	1 slice
	White rice	1 cup
Fruits + vegetables	Fresh apples or pears	1
	Avocado	1/2 fruit or 1/2 cup
	Beans or lentils, baked, dried or soup	1/2 cup
	Broccoli	1/2 cup
	Raisins or grapes	1 oz or small pack or 1/2 cup
	String beans	1/2 cup
Beverages*	Carbonated beverage with caffeine and sugar, e.g., Coke, Pepsi, Mt. Dew, Dr. Pepper	1 glass, bottle or can
	Carbonated beverage with sugar, e.g., 7-Up, Root Beer, Ginger Ale	1 glass, bottle or can
	Orange juice	small glass
	Other sugared beverages: Punch, lemonade, sports drinks, or sugared ice tea	1 glass, bottle, can
	Low-calorie beverage with caffeine, e.g., Diet Coke, Diet Mt. Dew	1 glass, bottle, can
	Other low-calorie beverage without caffeine, e.g., Diet 7-Up	1 glass, bottle, can
	Water: bottled, sparkling, or tap	8 oz cup
Sweeteners*	How many teaspoons of sugar do you add to your beverages or food each day?	1 tsp
	Splenda	1 packet
	Other artificial sweetener	1 packet

Abbreviations: NHS: Nurses' Health Study; ns: not specified

[a] Non-sweet, * Not included in food group analyses

Table A3.3. Calculating Cohen's Kappa Coefficient to determine how well two judges agree upon in which food group to place each food item

		Judge 1					
		Fatty (Non-sweet)	Salty	Dessert	Starchy	Fruits and Veggies	
Judge 2	Fatty	8 (1.78)					8
	Salty	2	6 (1.24)				8
	Dessert			16 (6.04)			16
	Starchy		1	1	5 (0.78)		7
	Fruits and Veggies					6 (.8)	6
		10	7	17	5	6	45

Total # agreements: 41
% agreement: 41/45 = 91%
Expected frequencies: (row total * column total) / overall total:
1.78
1.24
6.04
0.78
0.8
Sum of the expected frequencies of agreement by chance: 10.64
Kappa = (total # agreements - sum of expected frequencies of agreement by chance) / (Over all total - sum of expected frequencies of agreement by chance) kappa = (41 - 10.64) / (45 - 10.64) = 0.88

Table A3.4. The Modified Yale Food Addiction Scale used in the Nurses' Health Study Cohorts

Question 54. The following questions ask about your eating habits in the past year. People sometimes have difficulty controlling their intake of certain foods such as sweets, starches, salty snacks, fatty foods, sugary drinks, and others.

In the past 12 MONTHS, how often were each of these statements true for you?	**Never**	**Once per Month**	**2-4 times per month**	**2-3 times per week**	**4+ times per week**
1. I find myself consuming certain foods even though I am no longer hungry.					
2. I worry about cutting down on certain foods.					
3. I feel sluggish or fatigued from overeating.					
4. I have spent time dealing with negative feelings from overeating certain foods, instead of spending time in important activities such as time with family, friends, work, or recreation.					
5. I have had physical withdrawal symptoms such as agitation and anxiety when I cut down on certain food. (Do NOT include caffeinated drinks: coffee, tea, cola, energy drinks, etc.)					
6. My behavior with respect to food and eating causes me significant distress.					
7. Issues related to food and eating decrease my ability to function effectively (daily routine, job/school, social or family activities, health difficulties).					

IN THE PAST 12 MONTHS…	No	Yes
8. I kept consuming the same types or amounts of food despite significant emotional and/or physical problems related to my eating.		
9. Eating the same amount of food does not reduce negative emotions or increase pleasurable feelings the way it used to.		

Table A3.5. Food Addiction Questions in Yale Food Addiction Scale and Modified Yale Food Addiction Scale and Correspondence with DSM-IV Substance-use Dependence Criteria

DSM-IV Substance-Use Dependence Criteria	YFAS Questions	mYFAS Questions
1. Substance taken in larger amount and for longer period than intended	1, 2, and 3	1
2. Persistent desire or repeated unsuccessful attempt to quit	4, 22, 24, and 25	2
3. Much time/activity to obtain, use, recover	5, 6, and 7	3
4. Important social, occupational, or recreational activities given up or reduced	8, 9, 10, and 11	4
5. Characteristic withdrawal symptoms; substance taken to relieve withdrawal	12, 13, and 14	5
6. Use continues despite knowledge of adverse consequences	19	8
7. Tolerance (marked increase in amount; marked decrease in effect)	20, 21	9

Abbreviations: YFAS, Yale Food Addiction Scale; mYFAS, Modified Yale Food Addiction Scale
Questions 17, 18 and 23 in the YFAS are primer questions and are not scored
Questions 15 and 16 of the YFAS and 6 and 7 of the mYFAS assess clinically significant impairment or distress
A diagnosis of food addiction is met if a person endorses 3 or more of the 7 substance-use dependence criteria and has clinical significance

Figure 1. Directed Acyclic Graph

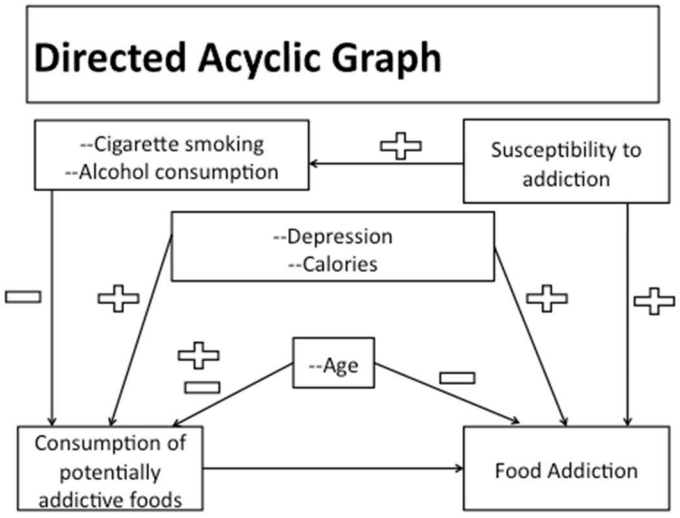


Table A3.6. Determining Confounders

	Relationship between Exposures (Nutrients, Food Items, and Food Groups) and Potential Confounder	**Confounder Status (according to 10% change in beta)**
Age	All associated (p <.10)	**Not a confounder:** Peanut butter, salami/bologna **A confounder:** In all other nutrient, food, and food group analyses
Smoking	Not associated with: Cake, cookies (store-bought), cheese, pie, string beans, no/low fat sweet roll, Salty foods	**A confounder:** Total fat, total sugar, added sugar, sucrose, fructose, glucose, starch, apples, Avocado, Beans/lentils, White bread, Carbon Bev w/Sugar no Caf, Cookies (home made), Cola, Sugar (tsp), Grapes, Ice cream, Peanuts, White Potatoes, Sugar beverage/punch, White Rice, Sweet roll/coffee cake (homemade), dessert group, fruits and vegetable group **Not a confounder:** In all other nutrient, food, and food group analyses
Alcohol	All associated (p <.10)	**Not a confounder:** Artificial sweetener, cheese, fries, hamburger (full-fat), fried food at home, fried food away from home, pizza, popcorn (fat free), pretzels, Splenda **A confounder:** In all other nutrient, food, and food group analyses
Depression	Not associated with: bacon, cookies (store-bought), fried food at home, white potato, sweet roll (home baked)	**Not a confounder:** Glucose, fructose, artificial sweetener, bacon, cake, candy bar, milk chocolate, cookies (store-bought), fried food at home, orange juice, potato/corn chips, fat-free popcorn, pretzels, string beans, sweet roll (home baked) white potato, steak, Salty foods **A confounder:** In all other nutrient, food, and food group analyses
Calories	All associated (p <.10)	**Not a confounder:** Artificial sweetener, low calorie beverage with caffeine, low calorie beverage without caffeine, Splenda **A confounder:** In all other nutrient, food, and food group analyses

Part 2. Missing Data

Table A3.7. Missing Numbers in the Food-Food Addiction Analysis

Exposures	Number missing after adjusting for confounders	Number missing after adjusting for confounders and deleting people who didn't fill out long questionnaire (n = 13,666)	% of dataset (n = 121,389)* missing	Final sample size after dropping missing	Number missing after adjusting for all*** variables	Number missing after adjusting for all variables and deleting people who didn't fill out long questionnaire (n = 13,666)	% of dataset (n = 121,389)* missing	Final sample size after dropping missing
Nutrients								
Total fat[b]	18974	5308	4%	116081	19493	5827	5%	115562
Saturated fat[b]	18974	5308	4%	116081	19493	5827	5%	115562
Trans fat[a]	19493	5827	5%	115562	19493	5827	5%	115562
Sodium[b]	18974	5308	4%	116081	19493	5827	5%	115562
Total sugar[a]	19493	5827	5%	115562	19493	5827	5%	115562
Added sugar[a]	19493	5827	5%	115562	19493	5827	5%	115562
Sucrose[a]	19493	5827	5%	115562	19493	5827	5%	115562
Fructose[f]	19493	5827	5%	115562	19493	5827	5%	115562
Glucose[f]	19493	5827	5%	115562	19493	5827	5%	115562
Starch[a]	19493	5827	5%	115562	19493	5827	5%	115562
Sucralose[b]	18974	5308	4%	116081	19493	5827	5%	115562
Foods								
Apples[a]	20875	7209	6%	114180	20875	7209	6%	114180
Avocado[a]	21783	8117	7%	113272	21783	8117	7%	113272
Bacon[c]	19729	6063	5%	115326	20243	6577	5%	114812
Beans/lentils[a]	21018	7352	6%	114037	21018	7352	6%	114037
White bread[b]	23295	9629	8%	111760	23790	10124	8%	111265
Broccoli[b]	19591	5925	5%	115464	20107	6441	5%	114948
Butter[b]	26001	12335	10%	109054	26481	12815	11%	108574
Cake (homemade)[c]	20211	6545	5%	114844	20721	7055	6%	114334
Candy bar[c]	21144	7478	6%	113911	21652	7986	7%	113403
Candy w/o chocolate[b]	22432	8766	7%	112623	22930	9264	8%	112125
Dark chocolate[b]	20697	7031	6%	114358	21210	7544	6%	113845
Milk chocolate[c]	20211	6545	5%	114844	20720	7054	6%	114335
Cola[a]	21477	7811	6%	113578	21477	7811	6%	113578

Exposures	Number missing after adjusting for confounders	Number missing after adjusting for confounders and deleting people who didn't fill out long questionnaire (n = 13,666)	% of dataset (n = 121,389)* missing	Final sample size after dropping missing	Number missing after adjusting for all*** variables	Number missing after adjusting for all variables and deleting people who didn't fill out long questionnaire (n = 13,666)	% of dataset (n = 121,389)* missing	Final sample size after dropping missing
Cookies (homemade)[a]	22425	8759	7%	112630	22425	8759	7%	112630
Cookies (no/low fat)[b]	25300	11634	10%	109755	25792	12126	10%	109263
Cookies (store-bought)[c]	22733	9067	7%	112322	23235	9569	8%	111820
Cheese[d]	20683	7017	6%	114372	21195	7529	6%	113860
Crackers[b]	20495	6829	6%	114560	21005	7339	6%	114050
Doughnuts[b]	20611	6945	6%	114444	21121	7455	6%	113934
Fries[e]	20141	6475	5%	114914	20654	6988	6%	114401
Grapes[f]	20901	7235	6%	114154	20901	7235	6%	114154
Hamburgers (full fat)[e]	29435	15769	13%	105620	29906	16240	13%	105149
Hamburgers (lean)[a]	23895	10229	8%	111160	24395	10729	9%	110660
Fried food at home[g]	20229	6563	5%	114826	20740	7074	6%	114315
Fried food away from home[e]	20727	7061	6%	114328	21242	7576	6%	113813
Ice cream[a]	24646	10980	9%	110409	24646	10980	9%	110409
Low calorie bev w/o caffeine[i]	21273	7607	6%	113782	21778	8112	7%	113277
Low calorie bev w/ caffeine[i]	20507	6841	6%	114548	21023	7357	6%	114032
Muffin[b]	20666	7000	6%	114389	21178	7512	6%	113877
Orange juice[c]	30774	17108	14%	104281	31235	17569	14%	103820
Pancakes/Waffles[b]	20141	6475	5%	114914	20654	6988	6%	114401
Pasta								
Potato/corn chips[c]	19939	6273	5%	115116	20454	6788	6%	114601
Peanut butter[d]	20287	6621	5%	114768	20803	7137	6%	114252
Peanuts[a]	20927	7261	6%	114128	20927	7261	6%	114128
Pie (store-bought)[b]	20498	6832	6%	114557	21011	7345	6%	114044
Pizza[e]	19678	6012	5%	115377	20193	6527	5%	114862
Popcorn (full fat)[b]	22640	8974	7%	112415	23140	9474	8%	111915
Popcorn (fat free)[g]	22605	8939	7%	112450	23110	9444	8%	111945

Exposures	Number missing after adjusting for confounders	Number missing after adjusting for confounders and deleting people who didn't fill out long questionnaire (n = 13,666)	% of dataset (n = 121,389)* missing	Final sample size after dropping missing	Number missing after adjusting for all*** variables	Number missing after adjusting for all variables and deleting people who didn't fill out long questionnaire (n = 13,666)	% of dataset (n = 121,389)* missing	Final sample size after dropping missing
White potatoes[f]	20298	6632	5%	114757	20298	6632	5%	114757
Pretzels[g]	20268	6602	5%	114787	20785	7119	6%	114270
Sugar beverage/punch[b]	20668	7002	6%	114387	21173	7507	6%	113882
Salami/bologna[d]	20461	6795	6%	114594	20971	7305	6%	114084
Sherbet/frozen yogurt[b]	25884	12218	10%	109171	26372	12706	10%	108683
Splenda[h]	71659	57993	48%	63396	73431	59765	49%	61624
String beans[c]	20360	6694	6%	114695	20870	7204	6%	114185
Carbon Bev w/Sugar no Caf[a]	21603	7937	7%	113452	21603	7937	7%	113452
Steak[c]	20421	6755	6%	114634	20934	7268	6%	114121
Sugar (tsp)[a]	27148	13482	11%	107907	27148	13482	11%	107907
Sweetroll, coffee cake (homemade)[f]	22769	9103	7%	112286	22769	9103	7%	112286
Sweetroll, coffee cake (fat free/reduced fat)[b]	22638	8972	7%	112417	23138	9472	8%	111917
Sweetroll, coffee cake (store-bought)[b]	21425	7759	6%	113630	21932	8266	7%	113123
White rice[a]	20563	6897	6%	114492	20563	6897	6%	114492
Water[b]	20020	6354	5%	115035	20530	6864	6%	114525
Artificial sweetener[j]	18826	5160	4%	116229	21800	8134	7%	113255
Food groups								
Fatty foods[a]	18974	5308	4%	116081	19493	5827	5%	115562
Salty foods[c]	19018	5352	4%	116037	19537	5871	5%	115518
Dessert[b]	18982	5316	4%	116073	19501	5835	5%	115554
Starchy foods[a]	19075	5409	4%	115980	19594	5928	5%	115461
Fruits and vegetables[a]	19505	5839	5%	115550	19505	5839	5%	115550

* After making exclusions, sample size = 135,055; after dropping people who didn't fill out the long questionnaire in 2006 or 2007 (n = 13,666), sample size = 121,389

*** Adjusted for age, calories, alcohol, smoking and depression
[a] Adjusted for age, calories, alcohol, smoking, and depression
[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**
[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**
[d] Adjusted for alcohol and depression **(not age, calories, or smoking)**
[e] Adjusted for age, calories, and depression **(not smoking or alcohol)**
[f] Adjusted for age, calories, alcohol, and smoking **(not depression)**
[g] Adjusted for age and calories **(not alcohol, smoking, or depression)**
[h] Adjusted for age and depression **(not calories, alcohol, or smoking)**
[i] Adjusted for age, alcohol and depression **(not calories or smoking)**
[j] Adjusted for age **(not calories, smoking, alcohol or depression)**

We dropped nurses from analyses if a) They did not fill out the long version of the questionnaire in 2006 or 2007 and therefore did not fill out the food frequency questionnaire in those years (n = 13,666), or b) They were missing data on any confounder included in the model. Approximately 4% of nurses did not provide data on alcohol consumption (n = 5,308), and .5% did not provide data on smoking. All nurses had data on age and depression, and 4% of nurses were missing data on total calorie consumption (due to missing information on alcohol intake). We also dropped nurses from food item analyses if they were missing dietary information on that particular food item. After dropping nurses who did not fill out the long questionnaire and after controlling for all variables, each nutrient analysis was missing 5,827 (5% of the data), food item analyses were missing between 6,441 (broccoli) and 17,569 (orange juice) (5-14% of the data), and food group analyses were missing between 5,835 and 5,928 nurses (5% of the data). In a sensitivity analysis, nurses missing food item information consumed fewer calories, and were younger, lighter drinkers, and more depressed compared with non-missing nurses. Missing nurses were not more likely to be heavier smokers compared with non-missing nurses. If missing nurses had been included in our analyses, our effect estimates likely would have been stronger (even given the calorie

finding), as there is evidence that younger age, depression, and lighter drinking are associated with higher odds of food addiction. Thus, our effect estimates may be underestimates of the truth. In further analyses, nurses missing dietary data had higher odds of food addiction (odds ratios ranged from 1.20 to 1.90). However, after controlling for age, calories, alcohol, smoking, and depression, the majority of these odds ratios dropped to around 1. Final sample sizes for each model were as follows: a) Nutrient analyses: n = 115,562; b) Food item analyses: n = 103,820 (orange juice) to 114,948 (broccoli) and c) Food group analyses: n = 115,518 (salty foods) to 115,561 (fatty foods).

We also examined differences between nurses who did and did not provide enough information to make a food addiction diagnosis among nurses who filled out the long questionnaire. Nurses who provided enough information ("Not-dropped") were similar to nurses who did not ("Dropped"). See Table below for mean values on a number of variables of nurses who we dropped versus did not drop.

Table A3.8. Differences Between Dropped Versus Not-dropped Nurses in 2008 and 2009 NHS I and NHS II

	Not Dropped Means	Dropped
BMI	27.07	27.48
Depression	0.13	0.145
Cigarettes/day	0.14	0.13
Alcohol g/day	6.29	5.85
Age	63.10	62.38
Calories kcal/day	1737.51	1755.00
Dessert	2.43	2.54
Fatty foods	4.11	4.14
Salty foods	1.73	1.74
Starchy foods	1.93	1.94
Fruits and vegetables	2.58	2.57

This table compares nurses who did versus did not provide enough information to make a food addiction diagnosis. We excluded nurses a priori from this analysis if they did not fill out the long questionnaire in 2006-2009 (years that diet and food addiction information were collected).

Table A3.9. Odds of Food Addiction Status Comparing Nurses Missing (Coded 1) Versus Not Missing (Referent Group) Information on Food Item

Exposures	OR	95% CI	Adjusted* OR	95% CI
Nutrients				
Total fat	1.90	1.73, 2.09	1.50**	1.36, 1.65
Saturated fat	1.90	1.73, 2.09	1.50**	1.36, 1.65
Trans fat	1.90	1.73, 2.09	1.50**	1.36, 1.65
Sodium	1.90	1.73, 2.09	1.50**	1.36, 1.65
Total sugar	1.90	1.73, 2.09	1.50**	1.36, 1.65
Added sugar	1.90	1.73, 2.09	1.50**	1.36, 1.65
Sucrose	1.90	1.73, 2.09	1.50**	1.36, 1.65
Fructose	1.90	1.73, 2.09	1.50**	1.36, 1.65
Glucose	1.90	1.73, 2.09	1.50**	1.36, 1.65
Starch	1.90	1.73, 2.09	1.50**	1.36, 1.65
Sucralose	1.90	1.73, 2.09	1.50**	1.36, 1.65
Foods				
Apples	1.59	1.42, 1.78	1.17	0.94, 1.45
Avocado	1.48	1.33, 1.64	1.06	0.89, 1.26
Bacon	1.69	1.50, 1.90	1.17	0.88, 1.56
Beans/lentils	1.53	1.37, 1.71	0.98	0.79, 1.22
White bread	1.34	1.22, 1.47	1.01	0.89, 1.16
Broccoli	1.71	1.52, 1.92	1.17	0.86, 1.59
Butter	1.37	1.27, 1.48	0.99	0.89, 1.09
Cake (homemade)	1.61	1.44, 1.80	1.07	0.85, 1.35
Candy bar	1.48	1.34, 1.64	1.12	0.94, 1.34
Candy w/o chocolate	1.28	1.16, 1.41	0.91	0.78, 1.06
Dark chocolate	1.55	1.39, 1.72	1.18	0.97, 1.44
Milk chocolate	1.49	1.33, 1.67	0.88	0.68, 1.15
Cola	1.54	1.38, 1.70	1.14	0.95, 1.37
Cookies (homemade)	1.47	1.33, 1.62	1.16	0.99, 1.35
Cookies (no/low fat)	1.25	1.15, 1.36	1.02	0.91, 1.14
Cookies (store-bought)	1.34	1.22, 1.47	0.99	0.85, 1.14
Cheese	1.52	1.36, 1.70	1.18	0.96, 1.44
Crackers	1.59	1.43, 1.77	1.08	0.88, 1.32
Doughnuts	1.59	1.43, 1.77	1.14	0.94, 1.38
Fries	1.57	1.40, 1.76	1.05	0.82, 1.35
Grapes	1.64	1.47, 1.83	1.28	1.04, 1.57
Hamburgers (full fat)	1.02	0.94, 1.10	0.86	0.79, 0.95
Hamburgers (lean)	1.35	1.23, 1.47	1.12	0.99, 1.27
Fried food at home	1.51	1.35, 1.70	1.01	0.79, 1.31

Exposures	OR	95% CI	Adjusted* OR	95% CI
Ice cream	1.34	1.22, 1.46	1.11	0.99, 1.25
Low calorie bev w/o caffeine	1.47	1.33, 1.63	1.15	0.96, 1.37
Low calorie bev w/ caffeine	1.38	1.24, 1.55	0.90	0.69, 1.16
Muffin	1.54	1.38, 1.71	1.07	0.88, 1.31
Orange juice	0.97	0.90, 1.05	0.85	0.77, 0.93
Pancakes/Waffles	1.66	1.48, 1.85	1.11	0.88, 1.40
Pasta	1.69	1.50, 1.90	1.33	1.00, 1.78
Potato/corn chips	1.57	1.40, 1.76	0.89	0.67, 1.19
Peanut butter	1.63	1.46, 1.82	1.23	1.00, 1.53
Peanuts	1.62	1.45, 1.81	1.15	0.94, 1.41
Pie (store)	1.62	1.45, 1.80	1.16	0.94, 1.41
Pizza	1.68	1.49, 1.88	1.24	0.92, 1.66
Popcorn (full fat)	1.41	1.29, 1.55	1.11	0.97, 1.28
Popcorn (fat free)	1.35	1.23, 1.49	1.04	0.90, 1.20
White potatoes	1.64	1.46, 1.84	0.93	0.69, 1.26
Pretzels	1.63	1.46, 1.81	1.17	0.94, 1.45
Sugar beverage/punch	1.55	1.39, 1.72	1.19	0.97, 1.45
Salami/bologna	1.61	1.44, 1.79	1.22	1.00, 1.50
Sherbet/frozen yogurt	1.27	1.17, 1.37	1.10	0.99, 1.22
Splenda	1.29	1.15, 1.44	1.16	0.95, 1.42
String beans	1.59	1.42, 1.77	0.97	0.78, 1.21
Carbon Bev w/Sugar no Caf	1.50	1.35, 1.66	1.09	0.91, 1.31
Steak	1.62	1.46, 1.81	1.21	0.98, 1.50
Sugar (tsp)	1.13	1.04, 1.23	0.99	0.89, 1.10
Sweet roll, coffee cake (homemade)	1.47	1.34, 1.61	1.17	1.01, 1.34
Sweet roll, coffee cake (no/low fat)	1.31	1.19, 1.44	0.98	0.85, 1.14
Sweet roll, coffee cake (store)	1.47	1.33, 1.63	1.06	0.90, 1.26
White rice	1.59	1.42, 1.79	1.00	0.78, 1.29
Water	1.69	1.51, 1.89	1.28	1.01, 1.63
Artificial sweetener	1.47	1.33, 1.63	1.05	0.88, 1.24
Food groups				
Fatty foods	1.86	1.63, 2.13	1.29**	1.13, 1.48
Salty foods	1.83	1.60, 2.08	1.25**	0.44, 3.56
Dessert	1.85	1.62, 2.11	1.28**	1.12, 1.47
Starchy foods	1.84	1.62, 2.09	1.28**	0.66, 2.49
Fruits and vegetables	1.84	1.61, 2.10	0.82**	0.10, 6.72

Abbreviations: OR, Odds Ratio; CI, Confidence Interval

* Adjusted for age, calories, alcohol, smoking and depression

** Adjusted for age and depression

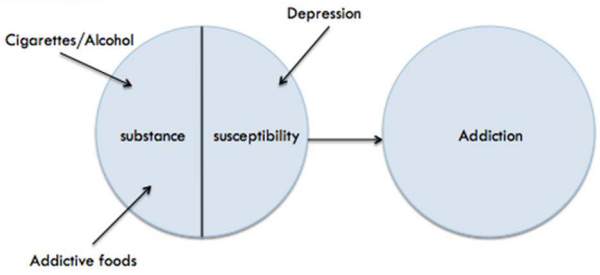
Part 3. Effect Measure Modification

Effect measure modification

Cigarette smoking and alcohol consumption

The relationship between consumption of potentially positively reinforcing foods and food addiction could be weaker among people who are current smokers and/or drinkers for the following reason: Preliminary research suggests the possibility of lifetime comorbidity of food addiction and alcohol consumption and food addiction and cigarette smoking, but an inverse relationship between current alcohol consumption and current food addiction and current cigarette smoking and current food addiction. This inverse relationship may exist because in certain types of people who may have a susceptibility to dysfunctional eating, certain substances (e.g., food and alcohol or food and cigarettes) may compete for the same neurotransmitters (e.g., dopamine) in the brain: thus people who have a susceptibility to dysfunctional eating may not need to abuse more than one of these substances concurrently. Therefore, hypothetically, a person who uses a positively reinforcing substance and who also has a susceptibility to addiction would end up with an addiction to the substance. In Figure 3ab, the substance component of the causal pie could be filled by either alcohol/cigarettes or food, but not both alcohol/cigarettes and food. This is also known as negative interaction or redundancy. While this is one proposed mechanism by which positively reinforcing foods could work in

Figure 3ab. Causal pies showing interaction between use of a substance and susceptibility to addiction and addiction



tandem with a susceptibility to addiction in general to then cause food addiction, we were not sure how this would manifest in our data.

Depression

The relationship between consumption of potentially positively reinforcing foods and food addiction might be stronger among people with depression. As Figure 3b depicts, depression may contribute to susceptibility toward addiction, which, in combination with use of a positively reinforcing substance, could cause addiction. Similar to the alcohol consumption/cigarette smoking and consumption of potentially positively reinforcing foods mechanism described above, we were not sure how the relationship between depression and potentially positively reinforcing foods would manifest in our data.

Analysis

We tested for additive interaction, (which assumes that without interaction, risks add in their effects),[80] using linear link binomial regression using maximum likelihood. This method does not assume that the residual errors are normally distributed, but rather takes into account that the outcome is Bernoulli distributed.[80] The beta for the cross-product term was interpreted as the interaction contrast, or the excess risk due to having both (i.e., being positive for both) independent variables relative to the sum of the independent effects at baseline.[80, 81] If the cross-product term was significant based on a Wald test, we interpreted the beta for the cross-product term as the interaction contrast. We also tested for effect measure modification on the multiplicative (log-odds) scale by creating cross-product terms for alcohol consumption*consumption of positively reinforcing foods, smoking*consumption of positively reinforcing foods, and depression*consumption of positively reinforcing foods. We placed each cross-product term into multivariable logistic regression analyses to determine the significance

of each cross-product term based on a Wald F-test where $\alpha = 0.05$. If the cross-product term was significant, we concluded that there was interaction on the log-odds scale.

Results

We found positive additive interaction between consumption of non-sweet fatty foods and depression, desserts and depression, and consumption of fruits and vegetables and alcohol consumption. However, we found negative additive interaction between consumption of the non-sweet fatty foods and smoking, non-sweet fatty foods and alcohol consumption, and between fruits and vegetables and alcohol consumption. This suggests that there are more people in the dataset for whom fatty food consumption and smoking and fatty food consumption and alcohol work in parallel (i.e., one or the other causes food addiction), rather than the two exposures working together to cause food addiction. This is not surprising, as non-sweet fatty food consumption, smoking and alcohol have strong independent associations with food addiction. We also found positive multiplicative interaction between salty food consumption and alcohol.

Table A3.10. Association Between Food Group Consumption (2006 and 2007) and Food Addiction (2008 and 2009) in NHS I and II: Additive Interaction Between Food Group Consumption and Alcohol, Smoking and Depression

	Additive Interaction					
	ORs and P-values for Interaction Contrast Ratios**					
Level of consumption*	Depression		Alcohol		Smoking	
	ICR	P-value	ICR	P-value	ICR	P-value
Non-sweet fatty foods	**1.65**	**<0.001**	**-0.30**	**<0.001**	**-0.34**	**0.001**
Salty foods	0.34	0.07	0.04	0.60	-0.05	0.59
Desserts	**0.69**	**0.0029**	0.03	0.73	-0.04	0.73
Starchy foods	-0.11	0.48	-0.02	0.69	-0.08	0.31
Fruits and Vegetables	**-0.32**	**0.03**	**0.12**	**0.03**	0.15	0.10

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; ICR, Interaction Contrast Ratio
Analyses control for age (3 groups), calories (quintiles), alcohol (0 grams/day, 0-15 grams/day, >15 grams/day), smoking (no cigs, 1-14 cigs/day, 15+ cig/day), and depression (yes/no)
* Food group divided into high versus low consumption (top 25th compared with bottom 75th percentile)
** Interaction Contrast Ratio = Relative Excess Risk Due to Interaction using Odds Ratio
Bold p <0.05

Table A3.11. Association Between Food Group Consumption (2006 and 2007) and Food Addiction (2008 and 2009) in NHS I and II: Multiplicative Interaction Between Food Group Consumption and Alcohol, Smoking and Depression

	Multiplicative Interaction Odds Ratio, Confidence Interval and P-value for Interaction Term*											
	Depression (yes/no)				**Alcohol** (0-15 g/day vs. >15 g/day)				**Smoking** (yes/no)			
Level of consumption**	OR	CI		p-value	OR	CI		p-value	OR	CI		p-value
Non-sweet fatty foods	0.96	0.86	1.08	0.50	1.05	0.87	1.26	0.62	0.80	0.61	1.04	0.09
Salty foods	0.94	0.84	1.06	0.34	**1.21**	**1.01**	**1.46**	**0.04**	1.05	0.80	1.38	0.74
Desserts	0.93	0.83	1.05	0.25	1.21	0.98	1.48	0.07	1.10	0.83	1.45	0.51
Starchy foods	1.02	0.91	1.15	0.72	0.92	0.76	1.12	0.41	0.84	0.64	1.10	0.20
Fruits and Vegetables	1.03	0.91	1.17	0.60	1.08	0.89	1.31	0.43	1.15	0.84	1.58	0.38

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

Analyses control for age, calories, alcohol, smoking and depression

* Example of interaction term: fatty foods*depression

** Food group divided into high versus low consumption (top 25th compared with bottom 75th percentile)

Bold $p < 0.05$

Part 4. Categorizing Depression

Examining Depression in 3 Different Ways

I did not include nurses who were taking medication for depression because many nurses take depression medication for issues other than depression. Using my current definition, approximately 13% of the nurses meet the criteria for depression. However, 15% of nurses are taking depression medication. Almost 11,000 nurses are taking depression medication, but do not have a diagnosis for depression. If I were to change my definition to include anyone who is taking depression medication or who has a diagnosis, the prevalence of depression would go up to about 20%.

To address this issue, I conducted a sensitivity analysis to examine whether changes in the definition of depression make a difference in adjusted effect estimates. I examined "physician diagnosis of depression," "physician diagnosis or taking depression medication" and "physician diagnosis and taking depression medication."

I examined effect estimates for consumption of 6 food items (Fries, Donuts, Crackers, Avocado, White bread, Carbonated beverage with caffeine and sugar) from 6 food groups as well as 4 food groups themselves (depression was not a confounder in the salty foods analysis, so I did not look at salty foods in this sensitivity analysis).

Analyses indicate that controlling for "depression diagnosis or taking medication" generally weakens effect estimates within 2 decimal places compared with controlling for "depression diagnosis" (exceptions include fries and white bread, whereby odds ratios become stronger). Controlling for "depression diagnosis and taking medication" compared with controlling for "depression diagnosis," sometimes weakens (crackers, white bread, all food

groups), and sometimes strengthens (donuts, avocado, caffeinated beverage with sugar) effect estimates, but always within 2 decimal places of each other (see Table A3.12).

Due to the variability of direction as well as similarity of effect estimates when controlling for different definitions of depression, I used my original definition of depression—depression diagnosis.

Table A3.12. Sensitivity Analysis: Does adjusting for different categorizations of depression make a difference in the results?

	Level of Consumption	Adjusted for physician dx OR	95% CI	Adjusted physician dx OR taking meds OR	95% CI	Adjusted for physician dx AND taking meds OR	95% CI
Fries[e]	<3/month	1.00		1.00		1.00	
	1-4/week	**1.30**	**1.22, 1.39**	**1.29**	**1.21, 1.38**	**1.30**	**1.22, 1.39**
	5+/week	**2.48**	**1.68, 3.67**	**2.50**	**1.69, 3.71**	**2.48**	**1.68, 3.67**
Donuts[b]	<3/month	1.00		1.00		1.00	
	1-4/week	**1.26**	**1.14, 1.38**	**1.25**	**1.13, 1.37**	**1.26**	**1.14, 1.38**
	5+/week	1.43	0.91, 2.26	1.40	0.89, 2.20	1.45	0.92, 2.28
Crackers[b]	<3/month	1.00					
	1/week to 2-3/day	1.00	0.95, 1.06	1.00	0.95, 1.05	1.00	0.95, 1.05
	4+/day	1.16	0.77, 1.74	1.11	0.74, 1.66	1.14	0.76, 1.70
Avocado[a]	<3/month	1.00		1.00		1.00	
	1-4/week	**0.83**	**0.76, 0.90**	**0.85**	**0.78, 0.92**	**0.84**	**0.78, 0.92**
	5+/week	0.74	0.51, 1.06	0.75	0.52, 1.08	0.73	0.51, 1.05
White bread[a]	<3/month	1.00					
	1/week to 2-3/day	1.03	0.97, 1.09	1.03	0.97, 1.08	1.03	0.97, 1.08
	4+/day	1.31	0.81, 2.11	1.35	0.84, 2.17	1.28	0.79, 2.06
Carbonated beverage with caffeine and sugar[a]	<3/month	1.00		1.00		1.00	
	1/week to 1/day	**0.734**	**0.67, 0.81**	0.74	**0.67, 0.81**	0.74	0.67, 0.81
	2+/day	**0.567**	**0.42, 0.76**	0.56	**0.42, 0.75**	0.57	0.43, 0.77
Fatty foods[c]							
	0 to 11 (ref)	1.00		1.00		1.00	
	12 to 15	1.04	0.95, 1.13	1.04	0.95, 1.13	1.04	0.95, 1.13
	16 to 18	1.07	0.98, 1.17	1.05	0.96, 1.15	1.06	0.97, 1.16
	19 to 23	**1.10**	**1.00, 1.20**	1.08	0.99, 1.18	1.08	0.99, 1.18
	24 to 118	**1.32**	**1.21, 1.45**	**1.29**	**1.18, 1.41**	**1.30**	**1.19, 1.43**

	Level of Consumption	Adjusted for physician dx		Adjusted physician dx OR taking meds		Adjusted for physician dx AND taking meds	
		OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Desserts[c]	0 to 5 (ref)	1.00		1.00		1.00	
	6 to 8	**0.87**	**0.79, 0.95**	**0.87**	**0.79, 0.95**	**0.87**	**0.79, 0.95**
	9 to 12	1.00	0.92, 1.08	0.99	0.91, 1.08	0.99	0.92, 1.08
	13 to 18	1.02	0.93, 1.10	1.00	0.92, 1.08	1.01	0.93, 1.09
	19 to 144	**1.17**	**1.07, 1.28**	**1.14**	**1.05, 1.24**	**1.16**	**1.06, 1.26**
Starchy foods[a]							
	0 to 3 (ref)	1.00		1.00		1.00	
	4 to 5	**0.89**	**0.82, 0.97**	**0.89**	**0.82, 0.97**	**0.89**	**0.82, 0.97**
	6 to 7	**0.85**	**0.78, 0.92**	**0.84**	**0.77, 0.92**	**0.84**	**0.77, 0.91**
	8 to 9	**0.81**	**0.74, 0.88**	**0.80**	**0.73, 0.87**	**0.79**	**0.72, 0.87**
	10 to 45	**0.80**	**0.73, 0.87**	**0.79**	**0.72, 0.86**	**0.78**	**0.71, 0.85**
Fruits and Vegetables[a]							
	0 to 5 (ref)	1.00		1.00		1.00	
	6 to 7	**0.91**	**0.84, 0.99**	**0.92**	**0.85, 1.00**	**0.91**	**0.84, 0.98**
	8 to 9	**0.83**	**0.77, 0.90**	**0.84**	**0.78, 0.91**	**0.83**	**0.76, 0.90**
	10 to 11	**0.75**	**0.69, 0.82**	**0.76**	**0.70, 0.83**	**0.74**	**0.68, 0.81**
	12 to 54	**0.73**	**0.67, 0.79**	**0.74**	**0.68, 0.81**	**0.73**	**0.67, 0.79**

Abbreviations: dx, diagnosis; OR, odds ratio; CI, confidence interval
Bold $p < 0.05$

Part 5. Controlling for Calorie Consumption

Does Controlling for Calories Make a Difference?

These tables present food groups and food item consumption and food addiction models, controlling for appropriate confounders, with and without calorie consumption in each model. Whether or not to include calorie consumption in these models is unclear. On the one hand, calorie consumption could be considered a confounder (a cause of the exposure and outcome); greater calorie consumption could lead to increased consumption of a particular food item due to increased consumption of all food in general (the exposure), and calorie consumption could increase the likelihood of food addiction if consuming more calories in general increases tolerance and/or leads to a physical (stomach stretching) or emotional dependence (the outcome). If it is correct to conceptualize calories as a confounder, lack of control for calories creates bias in the positive direction; upon controlling for calories, odds ratios are all pulled to the left--for positive odds ratios, this means towards the null; for odds ratios below 1, this means away from the null.

On the other hand, (increased) calorie consumption could be a result of eating more of a particular food item, and could also be a consequence of having a food addiction. If this is the reality, controlling for calorie consumption would cause more harm than good--it would create a bias ("collider bias"). As can be seen in the table below, this manifests as weakened odds ratios for odds ratios above 1, and stronger odds ratios for odds ratios below 1.

In the end, I controlled for calorie consumption. I felt that this approach was conservative.

See Tables A3.13 and A3.14.

Table A3.13. Association Between Quartiles Food Groups (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II with and without calories in models

	Adjusted for confounders		Adjusted for confounders No Calories	
Servings per day	**OR**	**95% CI**	**OR**	**95% CI**
Fatty foods[c]				
	1.00			
	1.05	0.96, 1.15	**1.09**	**1.00, 1.19**
	1.06	0.98, 1.14	**1.13**	**1.05, 1.22**
	1.40	**1.30, 1.52**	**1.60**	**1.49, 1.72**
Salty foods[b]				
	1.00			
	1.06	0.97, 1.15	**1.11**	**1.02, 1.20**
	1.14	**1.05, 1.24**	**1.25**	**1.15, 1.35**
	1.24	**1.14, 1.34**	**1.45**	**1.34, 1.58**
Desserts[a]				
	1.00			
	0.89	**0.82, 0.97**	**0.92**	**0.85, 1.00**
	0.96	0.89, 1.04	1.03	0.96, 1.11
	1.17	**1.08, 1.26**	**1.36**	**1.26, 1.46**
Starchy foods[c]				
	1.00			
	0.92	**0.84, 1.00**	0.97	0.89, 1.06
	0.84	**0.77, 0.91**	0.94	0.87, 1.02
	0.79	**0.73, 0.86**	0.97	0.90, 1.05
Fruits and Vegetables[a]				
0 to 5 (ref)	1.00			
6 to 7	**0.92**	**0.85, 1.00**	0.99	0.92, 1.07
8 to 9	**0.84**	**0.77, 0.91**	0.97	0.90, 1.04
10 to 11	**0.75**	**0.69, 0.82**	**0.92**	**0.86, 0.99**

Abbreviations: NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

Fatty foods: Bacon, French fries, Hamburger, Other cheese, e.g., American, cheddar, etc., plain or as part of a dish, Peanut butter, Peanuts, Pizza, Popcorn (regular), Potato chips or corn/tortilla chips, Pure butter, Salami, bologna, or other processed meat sandwiches, Steak (beef or lamb as a main dish, e.g., steak, roast), How often do you eat fried or sautéed food at home? (Exclude "Pam"-type spray), How often do you eat deep fried chicken, fish, shrimp, clams or onion rings away from home?

Salty foods: Crackers, regular or low fat e.g., Triscuits, Ritz, Peanuts, Popcorn (fat free or light, regular), Potato chips or corn/tortilla chips, Pretzels, Salami, bologna, or other processed meat sandwiches
Desserts: Cake, homemade or ready made, Candy bars, e.g., Snickers, Milky Way, Reeses, Candy without chocolate, Cookies or brownies (fat free or reduced fat, other ready made, home baked), Dark chocolate, e.g., Hershey's Dark or Dove Dark, Doughnuts, Frozen yogurt, sherbet or low-fat ice cream, Milk chocolate (bar or pack), e.g., Hershey's, M&M's, Muffins or biscuits, Pie, homemade or ready made, Regular ice cream, Sweet roll, coffee cake, or other pastry (fat free or reduced fat, other ready made, home baked)

Starchy foods: Pancakes or waffles, Pasta, e.g., spaghetti, noodles, couscous, etc., White bread, including pita, White potatoes, White rice

Fruits and Vegetables: Fresh apples or pears, Avocado, Beans or lentils, baked, dried or soup, Broccoli, Raisins or grapes, String beans

[a] = Adjusted for calories, age, alcohol, smoking, and depression
[b] = Adjusted for calories, age and alcohol **(not smoking or depression)**
[c] = Adjusted for calories, age, alcohol, and depression **(not smoking)**
Bold $p < 0.05$

Table A3.14. Association Between Foods (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II: Adjusted with and without calories in models

		Without Calories in Models		**With Calories in Models**	
		OR (95% CI)		**OR**	**95% CI**
Apples[a]	Less than once per month	1.00		1.00	
	1 per week to 1 per day	**0.94**	**(0.89, 0.99)**	**0.87**	**(0.83, 0.92)**
	2 or more per day	1.09	(0.80, 1.48)	0.91	(0.67, 1.25)
Avocado[a]	Less than once per month	1.00		1.00	
	1 to 4 per week	**0.88**	**(0.81, 0.95)**	**0.83**	**(0.76, 0.90)**
	5 or more per week	0.84	(0.59, 1.21)	0.74	(0.51, 1.06)
Beans/lentils[a]	Less than once per month	1.00		1.00	
	1 to 6 per week	0.96	(0.91, 1.01)	**0.88**	**(0.83, 0.93)**
	1 or more per day	0.81	(0.55, 1.19)	**0.67**	**(0.46, 1.00)**
White bread[b]	Less than once per month	1.00		1.00	
	1 per week to 2-3 per day	**1.08**	**(1.03, 1.14)**	1.03	(0.97, 1.09)
	4 or more per day	1.56	(0.97, 2.52)	1.31	(0.81, 2.11)
Broccoli[b]	Less than once per month	1.00		1.00	
	1 per week to 1 per day	1.05	(0.99, 1.10)	0.98	(0.93, 1.03)
	2 or more per day	1.50	(0.89, 2.55)	1.30	(0.77, 2.21)
Butter[b]	Less than once per month	1.00		1.00	
	1 per week to 2-3 per day	**1.09**	**(1.03, 1.15)**	1.04	(0.99, 1.10)
	4 or more per day	**2.30**	**(1.64, 3.23)**	**1.96**	**(1.40, 2.77)**
Cake (homemade)[c]	Less than once per month	1.00		1.00	
	1 to 4 per week	**1.31**	**(1.21, 1.41)**	**1.16**	**(1.07, 1.26)**
	5 or more per week	1.26	(0.78, 2.05)	1.05	(0.64, 1.70)
Candy bar[c]	Less than once per month	1.00		1.00	
	1 to 4 per week	**1.65**	**(1.53, 1.77)**	**1.51**	**(1.40, 1.63)**
	5 or more per week	**1.94**	**(1.49, 2.52)**	**1.62**	**(1.24, 2.11)**
Candy w/o chocolate[b]	Less than once per month	1.00		1.00	
	1 per week to 1 per day	**1.28**	**(1.19, 1.36)**	**1.19**	**(1.11, 1.27)**
	2 or more per day	1.38	(0.99, 1.94)	1.20	(0.86, 1.69)
Dark chocolate[b]	Less than once per month	1.00		1.00	
	1 per week to 1 per day	1.00	(0.94, 1.06)	**0.91**	**(0.86, 0.97)**
	2 or more per day	0.95	(0.62, 1.44)	0.75	(0.49, 1.14)
Milk chocolate[c]	Less than once per month	1.00		1.00	
	1 per week to 1 per day	**1.45**	**(1.38, 1.53)**	**1.35**	**(1.28, 1.43)**
	2 or more per day	**2.38**	**(1.63, 3.48)**	**1.93**	**(1.32, 2.82)**

		Without Calories in Models OR (95% CI)	With Calories in Models OR 95% CI
Cola[a]	Less than once per month	1.00	1.00
	1 per week to 1 per day	**0.784 (0.72, 0.86)**	**0.73 (0.67, 0.81)**
	2 or more per day	**0.638 (0.48, 0.85)**	**0.57 (0.42, 0.76)**
Cookies (homemade)[a]	Less than once per month	1.00	1.00
	1 per week to 1 per day	0.98 (0.92, 1.05)	**0.89 (0.84, 0.95)**
	2 or more per day	0.89 (0.59, 1.34)	0.73 (0.49, 1.10)
Cookies (no/low fat)[b]	Less than once per month	1.00	1.00
	1 per week to 1 per day	**1.29 (1.18, 1.40)**	**1.23 (1.13, 1.33)**
	2 or more per day	1.12 (0.75, 1.69)	1.00 (0.67, 1.51)
Cookies (store-bought)[c]	Less than once per month	1.00	1.00
	1 per week to 1 per day	**1.22 (1.15, 1.29)**	**1.12 (1.06, 1.19)**
	2 or more per day	1.15 (0.92, 1.44)	0.99 (0.79, 1.25)
Cheese[d]	Less than once per month	1.00	1.00
	1 per week to 2-3 per day	**1.08 (1.01, 1.15)**	0.98 (0.91, 1.05)
	4 or more per day	**2.01 (1.40, 2.89)**	**1.53 (0.99, 2.37)**
Crackers[b]	Less than once per month	1.00	1.00
	1 per week to 2-3 per day	**1.08 (1.03, 1.14)**	1.00 (0.95, 1.06)
	4 or more per day	1.46 (0.98, 2.19)	1.16 (0.77, 1.74)
Doughnuts[b]	Less than once per month	1.00	1.00
	1 to 4 per week	**1.37 (1.25, 1.51)**	**1.26 (1.14, 1.38)**
	5 or more per week	**1.65 (1.05, 2.59)**	1.43 (0.91, 2.26)
Fries[e]	Less than once per month	1.00	1.00
	1 to 4 per week	**1.40 (1.31, 1.49)**	**1.30 (1.22, 1.39)**
	5 or more per week	**3.05 (2.18, 4.28)**	**2.48 (1.68, 3.67)**
Grapes[f]	Less than once per month	1.00	1.00
	1 per week to 1 per day	**0.81 (0.76, 0.86)**	**0.74 (0.70, 0.78)**
	2 or more per day	1.00 (0.60, 1.66)	0.84 (0.50, 1.39)
Hamburgers (full fat)[e]	Less than once per month	1.00	1.00
	1 per week	**1.45 (1.36, 1.55)**	**1.39 (1.30, 1.50)**
	2 or more per week	**2.18 (1.94, 2.44)**	**1.95 (1.72, 2.20)**
Hamburgers (lean)[a]	Less than once per month	1.00	1.00
	1 to 4 per week	**1.26 (1.19, 1.33)**	**1.19 (1.12, 1.25)**
	5 or more per week	**2.13 (1.41, 3.21)**	**1.78 (1.18, 2.70)**

		Without Calories in Models OR (95% CI)	With Calories in Models OR 95% CI
Fried food at home[g]	<1 per week	1.00	1.00
	4-6 per week	**1.21 (1.15, 1.27)**	**1.13 (1.07, 1.19)**
	daily	**2.78 (1.97, 3.93)**	**2.60 (1.80, 3.75)**
Fried food away from home[e]	<1 per week	1.00	1.00
	1-3 times per week	**1.84 (1.68, 2.02)**	**1.74 (1.58, 1.92)**
	4 or more times per week	**3.27 (2.05, 5.20)**	**2.89 (1.76, 4.73)**
Ice cream[a]	Less than once per month		1.00
	1 to 6 per week	**1.07 (1.01, 1.14)**	0.99 (0.93, 1.06)
	1 or more per day	1.13 (0.83, 1.52)	0.96 (0.71, 1.30)
Low calorie bev w/o caffeine[i]	Less than once per month	1.00	1.00
	1 per week to 2-3 per day	**1.66 (1.57, 1.75)**	**1.66 (1.57, 1.75)**
	4 or more per day	**2.34 (1.82, 3.01)**	**2.34 (1.82, 3.01)**
Low calorie bev w/ caffeine[i]	Less than once per month	1.00	1.00
	1 per week to 2-3 per day	**1.75 (1.66, 1.84)**	**1.75 (1.66, 1.84)**
	4 or more per day	**2.71 (2.35, 3.13)**	**2.71 (2.35, 3.13)**
Muffin[b]	Less than once per month	1.00	1.00
	1 to 6 per week	1.06 (0.99, 1.13)	0.95 (0.89, 1.02)
	1 or more per day	1.12 (0.74, 1.70)	0.94 (0.62, 1.42)
Orange juice[c]	Less than once per month	1.00	1.00
	1 per week to 1 per day	**0.71 (0.66, 0.77)**	**0.66 (0.62, 0.71)**
	2 or more per day	**0.63 (0.34, 1.00)**	**0.54 (0.34, 0.85)**
Pancakes/Waffles[b]	Less than once per month	1.00	1.00
	1 to 4 per week	0.96 (0.89, 1.04)	**0.88 (0.81, 0.95)**
	5 or more per week	1.25 (0.83, 1.90)	1.09 (0.72, 1.66)
Pasta[a]	<3/month	1.00	1.00
	1-6/week	0.96 (0.91, 1.01)	**0.86 (0.81, 0.91)**
	1+/day	1.46 (0.97, 2.20)	1.10 (0.73, 1.66)
Potato/corn chips[c]	Less than once per month	1.00	1.00
	1 to 6 per week	**1.17 (1.11, 1.23)**	**1.08 (1.02, 1.14)**
	1 or more per day	**1.45 (1.15, 1.85)**	1.21 (0.95, 1.54)
Peanut butter[d]	Less than once per month	1.00	1.00
	1 per week to 2-3 per day	**1.08 (1.03, 1.14)**	**1.08 (1.03, 1.14)**
	4 or more per day	1.52 (0.88, 2.61)	1.52 (0.88, 2.61)
Peanuts[a]	Less than once per month	1.00	1.00

	1 per week to 1 per day	1.02 (0.96, 1.08)	**0.94 (0.88, 1.00)**
	2 or more per day	**1.52 (1.04, 2.21)**	1.22 (0.84, 1.78)

		Without Calories in Models	**With Calories in Models**
		OR (95% CI)	**OR 95% CI**
Pie (store-bought)[b]	Less than once per month	1.00	1.00
	1 per week	**1.22 (1.09, 1.36)**	1.08 (0.96, 1.20)
	2 or more per week	**1.44 (1.12, 1.85)**	1.19 (0.93, 1.53)
Pizza[e]	Less than once per month	1.00	1.00
	1 to 4 per week	**1.27 (1.21, 1.35)**	**1.18 (1.12, 1.25)**
	5 or more per week	**3.49 (2.38, 5.12)**	**2.72 (1.85, 4.00)**
Popcorn (full fat)[b]	Less than once per month	1.00	1.00
	1 to 6 per week	**1.29 (1.20, 1.40)**	**1.21 (1.12, 1.31)**
	1 or more per day	**1.74 (1.14, 2.65)**	**1.56 (1.02, 2.38)**
Popcorn (fat free)[g]	Less than once per month	1.00	1.00
	1 to 6 per week	**1.48 (1.39, 1.57)**	**1.42 (1.33, 1.51)**
	1 or more per day	**2.60 (2.10, 3.20)**	**2.23 (1.77, 2.80)**
White potatoes[f]	Less than once per month	1.00	1.00
	1 to 6 per week	0.99 (0.94, 1.04)	**0.89 (0.84, 0.94)**
	1 or more per day	1.21 (0.90, 1.61)	0.93 (0.70, 1.25)
Pretzels[g]	Less than once per month	1.00	1.00
	1 per week to 1 per day	**1.12 (1.06, 1.18)**	1.04 (0.99, 1.11)
	2 or more per day	**1.56 (1.11, 2.21)**	1.32 (0.91, 1.92)
Sugar beverage/punch[b]	Less than once per month	1.00	1.00
	1 per week to 1 per day	**0.68 (0.63, 0.74)**	**0.63 (0.58, 0.68)**
	2 or more per day	**0.60 (0.46, 0.80)**	**0.50 (0.38, 0.66)**
Salami/bologna[d]	Less than once per month	1.00	1.00
	1 to 4 per week	**1.27 (1.18, 1.37)**	**1.27 (1.18, 1.37)**
	5 or more per week	1.27 (0.94, 1.72)	1.27 (0.94, 1.72)
Sherbert/frozen yogurt[b]	Less than once per month	1.00	1.00
	1 to 6 per week	**1.16 (1.08, 1.23)**	**1.10 (1.03, 1.17)**
	1 or more per day	**1.50 (1.22, 1.84)**	**1.35 (1.10, 1.66)**
Splenda[j]	Less than once per month	1.00	1.00
	1 per week to 2-3 per day	**1.67 (1.58, 1.76)**	**1.67 (1.58, 1.76)**
	4 or more per day	**2.16 (1.93, 2.41)**	**2.16 (1.93, 2.41)**
String beans[c]	Less than once per month	1.00	1.00
	1 to 4 per week	0.99 (0.94, 1.05)	**0.93 (0.88, 0.98)**
	5 or more per week	**1.55 (1.32, 1.81)**	**1.33 (1.13, 1.56)**

Carbon Bev w/Sugar no Caf[a]	Less than once per month	1.00	1.00
	1 to 4 per week	**0.78 (0.70, 0.88)**	**0.72 (0.64, 0.81)**
	5 or more per week	0.92 (0.71, 1.20)	0.83 (0.63, 1.07)
		Without Calories in Models	**With Calories in Models**
		OR (95% CI)	**OR 95% CI**
Sugar (tsp)[a]	0 to 1 per day	1.00	1.00
	2 to 4 per day	**0.70 (0.63, 0.77)**	**0.66 (0.60, 0.73)**
	5 or more per day	0.94 (0.77, 1.16)	0.85 (0.69, 1.05)
Sweetroll, coffee cake (homemade)[f]	Less than once per month	1.00	1.00
	1 per week	1.00 (0.87, 1.15)	0.88 (0.77, 1.02)
	2 or more per week	0.99 (0.73, 1.34)	0.83 (0.61, 1.13)
Sweetroll, coffee cake (fat free/reduced fat)[b]	Less than once per month	1.00	1.00
	1 per week	**1.40 (1.19, 1.65)**	**1.28 (1.08, 1.51)**
	2 or more per week	**1.58 (1.20, 2.08)**	**1.42 (1.08, 1.86)**
Sweetroll, coffee cake (store-bought)[b]	Less than once per month	1.00	1.00
	1 per week	**1.36 (1.24, 1.50)**	**1.25 (1.13, 1.37)**
	2 or more per week	**1.59 (1.35, 1.86)**	**1.40 (1.19, 1.64)**
White rice[a]	Less than once per month	1.00	1.00
	1 to 4 per week	0.97 (0.91, 1.03)	**0.89 (0.83, 0.94)**
	5 or more per week	**0.57 (0.37, 0.86)**	**0.50 (0.33, 0.75)**
Water[b]	Less than once per month	1.00	1.00
	1 to 6 per week	**0.90 (0.81, 1.00)**	**0.89 (0.80, 0.99)**
	1 or more per day	0.93 (0.85, 1.02)	**0.89 (0.81, 0.98)**
Artificial sweetener[h]	Less than once per month	1.00	1.00
	1 per week to 2-3 per day	**1.63 (1.54, 1.73)**	**1.63 (1.54, 1.73)**
	4 or more per day	**2.18 (1.92, 2.47)**	**2.18 (1.92, 2.47)**
Bacon[c]	Less than once per month	1.00	1.00
	1 to 4 per week	**1.15 (1.08, 1.22)**	**1.07 (1.00, 1.14)**
	5 or more per week	**1.54 (1.18, 2.01)**	**1.39 (1.07, 1.82)**
Steak[c]	Less than once per month	1.00	1.00
	1 to 4 per week	**1.12 (1.07, 1.18)**	1.04 (0.99, 1.10)
	5 or more per week	**1.83 (1.38, 2.42)**	**1.49 (1.12, 1.98)**

NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for age, calories, alcohol, smoking, and depression
[b] Adjusted for age, calories, alcohol, and depression **(not smoking)**
[c] Adjusted for age, calories, and alcohol **(not smoking or depression)**
[d] Adjusted for alcohol and depression **(not age, calories, or smoking)**
[e] Adjusted for age, calories, and depression **(not smoking or alcohol)**
[f] Adjusted for age, calories, alcohol, and smoking **(not depression)**
[g] Adjusted for age and calories **(not alcohol, smoking, or depression)**
[h] Adjusted for age **(not calories, alcohol, smoking, or depression)**
[i] Adjusted for age, depression, and alcohol **(not calories or smoking)**
[j] Adjusted for age and depression **(not calories, smoking, or alcohol)**
Bold $p < 0.05$

Table A3.15. Association between Consumption of Grams of Fat and Sodium per Day (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II: Adjusted With and Without Calories in the Models

		Adjusted for confounders without calories			**Adjusted for confounders with calories**[a]		
	Cases	OR	95% CI		OR	95% CI	
Total fat: 9.6 - 49.95	741				1.00		
Total fat: 49.96 - 57.3	993	**1.12**	**1.02**	**1.24**	**1.11**	**1.00**	**1.22**
Total fat: 57.31 - 63.66	1251	**1.25**	**1.13**	**1.37**	**1.22**	**1.11**	**1.35**
Total fat: 63.67 - 71.44	1519	**1.36**	**1.24**	**1.49**	**1.34**	**1.22**	**1.47**
Total fat: 71.45 - 147	1996	**1.72**	**1.57**	**1.89**	**1.72**	**1.57**	**1.89**
Saturated fat: 2.31 - 14.93	772				1.00		
Saturated fat: 14.94 - 17.83	1023	**1.11**	**1.00**	**1.22**	**1.09**	**0.99**	**1.20**
Saturated fat: 17.84 - 20.42	1290	**1.28**	**1.16**	**1.40**	**1.25**	**1.14**	**1.38**
Saturated fat: 20.43 - 23.66	1475	**1.34**	**1.23**	**1.47**	**1.32**	**1.20**	**1.45**
Saturated fat: 23.67 - 65.86	1940	**1.60**	**1.46**	**1.75**	**1.59**	**1.46**	**1.74**
Trans fat: 0.11 - 1.26	859				1.00		
Trans fat: 1.27 - 1.55	1039	1.07	0.97	1.17	1.05	0.96	1.16
Trans fat: 1.56 - 1.81	1218	**1.18**	**1.08**	**1.30**	**1.16**	**1.06**	**1.27**
Trans fat: 1.82 - 2.14	1425	**1.27**	**1.16**	**1.38**	**1.24**	**1.14**	**1.36**
Trans fat: 2.15 - 7.04	1959	**1.60**	**1.47**	**1.74**	**1.59**	**1.46**	**1.73**
Sodium*: 323 - 1680	681				1.00		
Sodium: 1681 - 1908	971	**1.26**	**1.14**	**1.39**	**1.25**	**1.13**	**1.38**
Sodium: 1909 - 2111	1147	**1.34**	**1.21**	**1.47**	**1.32**	**1.20**	**1.46**
Sodium: 2112 - 2357	1580	**1.67**	**1.52**	**1.84**	**1.66**	**1.51**	**1.82**
Sodium: 2358 - 6817	2121	**2.05**	**1.87**	**2.25**	**2.04**	**1.86**	**2.24**

NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

P-value, test for trend was <0.0001 for all nutrients

[a] Adjusted for calories, age, alcohol and depression (not smoking)

* Milligrams

Bold p <0.05

Table A3.16. Association between Consumption of Grams of Sugar per Day (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II: Adjusted With and Without Calories in the Models

		Adjusted for confounders without calories			**Adjusted for confounders with calories**		
	Cases	OR	95% CI		OR	95% CI	
Total sugar[c]: 8.7 - 72.8	1599	1.00			1.00		
Total sugar: 72.9 - 87.5	1454	**0.84**	**0.78**	**0.90**	**0.82**	**0.76**	**0.88**
Total sugar: 87.6 - 100.8	1352	**0.74**	**0.68**	**0.80**	**0.72**	**0.67**	**0.78**
Total sugar: 100.9 - 117.5	1106	**0.59**	**0.55**	**0.65**	**0.58**	**0.53**	**0.63**
Total sugar: 117.6 - 370.4	989	**0.49**	**0.45**	**0.53**	**0.48**	**0.44**	**0.52**
Added sugar[c]: 0.01 - 24.02	1228	1.00			1.00		
Added sugar: 24.03 - 32.76	1348	0.97	0.90	1.06	0.95	0.88	1.04
Added sugar: 32.77 - 41.58	1322	**0.89**	**0.82**	**0.97**	**0.87**	**0.80**	**0.94**
Added sugar: 41.59 - 54.67	1358	**0.89**	**0.82**	**0.96**	**0.87**	**0.80**	**0.94**
Added sugar: 54.68 - 334.92	1244	**0.73**	**0.67**	**0.80**	**0.72**	**0.66**	**0.79**
Fructose[b]: 0.71 - 13.7	1808	1.00			1.00		
Fructose: 13.71 - 17.67	1512	**0.82**	**0.77**	**0.89**	**0.80**	**0.75**	**0.86**
Fructose: 17.68 - 21.57	1232	**0.67**	**0.62**	**0.72**	**0.65**	**0.60**	**0.70**
Fructose: 21.58 - 26.95	1016	**0.55**	**0.51**	**0.59**	**0.53**	**0.49**	**0.58**
Fructose: 26.96 - 144.6	932	**0.49**	**0.45**	**0.53**	**0.48**	**0.44**	**0.52**
Glucose[b]: 1.08 - 13.45	1775	1.00			1.00		
Glucose: 13.46 - 16.85	1536	**0.85**	**0.79**	**0.91**	**0.83**	**0.77**	**0.89**
Glucose: 16.86 - 20.28	1259	**0.69**	**0.64**	**0.74**	**0.67**	**0.62**	**0.73**
Glucose: 20.29 - 25.19	1035	**0.57**	**0.52**	**0.61**	**0.55**	**0.51**	**0.60**
Glucose: 25.2 - 150.27	895	**0.48**	**0.45**	**0.53**	**0.48**	**0.44**	**0.52**
Sucrose[c]: 0.53 - 24.83	1416	1.00			1.00		
Sucrose: 24.84 - 31.47	1429	**0.92**	**0.85**	**0.99**	**0.90**	**0.83**	**0.97**
Sucrose: 31.48 - 37.96	1278	**0.78**	**0.72**	**0.85**	**0.76**	**0.70**	**0.83**
Sucrose: 37.97 - 46.8	1220	**0.73**	**0.68**	**0.80**	**0.72**	**0.66**	**0.78**
Sucrose: 46.81 - 189.92	1157	**0.67**	**0.61**	**0.73**	**0.66**	**0.61**	**0.72**
Starch[c]: 0.9 - 60.4	1054	1.00			1.00		
Starch: 60.5 - 71.8	1113	0.99	0.90	1.08	0.97	0.89	1.06
Starch: 71.9 - 81.8	1262	1.02	0.94	1.12	1.01	0.92	1.10
Starch: 81.9 - 94.2	1405	1.02	0.94	1.11	1.01	0.92	1.10
Starch: 94.3 - 251.7	1666	1.06	0.97	1.15	1.06	0.98	1.15

		Adjusted for confounders without calories			**Adjusted for confounders with calories**		
	Cases	OR	95% CI		OR	95% CI	
Artificial sugar[a]: 0.02	761	1.00			1.00		
Artificial sugar: 0.03 - 0.26	651	**1.49**	**1.33**	**1.65**	**1.47**	**1.32**	**1.63**
Artificial sugar: 0.27 - 2.39	1285	**1.94**	**1.77**	**2.13**	**1.92**	**1.75**	**2.11**
Artificial sugar: 2.40 - 12.02	1691	**2.43**	**2.22**	**2.65**	**2.46**	**2.25**	**2.69**
Artificial sugar: 12.03 - 147.63	2112	**3.26**	**2.99**	**3.55**	**3.26**	**3.00**	**3.55**

NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

P-value, test for trend was <0.05 for all nutrients

[a] Adjusted for calories and age (not alcohol, smoking, or depression); artificial sugar includes intake of saccharine, aspartame, and sucralose

[b] Adjusted for calories, age, alcohol and smoking (not depression)

[c] Adjusted for calories, age, alcohol, smoking, and depression

* Milligrams

Bold p <0.05

Part 6. Nutrients and Food Addiction: Using Versus Not Using the Residual Method

Table A3.17. Association between Consumption of Nutrients (2006 and 2007) and Food Addiction (2008 and 2009) in NHS and NHS II: Comparing Adjustment for Nutrients Using "Residual Method" Versus Not

		Crude (residual method)			**Crude (no residual method)**			**Adjusted for all variables[a] (residual method)[b]**			**Adjusted for all variables[a] (no residual method)[b]**		
	Cases	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Total fat: 9.6 - 49.95	741	1.00			1.00			1.00			1.00		
Total fat: 49.96 - 57.3	993	**1.36**	**1.24**	**1.50**	**1.23**	**1.13**	**1.35**	**1.11**	**1.00**	**1.22**	**1.10**	**1.00**	**1.21**
Total fat: 57.31 - 63.66	1251	**1.73**	**1.58**	**1.90**	**1.35**	**1.24**	**1.48**	**1.23**	**1.11**	**1.35**	**1.15**	**1.04**	**1.27**
Total fat: 63.67 - 71.44	1519	**2.12**	**1.94**	**2.32**	**1.62**	**1.49**	**1.77**	**1.34**	**1.22**	**1.47**	**1.36**	**1.22**	**1.52**
Total fat: 71.45 - 147	1996	**2.85**	**2.62**	**3.11**	**2.29**	**2.11**	**2.48**	**1.74**	**1.59**	**1.91**	**1.86**	**1.63**	**2.13**
Saturated fat: 2.31 - 14.93	772	1.00			1.00			1.00			1.00		
Saturated fat: 14.94 - 17.83	1023	**1.34**	**1.22**	**1.48**	**1.25**	**1.14**	**1.36**	**1.10**	**1.00**	**1.21**	1.08	0.98	1.19
Saturated fat: 17.84 - 20.42	1290	**1.72**	**1.57**	**1.88**	**1.43**	**1.31**	**1.56**	**1.26**	**1.15**	**1.38**	**1.16**	**1.05**	**1.28**
Saturated fat: 20.43 - 23.66	1475	**1.99**	**1.82**	**2.18**	**1.61**	**1.47**	**1.75**	**1.34**	**1.22**	**1.47**	**1.24**	**1.12**	**1.38**
Saturated fat: 23.67 - 65.86	1940	**2.67**	**2.45**	**2.91**	**2.40**	**2.21**	**2.60**	**1.63**	**1.49**	**1.78**	**1.71**	**1.52**	**1.93**
Trans fat: 0.11 - 1.26	859	1.00			1.00			1.00			1.00		
Trans fat: 1.27 - 1.55	1039	**1.19**	**1.08**	**1.30**	**1.17**	**1.07**	**1.28**	1.06	0.96	1.16	1.04	0.94	1.14
Trans fat: 1.56 - 1.81	1218	**1.46**	**1.34**	**1.60**	**1.33**	**1.21**	**1.45**	**1.17**	**1.07**	**1.28**	1.08	0.99	1.19
Trans fat: 1.82 - 2.14	1425	**1.70**	**1.56**	**1.85**	**1.54**	**1.41**	**1.68**	**1.26**	**1.15**	**1.38**	**1.17**	**1.06**	**1.29**
Trans fat: 2.15 - 7.04	1959	**2.46**	**2.27**	**2.68**	**2.32**	**2.14**	**2.51**	**1.62**	**1.49**	**1.77**	**1.61**	**1.44**	**1.80**
Sodium[c]: 323 - 1680	681	1.00			1.00			1.00			1.00		
Sodium: 1681 - 1908	971	**1.44**	**1.30**	**1.59**	**1.24**	**1.13**	**1.36**	**1.26**	**1.14**	**1.39**	**1.17**	**1.06**	**1.29**
Sodium: 1909 - 2111	1147	**1.72**	**1.56**	**1.89**	**1.47**	**1.34**	**1.61**	**1.33**	**1.20**	**1.46**	**1.34**	**1.22**	**1.49**
Sodium: 2112 - 2357	1580	**2.40**	**2.19**	**2.63**	**1.82**	**1.66**	**1.98**	**1.66**	**1.51**	**1.82**	**1.63**	**1.46**	**1.81**
Sodium: 2358 - 6817	2121	**3.32**	**3.04**	**3.63**	**2.57**	**2.37**	**2.80**	**2.06**	**1.87**	**2.26**	**2.23**	**1.96**	**2.52**

		Crude (residual method)			**Crude (no residual method)**			**Adjusted for all variables[a] (residual method)[b]**			**Adjusted for all variables[a] (no residual method)[b]**		
	Cases	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Total sugar: 8.7 - 72.8	1599	1.00			1.00			1.00					
Total sugar: 72.9 - 87.5	1454	**0.90**	**0.84**	**0.97**	0.97	0.90	1.05	**0.82**	**0.76**	**0.88**	**0.76**	**0.70**	**0.83**
Total sugar: 87.6 - 100.8	1352	**0.84**	**0.78**	**0.90**	0.94	0.87	1.02	**0.72**	**0.67**	**0.78**	**0.63**	**0.57**	**0.68**
Total sugar: 100.9 - 117.5	1106	**0.68**	**0.63**	**0.73**	0.95	0.88	1.03	**0.58**	**0.53**	**0.63**	**0.52**	**0.47**	**0.57**
Total sugar: 117.6 - 370.4	989	**0.60**	**0.56**	**0.66**	0.97	0.89	1.05	**0.48**	**0.44**	**0.52**	**0.35**	**0.31**	**0.39**
Added sugar: 0.01 - 24.02	1228	1.00			1.00			1.00			1.00		
Added sugar: 24.03 - 32.76	1348	**1.10**	**1.02**	**1.19**	1.02	0.94	1.11	0.95	0.88	1.04	**0.85**	**0.78**	**0.92**
Added sugar: 32.77 - 41.58	1322	**1.09**	**1.00**	**1.18**	**1.12**	**1.03**	**1.21**	**0.87**	**0.80**	**0.94**	**0.81**	**0.74**	**0.88**
Added sugar: 41.59 - 54.67	1358	**1.11**	**1.03**	**1.20**	**1.20**	**1.11**	**1.30**	**0.87**	**0.80**	**0.94**	**0.76**	**0.70**	**0.84**
Added sugar: 54.68 - 334.92	1244	1.02	0.94	1.11	**1.26**	**1.17**	**1.37**	**0.72**	**0.66**	**0.79**	**0.65**	**0.58**	**0.71**
Fructose: 0.71 - 13.7	1808	1.00			1.00			1.00			1.00		
Fructose: 13.71 - 17.67	1512	**0.82**	**0.77**	**0.88**	**0.86**	**0.80**	**0.93**	**0.82**	**0.76**	**0.88**	**0.76**	**0.70**	**0.82**
Fructose: 17.68 - 21.57	1232	**0.66**	**0.61**	**0.71**	**0.81**	**0.75**	**0.87**	**0.66**	**0.61**	**0.71**	**0.64**	**0.59**	**0.70**
Fructose: 21.58 - 26.95	1016	**0.54**	**0.50**	**0.59**	**0.76**	**0.70**	**0.82**	**0.55**	**0.50**	**0.59**	**0.54**	**0.49**	**0.59**
Fructose: 26.96 - 144.6	932	**0.50**	**0.46**	**0.54**	**0.69**	**0.64**	**0.75**	**0.48**	**0.44**	**0.52**	**0.37**	**0.34**	**0.41**
Glucose: 1.08 - 13.45	1775	1.00			1.00			1.00			1.00		
Glucose: 13.46 - 16.85	1536	**0.85**	**0.80**	**0.92**	**0.87**	**0.80**	**0.94**	**0.84**	**0.78**	**0.91**	**0.74**	**0.69**	**0.81**
Glucose: 16.86 - 20.28	1259	**0.69**	**0.64**	**0.74**	**0.85**	**0.79**	**0.92**	**0.69**	**0.64**	**0.74**	**0.64**	**0.59**	**0.70**
Glucose: 20.29 - 25.19	1035	**0.57**	**0.52**	**0.61**	**0.83**	**0.76**	**0.89**	**0.56**	**0.52**	**0.61**	**0.55**	**0.50**	**0.60**
Glucose: 25.2 - 150.27	895	**0.49**	**0.45**	**0.53**	**0.70**	**0.65**	**0.76**	**0.48**	**0.44**	**0.52**	**0.36**	**0.32**	**0.40**

		Crude (residual method)			Crude (no residual method)			Adjusted for all variables[a] (residual method)[b]			Adjusted for all variables[a] (no residual method)[b]		
	Cases	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Sucrose: 0.53 - 24.83	1416	1.00			1.00			1.00			1.00		
Sucrose: 24.84 - 31.47	1429	1.01	0.93	1.09	0.97	0.90	1.05	**0.90**	**0.83**	**0.97**	**0.81**	**0.74**	**0.88**
Sucrose: 31.48 - 37.96	1278	**0.89**	**0.83**	**0.97**	0.98	0.91	1.06	**0.76**	**0.70**	**0.83**	**0.72**	**0.66**	**0.78**
Sucrose: 37.97 - 46.8	1220	**0.86**	**0.79**	**0.93**	1.06	0.98	1.15	**0.72**	**0.66**	**0.78**	**0.67**	**0.61**	**0.73**
Sucrose: 46.81 - 189.92	1157	**0.81**	**0.75**	**0.88**	1.08	0.99	1.16	**0.66**	**0.61**	**0.72**	**0.53**	**0.47**	**0.59**
Starch: 0.9 - 60.4	1054	1.00			1.00			1.00			1.00		
Starch: 60.5 - 71.8	1113	1.05	0.96	1.14	1.01	0.93	1.11	0.97	0.89	1.06	**0.90**	**0.82**	**0.98**
Starch: 71.9 - 81.8	1262	**1.21**	**1.11**	**1.32**	**1.13**	**1.04**	**1.23**	1.01	0.92	1.10	**0.90**	**0.82**	**0.99**
Starch: 81.9 - 94.2	1405	**1.36**	**1.25**	**1.47**	**1.26**	**1.16**	**1.37**	1.01	0.92	1.10	**0.90**	**0.82**	**0.99**
Starch: 94.3 - 251.7	1666	**1.62**	**1.49**	**1.75**	**1.74**	**1.61**	**1.88**	1.06	0.98	1.15	0.97	0.86	1.08
Artificial sugar: 0.02	761	1.00			1.00			1.00			1.00		
Artificial sugar: 0.03 - 0.26	651	**1.39**	**1.25**	**1.54**	**1.39**	**1.25**	**1.55**	**1.43**	**1.29**	**1.60**	**1.42**	**1.27**	**1.58**
Artificial sugar: 0.27 - 2.39	1285	**2.15**	**1.96**	**2.35**	**2.21**	**1.99**	**2.44**	**1.91**	**1.74**	**2.10**	**1.97**	**1.77**	**2.18**
Artificial sugar: 2.40 - 12.02	1691	**2.88**	**2.64**	**3.15**	**3.07**	**2.79**	**3.38**	**2.39**	**2.18**	**2.61**	**2.51**	**2.27**	**2.77**
Artificial sugar: 12.03 - 147.63	2112	**3.67**	**3.37**	**3.99**	**3.83**	**3.48**	**4.21**	**3.01**	**2.76**	**3.28**	**3.13**	**2.84**	**3.44**

NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval

[a] Adjusted for calories, age, alcohol, smoking and depression

[b] Energy adjusted nutrient intakes are calculated as residuals from the regression model with total caloric intake as the independent variable and absolute nutrient intake as the dependent variable. The residual method is advantageous because nutrient residuals offer a measure of nutrient consumption that is not correlated with total energy intake, and this method isolates the variation in nutrient intake caused by the nutrient composition of the diet. Total energy intake is held constant while the amount of the nutrient varies between exposure groups (see Willett, "Nutritional Epidemiology," 1998)

[c] Milligrams

Bold $p < 0.05$

Part 7. Further Examination of the Sugar-Food Addiction Results

Table A3.18. Further Examination of Sugar Analyses: Association Between Food Addiction (2008 and 2009) and Consumption of Sugar per Day in 2006/2007, 1980 and Among Normal Weight Nurses in 2006/2007

Quintiles of Consumption	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Added Sugar					
2006-2007					
Multivariable OR (95% CI)[a]	1.00	0.95 (0.88, 1.04)	**0.87 (0.80, 0.94)**	**0.86 (0.80, 0.94)**	**0.72 (0.66, 0.79)**
1980 (NHS only)					
Multivariable OR (95% CI)[a]	1.00	0.85 (0.71, 1.02)	0.87 (0.73, 1.05)	**0.79 (0.66, 0.95)**	**0.82 (0.68, 0.98)**
Nurses with BMI 18.5-25					
Multivariable OR (95% CI)[b]	1.00	0.96 (0.74, 1.26)	0.96 (0.74, 1.25)	0.96 (0.74, 1.25)	0.90 (0.69, 1.18)
Fructose					
2006-2007					
Multivariable OR (95% CI)[a]	1.00	**0.82 (0.76, 0.88)**	**0.66 (0.61, 0.71)**	**0.55 (0.51, 0.59)**	**0.48 (0.44, 0.52)**
1980 (NHS only)					
Multivariable OR (95% CI)[a]	1.00	**0.80 (0.67, 0.95)**	**0.81 (0.68, 0.97)**	**0.80 (0.67, 0.95)**	0.86 (0.72, 1.02)
Nurses with BMI 18.5-25					
Multivariable OR (95% CI)[b]	1.00	0.82 (0.64, 1.05)	**0.72 (0.56, 0.92)**	**0.49 (0.38, 0.65)**	**0.62 (0.48, 0.79)**
Glucose					
2006-2007					
Multivariable OR (95% CI)[a]	1.00	**0.84 (0.79, 0.91)**	**0.69 (0.64, 0.74)**	**0.56 (0.52, 0.61)**	**0.48 (0.44, 0.52)**
1980 (NHS only)					
Multivariable OR (95% CI)[a]	1.00	**0.79 (0.66, 0.95)**	**0.75 (0.63, 0.90)**	**0.82 (0.69, 0.98)**	0.85 (0.71, 1.01)
Nurses with BMI 18.5-25					
Multivariable OR (95% CI)[b]	1.00	0.91 (0.71, 1.15)	**0.69 (0.54, 0.89)**	**0.58 (0.44, 0.75)**	**0.56 (0.43, 0.73)**

Quintiles of Consumption	Q1	Q2	Q3	Q4	Q5
Sucrose					
2006-2007					
Multivariable OR (95% CI)[a]	1.00	**0.90 (0.83, 0.97)**	**0.76 (0.70, 0.83)**	**0.71 (0.66, 0.77)**	**0.66 (0.61, 0.72)**
1980 (NHS only)					
Multivariable OR (95% CI)[a]	1.00	0.89 (0.75, 1.06)	**0.79 (0.66, 0.95)**	0.88 (0.73, 1.05)	**0.75 (0.63, 0.91)**
Nurses with BMI 18.5-25					
Multivariable OR (95% CI)[b]	1.00	1.13 (0.87, 1.48)	0.94 (0.71, 1.24)	0.96 (0.73, 1.26)	0.94 (0.71, 1.23)
Artificial Sugar					
2006-2007					
Multivariable OR (95% CI)[a]	1.00	**1.44 (1.29, 1.60)**	**1.91 (1.74, 2.10)**	**2.38 (2.18, 2.61)**	**3.01 (2.76, 3.28)**
1980 (NHS only)					
Multivariable OR (95% CI)[a]	1.00	**1.47 (1.32, 1.63)**	**1.92 (1.75, 2.11)**	**2.46 (2.25, 2.69)**	**3.26 (3.00, 3.55)**
Nurses with BMI 18.5-25					
Multivariable OR (95% CI)[b]	1.00	**1.44 (1.08, 1.93)**	**1.67 (1.27, 2.19)**	**2.07 (1.59, 2.70)**	**2.74 (2.12, 3.53)**

NHS, Nurses' Health Study; OR, Odds Ratio; CI, Confidence Interval; BMI, body mass index

P-value, test for trend was <0.0001 for all nutrients

[a] Adjusted for alcohol (never, 1-15 g/day, 15+ g/day), smoking (never, 1-14 cig/day, 15+ cig/day) and depression (yes or no)

[b] Additionally adjusted for BMI

Bold p <0.05

Part 8. Number of Significant Analyses

Table A3.19. Number of Significant Analyses

Exposure type	Analyses (n)	Significant Analyses (n)
Nutrients	11	11
Fatty foods	11	11
Salty foods	7	5
Desserts	17	13
Starchy foods	5	4
Fruits and Vegetables	6	5
Beverages	7	7
Artificial sweeteners	2	2
Food groups	5	5
	71	63

Chapter 5. Conclusions

"The classification of symptoms into discrete disease entities is perhaps the most essential component of diagnostic psychiatry because precise diagnostic schemes presumably distinguish particular conditions from one another in ways that matter for their etiology, prognosis, and treatment."

– Allan Horwitz, *Creating Mental Illness*

At the beginning of the 19th century in the United States, asylums treated only the most serious mental disorders—dementia praecox (schizophrenia) and depression (including bipolar disorder).[1] Mental disorder labels were reserved only for the most bizarre or inappropriate behavior. At the end of the 19th century, Freud transformed the field of psychiatry by introducing a broad range of neuroses and blurring the boundary between what is considered normal versus pathological.[1, 2] Since its first edition in 1952, the Diagnostic and Statistical Manual of Mental Disorders has reflected our society's changing perceptions and understanding of mental illness through its evolving dictionary of symptoms and diagnoses. Over the years, the American Psychiatric Association has entered, moved, and removed disorders from the manual: homosexuality was included in 1952 and removed in 1973, problem gambling was added under one category (Impulse Control Disorders) in 1980 and moved to a new one in 2013 (Substance-Related and Addictive Disorders), and Aspergers syndrome was added in 1994 and removed in 2013. The evolving taxonomy of mental disorders influenced the writing of this dissertation.

The aim of this dissertation was to determine whether food addiction, an unofficial yet popularized condition, could be a valid mental disorder and substance-related disorder such that it deserves inclusion in the Diagnostic and Statistical Manual of Mental Disorders. I tackled this by identifying elements that contribute to validating a disorder in general, detecting gaps in the

food addiction literature, and analyzing data to answer remaining questions. Many characteristics contribute to the validation of a disorder: face validity, construct validity, reliable and valid operationalized measures, and a prevalence of the disorder in different populations. I examined each of these in Chapters 2 through 4.

Summary of Results

Part 1 of Chapter 2 evaluated the face validity of food addiction. I assessed whether the disorder could meet the criteria for a mental disorder and substance-related disorder as defined by the Diagnostic and Statistical Manual of Mental Disorders and an addiction as defined by the National Institute on Drug Abuse. I concluded that food addiction could plausibly be a mental disorder as it could be characterized by dysfunction leading to harm and impairment, and it could be a substance-related disorder and addiction as it could plausibly have the same internal dysfunction as an addiction. Although evidence from animal studies generally supports this, the neurological evidence on food addiction is limited and indirect. Most studies have examined obese versus non-obese subjects rather than those with and without food addiction. The two studies comparing subjects with and without food addiction found greater neurological changes in response to consuming palatable food among those with higher food addiction scores. Based on the phenomenological, animal and neurological evidence, I concluded that food addiction has face validity.

Part 2 of Chapter 2, I evaluated the construct validity of human food addiction through a systematic review of the literature. I evaluated whether operationalized measures of the disorder were associated with other constructs in hypothesized directions. Part 2 also summarized the operationalized tools used to measure food addiction and prevalence estimates in different populations. I began with hypotheses about variables expected to be associated with food

addiction in certain ways, and ended with a report about whether the literature supported these hypotheses. Associations found to support my hypotheses, support the construct validity of food addiction.

The systematic review identified 36 published studies on human food addiction and found that prevalence estimates ranged from approximately 5% in the general population to over 50% in obese groups, standardized scales generally had good psychometric properties, and the disorder appeared to be associated with other constructs in hypothesized directions in some studies. I hypothesized that food addiction would be positively associated with variables related to consumption of high fat and high sugar foods, binge eating disorder, body mass index, and depression and inversely associated with age and current substance use. Fifty percent of reported associations supported my hypotheses; the vast majority of the other fifty percent were consistent with the null hypothesis. All associations reported between food addiction and binge eating disorder were positive. Theoretical evidence supported the disorders being distinct from one other, and although the empirical evidence was more nuanced, the disorders appeared to be statistically distinguishable. Depression was almost always positively associated with food addiction; however, most studies reported no, rather than inverse associations with age and substance use. Only 50% of findings supported a positive relationship with body mass index. Almost all studies reporting no association with body mass index were in overweight and obese populations; none of the positive associations were. While methodological limitations likely explained some of these findings (e.g., small sample sizes, restricted variation of the outcome variable, insufficient confounder control, etc.), other findings were more inexplicable. In particular, there was no association between food addiction and sugar-related variables—including sugar craving and percent of diet from carbohydrates—in 75% of the reported findings.

This contradicts a sugar addiction hypothesis, which, as evidenced in Chapter 2, Part 1, is supported by a large body of animal research. It is possible that subjects with food addiction are more likely than subjects without food addiction to underreport their true experience with sugar-related cravings and liking; however, it is unclear why they would underreport these variables as opposed to also ones related to fatty foods. Chapter 4 explored these relationships further.

The systematic review indicated that the food addiction scales have good psychometric properties. However, studies did not measure certain important aspects of their reliability and validity—namely test-retest reliability and the sensitivity and specificity of the shorter scale compared with the original. As such, in Chapter 3, I used two community-based convenience samples to assess whether two operationalized measures of food addiction—the original Yale Food Addiction Scale and the shorter Modified Yale Food Addiction Scale (proxy) have good internal and test-retest reliability. In addition, I evaluated whether the shorter scale has good sensitivity and negative predictive value using the original scale as the standard. Finally, I estimated the prevalence of food addiction, overall and stratified by gender. I found that the original and shorter scales had good internal and test-retest reliability, and the shorter scale had good sensitivity and negative predictive value using the original scale as the standard. The prevalence of food addiction ranged from 5% to 10%, and was higher among women, which corroborated findings from the systematic literature review. Significant limitations of these analyses were the small sample sizes leading to unstable estimates and the non-representative samples.

The systematic literature review in Chapter 2 as well as reviews by others[3-6] indicated that a critical gap in the literature was the relationship between addictive eating and the substance itself—potentially positively reinforcing foods. Chapter 4 used data from the Nurses'

Health Study cohorts— two large cohorts of female nurses—to evaluate relationships between food addiction and consumption of nutrients, food items, and food groups. I hypothesized that food addiction, measured by the Modified Yale Food Addiction Scale in 2008 and 2009 would be positively associated with consumption of nutrients and foods high in fat, salt, sugar, and/or starch, measured by the Food Frequency Questionnaire in 2006 and 2007. I used multivariable logistic regression and controlled for age, calorie consumption, depression, smoking, and alcohol consumption.

While some findings supported my hypotheses, others did not. In general, fatty and salty foods were positively associated with food addiction. In particular, consumption of fat and sodium, pizza, French fries, hamburgers, and popcorn had the strongest associations with food addiction. Consumption of certain sweet foods, such as milk chocolate and candy bars were also strongly associated with food addiction. Contrary to our hypothesis, consumption of starch, starchy food items, and the starchy food group was not or inversely associated food addiction. In addition, contrary to the sugar addiction hypothesis, consumption of most sweet food items, including ice cream, donuts, cake, and cookies were not or inversely associated with food addiction. In addition, consumption of total sugar, added sugar, fructose, glucose, and sucrose were significantly inversely associated with food addiction. Further post-hoc analyses indicated that consumption of diet foods and artificial sugar was positively associated with food addiction. These surprising findings corroborated those from the systematic review, which indicated that most studies found no association between food addiction and sugar-related variables. Although it is tempting to conclude that sugar consumption lowers the odds of food addiction and diet food consumption increases them, there was potential for reverse causation bias due to cross-sectional data and analyses. It is unclear whether consumption of sugar increased the odds of food

addiction, or whether having food addiction lowered the odds of sugar consumption. Likewise, it would be rash to conclude that consumption of certain fatty and salty foods causes food addiction. Future prospective analyses could help tease apart these relationships. Despite these controversial findings, the biggest contribution of Chapter 4 was that it provided the first evaluation of the associations between consumption of different foods and food addiction. These associations are fundamental to understanding the internal dysfunction of addictive eating, i.e., the relationship between compulsive eating and the substance itself.

My dissertation added to the burgeoning literature on food addiction by evaluating the theoretical (review of the literature) and empirical (two quantitative analyses) evidence on whether food addiction could be a valid mental disorder and substance-related disorder. My analysis of the food addiction literature in Chapter 2, quantitative analyses of never-before evaluated psychometric properties of two scales in Chapter 3, and use of two large epidemiologic samples to quantify the relationship between consumption of potentially positively reinforcing nutrients, foods, and food groups and food addiction in Chapter 4, helped close some critical gaps in the literature.

Despite these contributions, my dissertation had limitations. First, as I was the only author who reviewed, extracted and tabulated food addiction data for the literature review in Chapter 2, it is possible that I made tabulation and/or categorization errors. However, multiple tabulation and categorization checks limited this potential. Second, I did not search unpublished literature (e.g., conference abstracts), and it is possible that the literature I identified was biased towards positive findings. Third, the analyses of the reliability and validity of food addiction scales in Chapter 3 were based on small samples, which led to unstable estimates. In addition, as these samples were convenience-based and not representative, findings may not extrapolate to

the general population. In Chapter 4, cross-sectional analyses were not ideal for determining causality, and potential reverse causation bias threatened the validity of results. In addition, because the sample comprised mostly Caucasian female nurses, findings may not extrapolate to men or women of other socioeconomic groups or races.

Implications

In my application for the Psychiatric Epidemiology Training program at Columbia in 2009, I wrote:

"…I believe that addictive eating should be examined more rigorously. I would like to define the construct of addictive eating, to evaluate how it might differ from current established eating disorders such as bulimia and binge eating, and to determine whether it might be associated with anxiety and mood disorders, other substance use disorders, and/or obesity. I realize that operationalizing my idea into practice will take a lot of work and consideration, but if it is feasible, I am determined to pursue it."

My "gut" told me that food addiction was a valid mental disorder and substance-related disorder. For years I had observed people I believed were addictive eaters—not just strangers on the street, but also friends and family. These individuals struggled with eating their whole lives: they tried, but could not lose weight; they ate in secret; they hid snack food; they ate in their car. Their relationship with food was emotional—they ate when they were angry, sad, or lonely; they used food to "fill a void," which, for others, might be filled by alcohol, cigarettes or more dangerous substances. For these individuals, food had become their drug of choice. The consequences of their eating caused distress. They were obese and almost diabetic. They had high blood pressure and elevated liver enzymes. Physical activity was painful, so it was easier not to move.

And then I realized: if food addiction were a valid mental disorder and addiction, my friends and family would not feel alone anymore. Their disordered eating would finally be validated with a label. Many addictions are treatable. Maybe drug companies could develop a medication to help control their food cravings.

The same year that I applied to the Psychiatric Epidemiology Training program, Gearhardt and colleagues published the first study to use a validated measure of food addiction. Well, I thought, this will make my dissertation easier; now I won't have to create a scale from scratch. But will I have to collect my own data? Or could I use existing samples that measured food addiction? I contacted Dr. Ashley Gearhardt, who told me that she and her colleagues had collected food addiction data in two community-based convenience samples in New Haven; one was intended to measure the test-retest reliability of the Yale Food Addiction Scale. Serendipitously, they gave me permission to use their data. I then learned that Harvard Medical Center had recently piloted a modified version of the food addiction scale in the Nurses' Health Study cohorts, two large samples of female nurses. If I could use these data, I thought, my committee might allow me to write a dissertation on food addiction. I had connections at the Harvard School of Public Health from my time there as a Master's student, so I contacted my former professor, Dr. Eric Rimm, and he helped me secure use of certain variables for my dissertation.

Now, six years later, my dissertation on food addiction is near completion, and 36 other studies have been published on the topic. We now know that food addiction is prevalent in different populations, scales used to operationalize the construct are reliable and valid, and it is positively correlated with binge eating disorder, body mass index, emotional eating, and

depression. Although gaps in the literature remain, it seems that food addiction is on its way to becoming a valid mental disorder and substance-related disorder.

Classifying food addiction as a valid mental disorder could have significant treatment, public health, and prevention consequences.[7, 8]

First, if research supports the validity of food addiction, we will better understand a group of behaviors that is not new, but rather has been previously overlooked and not well-understood. Although the public advocates for addictive eating to be recognized as a devastating disorder leading to shame, isolation, and physical illness, scientific evidence supporting its validity would help convince researchers and clinicians to research and treat the disorder. Validation of the disorder could provide suffering individuals with a sense of control over their condition, and it may empower them to seek appropriate help, whether from mental health professionals, community-run organizations such as Overeaters Anonymous, or new medications. Behavioral or psychological treatment for food addiction may be different from treatment for binge eating disorder, as treatment for substance dependence commonly focuses on reduction of or abstinence from a substance and/or identifying triggers for overuse of the substance, while binge eating disorder treatments focus on shape and weight concerns and dieting behaviors.[9] However, being labeled a "food addict" could also increase stigma and lower self-esteem. Promisingly, a study assessing feelings and beliefs toward eight different types of people (obese, food addict, physically disabled, obese food addict, obese physically disabled, mentally ill, cocaine addict, and smoker) found that the stigma associated with the label "food addict" might be less severe than stigma associated with other types of addiction.[10]

Validating food addiction as a mental disorder could have significant public health implications. Prevalence estimates suggest that 5 to 10% of individuals may have food addiction.

This disorder could contribute to the development of chronic diseases such as obesity, diabetes, depression, or cardiovascular disease. We therefore may need to shift from standard prevention measures such as increasing exercise and eating a healthy diet, to treating or preventing the onset of addiction, focusing on avoiding consumption of specific nutrients, foods or food groups that may trigger addictive eating.

Preventing food addiction could have serious consequences for the food industry. In the fight against tobacco, the public was informed when research determined that nicotine was an addictive substance.[11, 12] If research finds that certain foods have addictive potential, the public's belief that food can be addictive would be validated, and people would deserve to know which foods have addictive potential. The consequences for the food industry could be dire.

The food industry is currently resistant to taxing unhealthy food products or restricting food portion sizes. Their primary motivator, as for all private industries, is profit. Many unhealthy foods are advertised to children, and ingredients often lack clear and proper labeling (e.g., many companies—especially those selling organic products—label sugar as "evaporated cane juice"). If certain foods are deemed addictive, it is unlikely that the food industry or individuals would regulate themselves; the legal system would have to control advertising to children and enforce proper labeling of food products, just as it currently does with tobacco, and to some degree, alcohol.

Thus, the validation of food addiction as a mental disorder would likely have individual, community, political, and industry-wide consequences. While these consequences have the potential to help individuals receive new improved treatment that they may currently lack, they could also lead to heated controversy surrounding food labeling, advertising, taxation, and public health.[13]

At the beginning of the dissertation process, I believed that food addiction was a legitimate mental disorder. Each chapter of my dissertation arguably contributed to better understanding the construct; however, my findings must be considered within the larger context of the extant literature. Generally, studies have been small, cross-sectional in design or analysis, and/or did not sufficiently control for confounders. Also, while studies have examined many potential correlates of food addiction, most variables have been examined in only one to a few studies, and sometimes findings conflicted with one another. We particularly need to better understand food addiction's relationship with consumption of potentially positively reinforcing foods, age, body mass index, and substance use.

Future research should investigate the onset and course of food addiction. We do not know whether food addiction is an adult disorder, whether it occurs among children or adolescents, and/or whether the onset is during childhood, adolescence, or adulthood. We also do not know whether and to what degree the disorder may start and stop, or whether it is chronic throughout the life course. Researchers have begun to evaluate some of its correlates, but we have very little knowledge of its causes and consequences. Prospective data will allow us to better understand the timing of the onset and course of food addiction, and whether variables such as consumption of palatable foods, total energy intake, depression, and obesity precede or follow food addiction. These data will also allow us to explore whether food addiction may be preventable.

In addition, while we are beginning to understand its prevalence in different populations (e.g., among overweight and obese adults and middle-aged and elderly women), we have little information about its occurrence in the general population. The majority of study samples have been small and non-representative. Further, studies have only investigated the disorder among

European, Canadian and American populations—all of which have high rates of obesity and access to an overabundance of highly processed palatable foods. We do not know whether food addiction only affects the developed world where obesity is common, or whether it also occurs in parts of the world where obesity is non-endemic and/or processed food is scarce.

At the end of this process, I realize that our understanding of food addiction is incomplete, and entry into the Diagnostic and Statistical Manual of Mental Disorders would be premature. Larger, representative samples, prospective analyses, and appropriate control for confounders will help strengthen the validity of the construct.

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