

# Exploring the Relationship between the Fast Food Environment and Obesity Rates in the US vs. Abroad: A Systematic Review

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## Abstract

Obesity remains one of the greatest public health concerns in our modern-day society, necessitating an understanding of the underlying contributing factors. This systematic review examines the existing literature to better understand the relationship between the fast food environment and obesity rates within the United States (US) compared to other countries throughout the world. To be included in our review, studies must have been peer-reviewed, published in English, and had to include some measure of analysis of the fast food environment and rates of obesity. Based on the results of our review (n=46 studies), the findings were largely similar between US and non-US studies; in both cases, there were inconsistent associations between the fast food environment and rates of obesity/overweight. However, in terms of socioeconomic status (SES), our findings were consistent across both US and non-US studies; lower SES was associated with unfavourable fast food environments, higher concentrations of fast food restaurants, higher consumption of junk food, and higher obesity rates. Based on the results of our review, we conclude that more longitudinal research must be performed with consistent methodology in order to more clearly understand the role of the fast food environment in the development of obesity.

**Keywords:** Fast food environments; Obesity rates; Socioeconomic status; Obesity risk factors

## Introduction

In modern day society, the prevalence of childhood and adult obesity remains one of the greatest public health concerns, especially in the United States (US). Obesity is officially defined by the World Health Organization as a Body Mass Index (BMI) of 30 and above [1]. An estimated 36.5% of US adults and 17.0% of US youth aged 2-19 are affected by obesity. Both youth and adult obesity rates have increased in the US in recent years [2]. Similar concerns regarding increasing rates of obesity exist in other countries throughout the world, particularly those considered developed [3]. Obesity can lead to the development of a myriad of adverse health conditions in affected individuals; for example, obesity has been linked to serious, complex medical conditions such as diabetes, sleep apnea, and cancer [4]. One of the particular concerns is the link between obesity and the prevalence of abnormal levels of cardio metabolic variables, which may eventually lead to the development of cardiovascular disorders [5]. With the wide range of severe health concerns associated with obesity, an understanding of the factors contributing to the development of obesity is essential.

In recent years, there has been a greater focus on environmental factors potentially contributing to the development of obesity. There has been growing consensus that environmental factors play a prevalent role in determining body weight, leading to a shift in focus from individual to population level issues. The presence of fast food restaurants is one particular environmental factor of interest. An increase in the consumption of fast food has been associated with poorer diet quality and higher energy intake at the individual level [6-8]. However, previously conducted reviews examining the associations between the fast food environment and obesity have largely found inconsistent associations at the population level [9,10]. In addition, no previous study has examined associations between fast food restaurants and rates of obesity across various settings, such as across countries. Building on previously conducted reviews, this review sought to explicitly examine the methodology used in studies and to compare the associations between the fast food environment, socioeconomic factors, and obesity in the US and other countries throughout the world where literature was present to better understand the cross-cultural impact of the fast food environment. To our knowledge, no such review

directly comparing study methodology and the associations between the fast food environments and rates of obesity within and outside the US has previously been conducted. This topic of interest has a variety of potential policy and land-use implications and is particularly relevant as increasing attention has been brought to food environments as a potential contributor to the development of obesity [11-18].

## Materials and Methods

A review of the existing literature was performed to identify peer-reviewed works studying the relationship between the fast food environment and obesity. Searches for this review were performed in the online databases Pubmed (Medline) and Scopus for studies published between January 1<sup>st</sup>, 2005 and December 31<sup>st</sup>, 2015. Based on an examination of previously conducted review articles, the key words included in the online search were “fast food,” “fast food outlet,” “fast food restaurant,” “fast food environment,” “quick service restaurant,” “concentration of fast food restaurants,” “obesity,” “overweight,” “BMI,” “rate of obesity,” and “global obesity.” Several (Put exact number) duplicate studies from Pubmed (Medline) and Scopus were found in the initial search. To be included in our review, studies must have been published in English. Case studies and expert opinion published works were excluded. Studies that met our inclusion criteria were then further filtered based on their abstract; the abstract must have discussed a measure of the surrounding food environment involving fast food restaurants and a measure of rates of overweight/obesity [19]. Finally, the full papers of studies that passed the abstract criteria were reviewed one more time before inclusion to confirm the presence of the desired inclusion criteria. Screening was performed in accordance with the PRISMA statement.

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Once a study had met all the inclusion criteria, the following data were extracted from the study: 1) Type of Study, 2) Type of Statistical Analysis, 3) Sample Size, Source of Data, 4) Location/Scale of Study (Country, City, Urban/Rural, School, etc.), 5) Fast-Food Definition Utilized, 6) Measure of Fast Food Environment, 7) Other Variables Considered, 8) Health Outcomes Measured, 9) Relationship with Socioeconomic Status, 10) Key Findings.

## Results

After excluding repeats, 59 papers passed the abstract criteria, and 46 papers (12-56) were included in the final set of data. A flowchart of the selection and evaluation process is detailed in (Figure 1). The included studies and the extracted data are presented in (Table 1). A summary of the extracted data is present in (Tables 2 and 3).

### Further categorization of included studies

Fast food access studies categorized by country: One of the 46 studies included in the final review, 34 studies were conducted in the US, three studies were performed in the United Kingdom, three studies were performed in Canada, one study was performed in Taiwan, one study was performed in Australia, one study was performed in China, and one study was performed in Germany. Two studies examined multiple countries simultaneously: One study examined 26 countries at once [20-26], and another study [27-30] examined three countries simultaneously (US, Scotland and Canada). A majority of studies (76%) were performed within the US.

### Study designs and statistical analyses utilized by included studies

The vast majority (n=41, 89%) of the included studies were cross-sectional in design; only five [14,16,21,30] of the included studies were

longitudinal. Every included study performed some sort of regression or correlation analysis to study the relationship between the fast food environment and rates of obesity in a certain study population; a large portion (n=25, 54%) of included studies also utilized a multi-level/multivariable/weighted/hierarchical regression analysis.

### Populations studied and outcomes measured in included studies

Included studies differed in terms of the populations they examined. Some studies (n=17, 37%) explicitly stated that they only studied children (under the age of 18). Other studies (n=18, 39%) explicitly stated that they only studied adults (over the age of 18); the adults included in these studies ranged from young adults to pregnant mothers to adults over the age of 50. Finally, the remainder of studies either did not mention the specific ages of their study populations or studied some combination of both children and adults. The included studies that examined children often studied the effects of fast food environment around schools (elementary school and/or high school). A total of five studies in the US studied the food environment specifically around schools, a total of three studies outside the US studied the food environment around schools, and one study [30-35] compared the effects of the food environment around schools in US, Canada, and Scotland. Included studies were relatively similar in terms of the outcomes they measured; almost all the included studies obtained height and weight measures to calculate the BMI of the study population and used the BMIs to find the rate of obesity. Only one study [36-41] did not include a measurement for obesity/overweight rates; this study examined pregnant women and their infants, and examined the probability of “excessive weight gain” during pregnancy, defined in the study as weight gain of over 40 pounds in the expecting mother. Several studies studied outcomes in addition to BMI, such as dietary behaviour and psychosocial profiles. Although nearly all the included

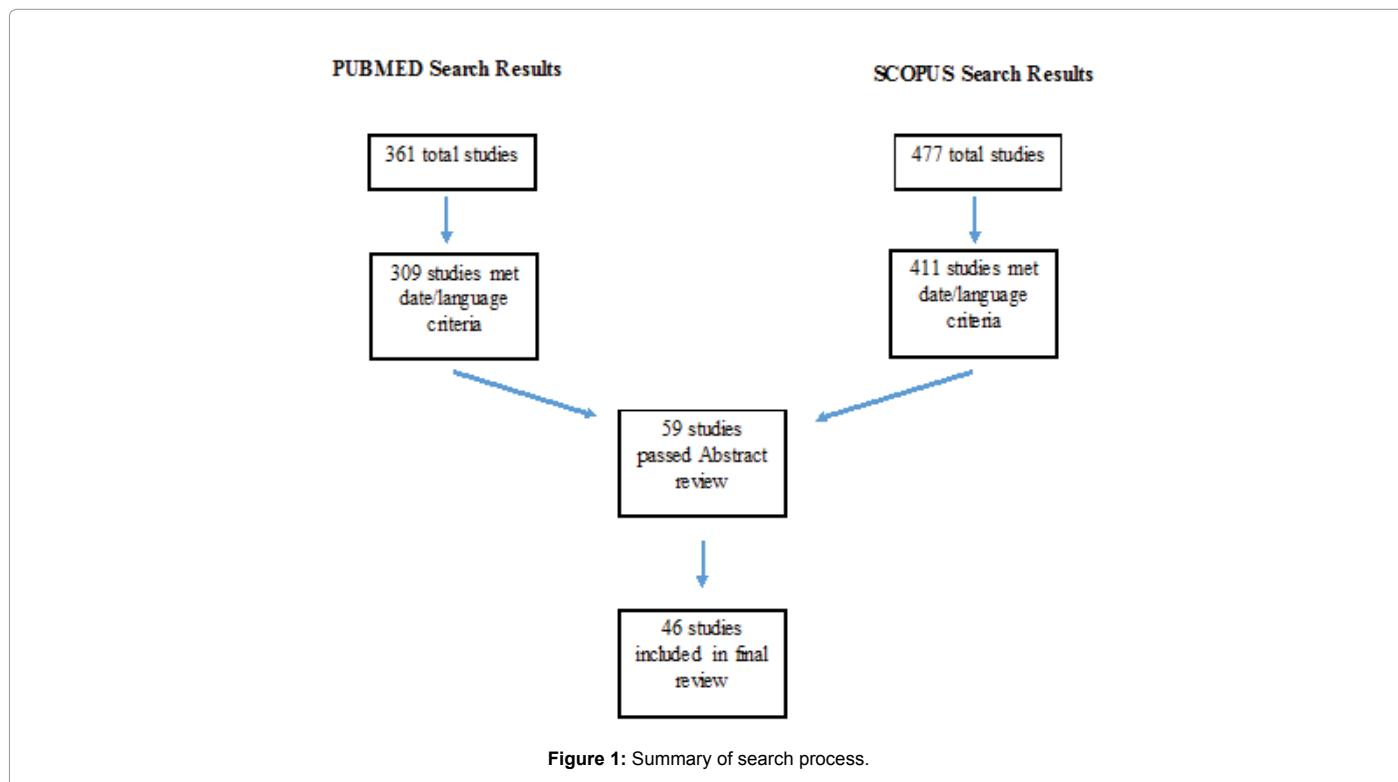


Figure 1: Summary of search process.

Name of Article, First Author, Year, Type of Study, Statistical Analysis Used	Sample Size, Source of Data	Location/Scale (Country, City, Urban/Rural, Schools, etc.)	Fast-Food Definition	Measures of Fast Food Environment (Density, Proximity, etc...)	Other Variables Considered	Health Outcomes Measured	Relationship between Fast Food Restaurants and Socio-economic Status (SES)	Key Findings
<i>A National Study of the Association Between Food Environments and County-Level Health Outcomes</i> , Ahern, 2011 -Cross-Sectional analysis, linear regression models (12)	An unspecified number of participants in the Behavioral Risk Factor Surveillance System (BRFSS)	-US	-Food outlet data obtained from Food Environment Atlas, and 2007 County Business Patterns	-Number of fast food restaurants per 1,000 county residents	-Number of full-service restaurants, grocery stores, and supercenters, urban/rural	-BMI calculated using self-reported data from the BRFSS	-Included SES covariates like race, education, and poverty	-In a metro setting, more fast food restaurants are associated with negative health outcomes; however, in a non-metro setting, negative association between obesity rates and fast food restaurants. -Food access/availability is a key determinant of health outcomes.
<i>The effect of fast-food restaurants on childhood obesity: A school level analysis</i> , Alviola IV, 2014 -Cross-Sectional, Instrument Variable Regression (13)	Unspecified number of Arkansas school children	-US -Arkansas	-Fast food restaurants included "major hamburger chains, drive-in, take-out pizza, quick service tacos, sandwich, and fried chicken outlets	-Geocoded restaurant data purchased from Dun and Bradstreet; then counted number of fast food establishments within various distances from each school	-Gender, Race, Students eligible for free/reduced lunch	-BMI screening data obtained from Arkansas Center for Health Improvement; measurements obtained by trained personnel within schools	-Did not study effects of SES	-From their model, found that addition of a fast food restaurant within a 1-mile radius from school increases obesity rates by 1.23% points. -Found significant evidence of a relationship between school obesity rates and fast food restaurants within one mile.
<i>Proximity to food establishments and body mass index in the framingham heart study offspring cohort over 30 years</i> , Block, 2011 -Longitudinal Cohort Study, Cross-classified/multilevel study (14)	N = 3,113 subjects enrolled in the Framingham Heart Study Offspring Cohort from 1971-2001	-US -4 principal towns: Framingham, Natick, Ashland, and Holliston located in Massachusetts	-Food outlet data classified based on NAICS	-Measured the driving distance between each subject's residential address and the nearest fast food outlet	-Driving distance to the 5 nearest closest food outlets. -Repeated procedure for convenience stores, grocery stores, and chain supermarkets.	-Height and weight were measured individually and BMI was calculated.	-Included measures of SES including poverty, median household income, and percentage black/Hispanic	-Each 1 km increase in distance to the nearest fast food store was associated with a small, significant decrease in BMI of 0.19 only for women in sex-stratified analyses. -No other consistent relationship found between access to food environment and BMI.
<i>The association between obesity and urban food environments</i> , Bodor, 2010 -Cross-Sectional Analysis, Hierarchical Linear Models (15)	N = 3,925 responds to a local BRFSS 2004-2005 telephone survey	-US -167 census tracts across the city of New Orleans	-Food outlet data was obtained from the Louisiana Office of Public Health (OPH) -Fast food restaurants defined as national, regional, and local chain fast food establishments.	-Determined the number of fast food restaurants within a 2 km network buffer around the center of a respondent's census tract.	-Determined number of supermarkets, medium/small food stores, convenience stores, general merchandise stores, physical activity, TV time.	-Self Reported heights and weights from BRFSS survey. -BMI was calculated based on heights and weights.	-Accounted for SES through race/ethnicity variable, poverty index ratio, educational attainment.	-After adjusting for individual characteristics, fast food restaurant access was predictive of greater odds of obesity. -Greater access to convenience stores was also associated with greater rates of obesity. -Each additional supermarket in a respondent's neighborhood was associated with lower rates obesity
<i>The neighborhood energy balance equation: Does neighborhood food retail environment + physical activity environment = obesity? The CARDIA study</i> , Boone-Heinonen, 2013 -Longitudinal, Regression Analysis (16)	N = 5115, participants involved in CARDIA (Coronary Artery Risk Development in Young Adults)	-US - Birmingham, AL, Chicago, IL, Minneapolis, MN, Oakland, CA	-Obtained fast food restaurant data from Dun and Bradstreet.	-Calculated Density of fast food restaurants by calculating the number of fast food restaurants per 10,000 individuals within 3 km buffer	-Density of supermarkets, convenience stores, commercial physical activity spaces, public physical activity spaces, and development intensity	-BMI of participants, measured at examinations during CARDIA study	-Included neighborhood level poverty	- Density of fast food restaurants, convenience stores, and development intensity not associated with BMI. - Simulation suggested that increasing the concentration of supermarkets and commercial physical activities are promising targets for reducing and maintaining BMI. -Significant three-way interaction between commercial public facilities, sex, and neighborhood poverty.

<p><i>Clustering of unhealthy food around German schools and its influence on dietary behavior in school children: A pilot study</i>, Buck, 2013 -Cross-Sectional, multivariate regression models (17)</p>	<p>N = 384 children aged 6 to 9 years old in the German IDEFICS study</p>	<p>-Germany -Delmenhorst, Lower Saxony</p>	<p>-Obtained fast food data from public domain data sources</p>	<p>-Calculated Food Retail Index based on number fast food restaurants and convenience stores divided by the number of residents per area to describe the food supply.</p>	<p>-Age, household income, ISCED level</p>	<p>-Measured height and weight using standardized procedures, used data to calculate BMI z-score.</p>	<p>-Studied effects of household income, International Standard Classification of Education (ISCED)</p>	<p>-No significant association between food retail index and BMI. -For those with low SES, found higher retail food indices, fat intake, and higher consumption of junk food.</p>
<p><i>Fast-food outlets and walkability in school neighbourhoods predict fatness in boys and height in girls: A Taiwanese population study</i>, Chiang, 2011 -Cross-Sectional Analysis, multivariable regression models (18)</p>	<p>N = 2,283 school children age 6-13 who participated in the Nutrition and Health Survey in Taiwan (NAHSIT)</p>	<p>-Taiwan -359 different townships/Districts across the country</p>	<p>-Food outlet data was obtained from RITI Technology. -Fast food defined as stores like McDonalds, Burger King, and KFC.</p>	<p>-Fast food availability was calculated within a 500-meter buffer around each school.</p>	<p>-Availability of Convenience stores. -Accounted for urbanization and regional dietary patterns. -Included measure of dietary quality, physical activity, and time spent on television.</p>	<p>-Anthropometric data collected from NAHSIT standardized exams. -Data included BMI, height/weight, waist circumference, and triceps skinfold thickness.</p>	<p>-Included SES measures like ethnicity, father's education, and income.</p>	<p>-Availability of fast food restaurants significantly predicted body weight and BMI for boys, but not significantly for girls. -With greater fast food exposure, girls tended to be taller, but this effect was not found in boys.</p>
<p><i>Neighbourhood fast food outlets and obesity in children and adults: The CLAN Study</i>, Crawford, 2008 -Cross-Sectional, bivariate logistic regression analysis (19)</p>	<p>N = 1064 children (aged 8-9 and 13-15 years) and parents participating in Children Living in Active Neighbourhoods (CLAN)</p>	<p>-Australia -City of Melbourne</p>	<p>-Street addresses of fast-food restaurants were obtained using on-line telephone directories and company websites. -Included 8 common fast food restaurants where ready to eat meals are purchased without table service.</p>	<p>-Created a 2 km radius around each residential point and the number of fast food outlets were counted within each buffer. -Also calculated the distance from each residential address to the nearest fast food outlet.</p>	<p>-Measured physical activity of both children and parents.</p>	<p>-Height and weight of children were measured at , while heights and weights of parents were self-reported. -Calculated BMI z-scores from heights and weights.</p>	<p>-Incorporated Socio-demographic information like marital status and education level of parents, area-level disadvantage.</p>	<p>-A few significant associations between fast food exposure and overweight/obese observed in this study, but no consistent associations. -Study provides little support to the idea that fast food exposure is associated with risk of obesity.</p>
<p><i>'Globesization': Ecological evidence on the relationship between fast food outlets and obesity among 26 advanced economies</i>, De Vogli, 2011 -Cross-Sectional, multivariate linear regression (20)</p>	<p>N = 26 advanced economies around the world</p>	<p>-Various countries throughout the world</p>	<p>-Used Subway restaurants to represent fast food restaurants -Obtained Subway data from the Subway website.</p>	<p>-Measured the number of Subway restaurants per 100,000 people.</p>	<p>-Gross National Income (GNI) per capita, urbanization, Gini coefficient, internet users per 100 people</p>	<p>-Obesity prevalence data were taken from the World Health Statistics.</p>	<p>-Assessed various measures of SES across the 26 countries.</p>	<p>-Density of Subway outlets is significantly positively associated with the prevalence of obesity across both women and men. -Results remained significant even after adjusting for SES.</p>
<p><i>Is density of neighbourhood restaurants associated with BMI in rural Chinese adults? A longitudinal study from the China Health and Nutrition Survey</i>, Du, 2014 -Retrospective longitudinal, multilevel correlation analysis (21)</p>	<p>N = 24,396 male and female (over age 18) person years. Data obtained from Chinese Health and Nutrition Survey (CHNS)</p>	<p>-China -Rural</p>	<p>-Defined as restaurants that served western-style fast food products</p>	<p>-Calculated the density of fast food restaurants.</p>	<p>- Density of indoor restaurants, fixed outdoor food stalls -Urbanicity index</p>	<p>-Height and weight measured by qualified field staff using standardized procedures -Calculated BMI</p>	<p>-Did not study effects of SES</p>	<p>-No association found between density of fast food restaurants and BMI for men; significant negative association between fast food restaurants and BMI for women. -Density of fixed outdoor stall negatively associated with BMI - Neighborhood Density of indoor restaurants were associated with BMI increase in adults. -Urbanization also positively associated with BMI.</p>



<p><i>The women's health initiative: The food environment, neighborhood socioeconomic status, BMI, and blood pressure</i>, Dubowitz, 2012 -Cross-Sectional, Multivariate Regression Analysis (22)</p>	<p>N = 60,775 women aged 50 years or older from the Women's Health Initiative Clinical Trial (WHI CT)</p>	<p>-US -various locations throughout the US</p>	<p>- Food outlet data classified based on NAICS</p>	<p>-Calculated the number of fast food restaurants located in a 0.75 mile, 1.5 mile, and 3.0-mile buffer around each resident's address</p>	<p>-Number of supermarkets/grocery stores</p>	<p>-Body weight, height, and systolic blood pressure were measured by trained professionals in a standardized manner. -Calculated BMI based on these measurements.</p>	<p>-Measured Neighborhood socioeconomic status (NSES)</p>	<p>-Significant negative association between the availability of grocery stores/supermarkets and BMI, positive association between availability of fast food and BMI, negative association between NSES and BMI. -Significant association between NSES and systolic blood pressure; no such association found for fast food or grocery stores/supermarkets.</p>
<p><i>The effect of fast-food availability on obesity: An analysis by gender, race, and residential location</i>, Dunn, 2010 -Cross-Sectional, Instrument Validity Regression, and Ordinary Least Squares Regression (23)</p>	<p>N = an unspecified number of participants age 18-75 from the BRFSS 2004-2006 study.</p>	<p>-US</p>	<p>-Food outlet data obtained from MapQuest search engine; fast food defined as McDonald's, Burger King, Wendy's, and Kentucky Fried Chicken (KFC)</p>	<p>-Determined number of the fast food restaurants in each county, and determined the density as number of fast-food restaurants per 100,000 county residents as reported by the June 2005 Census estimates.</p>	<p>-Accounted for population density, county population, violent crime/property crime rates and mean travel time to work.</p>	<p>-Self Reported heights and weights from BRFSS survey. -BMI was calculated based on heights and weights.</p>	<p>-Accounted for SES through median county income.</p>	<p>-Fast food availability does not affect weight outcomes in rural counties. -Fast food availability does affect weight outcomes among females and non-Whites in medium-density counties.</p>
<p><i>Food environment and childhood weight status</i>, Feichtner, 2015 -Cross-Sectional, Multivariable Linear Regression Models (24)</p>	<p>N = 49, 770 pediatric patients age 4-18</p>	<p>-US - Various regions of Massachusetts</p>	<p>-Defined food outlets according to NAICS classification</p>	<p>-Determined distance to the nearest fast food restaurant in various ranges: &lt;0.5, 0.5-1.0, 1-2, and &gt; 2 miles</p>	<p>-Distance to large/small supermarkets, full-service restaurants, convenience stores, bakeries/coffee shops</p>	<p>-BMI z-score, height and weight measured during patient visits</p>	<p>-Considered race/ethnicity, neighborhood median outcome</p>	<p>-Observed a statistically significant (p&lt; 0.001) negative relationship between proximity to fast-food restaurants and BMI z-score -Neighborhood median income was cited as an effect modifier: closest proximity to convenience stores and large supermarkets had strong adverse effects in low-income neighborhoods</p>
<p><i>The association between the geography of fast food outlets and childhood obesity rates in Leeds, UK</i>, Fraser, 2010 -Cross-Sectional Analysis, regression analysis. (25)</p>	<p>N = 33,594 students aged 3-14 years who took part in the TRENDS, Rugby League and Athletic Development Scheme (RADS), Primary Care Trusts (PCT)</p>	<p>-UK -City of Leeds -Geographical units were Output Areas (OA) which consists of about 125 households, and super-output areas, which consist of 4-6 OA's.</p>	<p>-Food outlet data was obtained from Leeds city health and hygiene website and cross checked with online yellow pages.</p>	<p>-Calculated the number of fast food outlets per SOA and performed a density analysis. -Calculated the straight line distance from the child's home address to the nearest FF outlet.</p>	<p>-Accounted for age and gender of students.</p>	<p>-BMI was calculated from the height and weight of each child</p>	<p>-Accounted for SES through a deprivation score.</p>	<p>-Significant association between higher density of fast food outlet and the child being obese. -No significant association between proximity to fast food outlet and being overweight/obese. -Children living in areas of higher deprivation have higher densities of fast food outlets in their SOA.</p>
<p><i>Food outlet availability, deprivation and obesity in a multi-ethnic sample of pregnant women in Bradford, UK</i>, Fraser, 2012 -Cross-Sectional (26)</p>	<p>N = 1,485 pregnant mothers from 2007-2010 in the Born in Bradford Study</p>	<p>-UK -5 contiguous city wards within the Bradford Metropolitan District Council</p>	<p>-Food outlet details obtained from Bradford Metropolitan District Council list of food outlets, and Bradford Yellow Pages</p>	<p>-Distance to the nearest fast food outlet, number of fast food outlets in a 250 m, 500 m, and 1000 m radius, density of fast food outlets, identified clusters of fast food outlets</p>	<p>-South Asian/non-South Asian</p>	<p>-Height and weight measured in standardized way as part of the Bradford Study</p>	<p>-Level of deprivation</p>	<p>-Negative relationship between BMI and fast food availability in the South Asian group, no significant association between BMI and access to fast food restaurants. -Significant positive correlations between level of deprivation and the number of food outlets in all categories. -South Asian group had greater access to all food outlets.</p>

<p><i>A cross sectional study investigating the association between exposure to food outlets and childhood obesity in Leeds, UK, Griffiths, 2014</i> -Cross-Sectional, Linear Regression Models, Logistic Regression Models (27)</p>	<p>N = 13,291 participants in Rugby League and Athletics Development Scheme (RADs)</p>	<p>-UK -City of Leeds</p>	<p>-Food outlet information taken from the Leeds City Council</p>	<p>-Determined number of food outlets within 2 km buffer of home address, school address, and commuting routes</p>	<p>-Age, gender, ethnicity, number of supermarkets, number of retail outlets</p>	<p>-Converted BMI to a standard deviation score(sBMI) - sBMI = 1.04 and above was overweight, sBMI = 1.64 and above was obese -Height and Weight measures were all taken by the same individual</p>	<p>-Deprivation scores (Income of Deprivation Affecting Children)</p>	<p>-After adjusting for gender, ethnicity, and IDACI, no significant associations between number of food outlets and sBMI in the child household and commute environments (with the exception of supermarkets, which had negative association with sBMI) -Some significant associations between exposure to outlets and obesity, but were borderline/negative. -No evidence of a significant association between distance to the nearest food outlet and sBMI. -Significant positive relationship between number of food outlets and SES at school and household level.</p>
<p><i>Location of Food Stores Near Schools Does Not Predict the Weight Status of Maine High School Students, Harris, 2011</i> -Cross-Sectional Analysis, logistic regression analysis (28)</p>	<p>N = 552 students in Maine high schools</p>	<p>-US -state of Maine; across 16 counties</p>	<p>-Food outlets were classified on the basis of what type of foods they sold: some classifications include burger and fries fast food, Mexican fast food, and fried chicken restaurants.</p>	<p>-Number of food outlets that were categorized as burgers and fries fast food, Mexican fast food, fried chicken, sandwiches, pizza, bakeries, coffee shops, ice cream shops, or snack bars within 2 km of a school was determined.</p>	<p>-Number of convenient stores, grocery stores, supermarkets, pizza parlors, and sit-down restaurants.</p>	<p>-Self-reported data on sex, weight, height, and date of birth were collected from surveys. -BMI calculated from self-reported data.</p>	<p>-Accounted for levels of poverty and household median income.</p>	<p>-Neither the proximity of fast food stores near schools nor the number of food stores significantly predicted weight outcomes. -No correlation between unhealthy food choices and risk of overweight/obese.</p>
<p><i>Neighborhood food outlets, diet, and obesity among California adults, 2007 and 2009, Hattori 2013</i> -Cross-Sectional, Multivariable regression model (29)</p>	<p>N = 97,678 aged 18 years or older from 2007-2009 California Health Interview Survey</p>	<p>-US -California</p>	<p>-Classified food outlets according to the NAICS</p>	<p>-Calculated number of fast food restaurants in circular buffers of 0.25, 0.5, 1.0, 1.5, and 3.0 miles around respondent's address.</p>	<p>-Number of full-service restaurants, convenience stores, small food stores, grocery stores, large supermarkets</p>	<p>-Self-reported height and weight were used to calculate BMI</p>	<p>-Studied effects of income</p>	<p>-No strong evidence of association between fast-food outlets, dietary intake, and probability of BMI if &gt; 25/30. -Lower income respondents were surrounded by more food outlets of each type.</p>
<p><i>The food retail environment in school neighborhoods and its relation to lunchtime eating behaviors in youth from three countries, Heroux, 2012</i> - Cross-Sectional, Multivariable regression model (30)</p>	<p>N = 26,778 participants age 13-15 years old from 687 schools in Canada, US, and Scotland.</p>	<p>-US, Scotland, Canada</p>	<p>-Obtained food outlet data from Yellow Pages Directories</p>	<p>-Calculated number of food restaurants within a 1 km buffer around each of the schools.</p>	<p>-Number of convenience stores, cafes</p>	<p>-Self-reported height and weights were used to calculate BMI</p>	<p>-Did not study effects of SES</p>	<p>-No relationships observed between BMI and food environment observed in any of the three countries. -The availability of food retailers was only significantly related to eating behaviors in Canada (increased food retailer availability increased odds of eating at a certain food retailer -Cross-national differences do exist in the food environment around schools and lunchtime eating behaviors.</p>
<p><i>Associations of fast food restaurant availability with dietary intake and weight among African Americans in the Jackson Heart study, 2000-2004, Hickson, 2011</i> -Cross-Sectional, multilevel regression model (31)</p>	<p>N = 4,740 African American adults participating in the Jackson Heart Study</p>	<p>-US -Hinds County, Madison County, Rankin County in central Mississippi</p>	<p>-Fast food restaurant defined as outlet that has plastic utensils and doesn't offer wait service.</p>	<p>-Counted the number of fast food restaurants in 0.5, 1, 2.0, and 5.0 mile buffers around the participant's location.</p>	<p>-none</p>	<p>-Measured height and weight using standardized procedures. -Calculated BMI from these measurements</p>	<p>-Assigned a neighborhood SES score based on measures of advantage and disadvantage.</p>	<p>-No consistent/significant relationship observed between fast food restaurant availability and BMI/waist circumference. -Greater fast food availability was associated with higher energy intake in men and women younger than 55 years old, even after adjusting for socioeconomic factors. -Greater fast food restaurant availability in restaurants with higher African American populations and lower SES.</p>

<p><i>A spatial analysis of the association between restaurant density and body mass index in Canadian adults</i>, Hollands, 2013 -Cross-Sectional, Linear Regression Model (32)</p>	<p>N = 1269 Forward Sortation Areas (FSA's)</p>	<p>-Canada</p>	<p>-Fast food defined as outlets where food is ordered and paid for before eating or taking out.</p>	<p>-Calculated number of fast food restaurants per 10,000 persons at the FSA level.</p>	<p>-Number of full-service restaurants, non-chain restaurants</p>	<p>-BMI obtained using self-reported data from 2007-2008 Canada Community Health Survey (CCHS)</p>	<p>-Did not study effects of SES</p>	<p>-Area-level fast food restaurant density was positively associated with area level mean BMI. -Non-Chain restaurants density was negatively associated with area level mean BMI</p>
<p><i>Association between neighbourhood fast-food and full-service restaurant density and body mass index: A cross-sectional study of Canadian adults</i>, Hollands, 2014 -Cross-Sectional, Ordinary Least Squares Regression (33)</p>	<p>N = 131, 959 individuals from the Canada Community Health Survey (CCHS) 2007-2008 conducted by Statistics Canada</p>	<p>-Canada</p>	<p>-Fast food data obtained from InfoCanada business database; Fast-food restaurants defined as establishments that food is ordered and paid for it is eaten or taken out.</p>	<p>-Density of fast food outlets determined as number of outlets per forward sortation area (FSA), divided by FSA population (per 10,000)</p>	<p>-Metropolitan areas vs. non-metropolitan areas, full-service restaurants, other restaurant service</p>	<p>-Individual self-reported height/weight measurements obtained from CCHS 2007-2008 used to calculate BMI; included error-correction factor</p>	<p>-Did not study effect of SES</p>	<p>-Statistically significant, positive association between fast food restaurant density and BMI; association found primarily in urban areas -significant negative association between full-service restaurants and BMI</p>
<p><i>Proximity of food retailers to schools and rates of overweight ninth grade students: An ecological study in California</i>, Howard, 2011 -Cross-Sectional Analysis, linear regression analysis (34)</p>	<p>N = 879 public schools participating in FITNESS-GRAM 2007 (physical fitness test)</p>	<p>-US -state of California, public high schools</p>	<p>-Food outlet data was obtained from publicly available dataset from Environmental Systems Research Institute (ESRI). Used NAICS classification codes.</p>	<p>-Number of fast food outlets within an 800 m network buffer around schools.</p>	<p>-Number of convenience stores, supermarket retailers, ethnic composition of student body, and location of school (urban/non-urban).</p>	<p>-Determined rate of overweight using FITNESS-GRAM, which measured body composition through skinfold, BMI, or bioelectric impedance analyzers. -Overweight standards determined by Cooper Institute of Dallas.</p>	<p>-Accounted for SES through percentage of students receiving free/reduced priced meals.</p>	<p>-Nearby fast food restaurants and supermarkets were not associated with overweight rates. -Presence of a convenience store within the 800 m network buffer, however, was associated with a higher rate of overweight students than schools without a nearby convenient store.</p>
<p><i>Body mass index, neighborhood fast food and restaurant concentration, and car ownership</i>, Inagami, 2009 -Cross-Sectional, Multilevel weighted linear regression model (35)</p>	<p>N = 2,156 adults in Los Angeles County as part of the Los Angeles Family and Neighborhood Study (L.A. FANS)</p>	<p>-US -63 neighborhoods across Los Angeles County</p>	<p>-Obtained a list of all fast food restaurants in L.A. County from L.A. County Department of Public Health, Environmental Health Division. Used 1997 NAICS to identify fast food restaurants.</p>	<p>-Number of fast-food restaurants within a given census tract was divided by census tract roadway miles to create a fast food density measure for each tract.</p>	<p>-Total food outlets per roadway mile were also calculated. -Car ownership</p>	<p>-Self-reported height and weights from L.A. FANS used to calculate BMI.</p>	<p>-Incorporated percent living below poverty line, percent of households headed by a woman, male unemployment, receiving public assistance.</p>	<p>-Density of fast food restaurants and total number of restaurants were highest in low SES neighborhoods. -Higher restaurant density is associated with higher BMI among local residents. The local fast food environment has a stronger association with BMI for local residents who do not have access to cars.</p>
<p><i>Understanding the Relationship Between the Retail Food Environment Index and Early Childhood Obesity Among WIC Participants in Los Angeles County Using GeoDa</i>, Koleilat, 2012 -Cross-Sectional, Regression Analysis (36)</p>	<p>N = 538,555 women, infants, and children from Los Angeles County</p>	<p>-US -Los Angeles County</p>	<p>-Food outlet information obtained from InfoUSA Business file, classified outlets based on NAICS.</p>	<p>-Calculated the Retail Food Environment Index (RFEI) for every zip code. -High RFEI associated with large numbers of fast food restaurants and convenience stores.</p>	<p>-Included data on grocery stores and produce vendors</p>	<p>-Measured heights and weights of the children aged 2-5, calculated BMI.</p>	<p>-Accounted for race, income, and education level as covariates.</p>	<p>-Found no statistically significant association between the proportion of obese 3-4-year-old children and the relative availability of certain outlets based on the RFEI. -However, there is a statistically significant positive association between number of convenience stores and obesity.</p>
<p><i>Local concentration of fast-food outlets is associated with poor nutrition and obesity</i>, Kruger, 2014 -Cross-Sectional, stepwise linear regression (37)</p>	<p>N = 1345 respondents to the Speak to your Health! Community Survey</p>	<p>-US -Michigan -Genesee County</p>	<p>-Identified fast food restaurants using NAICS</p>	<p>-Calculated the number of fast-food respondents within a 2-mile buffer zone of each survey respondent</p>	<p>-Residence, race, age, gender, education in years, exercise level</p>	<p>-Calculated BMI using self-reported heights and weights -Also measured number of fruits/vegetables consumed per day</p>	<p>-Did not study SES</p>	<p>-Local concentration of fast-food outlets significantly negatively associated with fruit and vegetable consumption; significantly positively associated with BMI -Race, exercise, and gender also significantly predicted BMI.</p>

<p><i>The food environment and student weight status, Los Angeles county, 2008-2009, Langellier, 2012</i> -Cross-Sectional, Multilevel linear regression model (38)</p>	<p>N = 1,694 Los Angeles County schools</p>	<p>-US -Los Angeles County public schools</p>	<p>-Food outlet information purchased from Dun &amp; Bradstreet information service by California Department of Public Health (CDPH)</p>	<p>-Created a half-mile buffer around each school, determined whether buffer contained any fast food restaurants.</p>	<p>-Corner Stores within a half mile buffer</p>	<p>-Assessed BMI in California Department of Education (CDE) Physical Fitness Program, measured by trained professionals</p>	<p>-Measured neighborhood socioeconomic status based on median annual family income</p>	<p>-The presence of a fast food restaurant within a half mile of a school was not associated with a statistically significant difference in the prevalence of student overweight. -The presence of a corner store within a half mile of a majority Latino school was significantly associated with an increase in overweight students.</p>
<p><i>Food access and children's BMI in Toronto, Ontario: assessing how the food environment relates to overweight and obesity, Larsen, 2014</i> -Cross-Sectional, Logistic Regression (39)</p>	<p>N = 1035 grade 5 and 6 students</p>	<p>-Canada -City of Toronto</p>	<p>-Fast food definition obtained from Toronto Healthy Environments Inspection System (THEIS)</p>	<p>-Distance from participant's home to the nearest food outlet -Fast food density defined as number of fast food outlets in a 1 km network service area around each of the respondent's home</p>	<p>-Distance to the nearest and density of: less healthy food outlets, supermarkets, healthier food markets</p>	<p>-Researchers measured the height and weight to calculate BMI of students</p>	<p>-Studied effects of neighborhood income</p>	<p>-Density of fast food outlets and distance from home to the nearest fast food outlet not significantly associated with obesity; same effect noticed with "less healthy outlets" -Distance to the nearest supermarket was significantly related with odds of being overweight or obese; as distance increases, odds of obese increases. -Density of healthy food outlet had significant negative association with obesity -Living in a higher income neighborhood decreases likelihood of obese/overweight</p>
<p><i>The association between neighborhood economic hardship...findings from the Survey of the Health of Wisconsin, Laxy, 2015</i> -Cross-Sectional, Logistic Regression (40)</p>	<p>N = 1570 from Survey of the Health of Wisconsin (SHOW), 2008-2010</p>	<p>-US -Various areas throughout Wisconsin</p>	<p>- Fast food outlets identified through NAICS</p>	<p>- Retail Food Environment defined by Wisconsin Retail Food Environment Index (WRFEI)- ratio of the mean distance of the three closest "healthier" outlets to the mean distance of the stores providing less healthy options (fast food restaurants - high RFEI values correspond with a potentially unhealthy environment</p>	<p>- Frequency of fast food consumption, economic hardship, urbanicity</p>	<p>- Obesity defined as BMI &gt; 30 kg/m<sup>2</sup>, weight/height measured as part of a physical exam - Calculated as Odds of Obesity</p>	<p>- Did not explicitly study effects of SES; however, studied effects of economic hardship</p>	<p>-Neighborhood economic hardship associated with an unfavorable retail environment -Weak indication that higher access to fast food restaurants was associated higher consumption (association found in urban areas only), and that fast food consumption is associated with obesity. Large uncertainty in these estimates -No direct link between the fast food environment and obesity</p>
<p><i>Does access to fast food lead to super-sized pregnant women and whopper babies? Lhila, 2011</i> -Cross-Sectional, Ordinary Least Squares Regression (41)</p>	<p>N = 3,922,957 pregnant mothers from the Natality Detail Files (NDF)</p>	<p>-US -Used Metropolitan Statistic Areas (MSA's) with population greater than 100,000 people</p>	<p>-Food outlet data classified based on NAICS</p>	<p>-Obtained total count of fast food-restaurants in each MSA; then divided total number by population per thousand.</p>	<p>-Grocery stores/full-service restaurants divided by population per thousand. -Measured infant health outcomes</p>	<p>-Obtained data on prenatal weight gain from the NDF. -Defined excessive weight gain as weight gain &gt; 40 pounds.</p>	<p>-Included SES measures such as number of households headed by single parent, fraction with a college degree, per-capita income.</p>	<p>-Greater access to fast food restaurants is positively correlated with increased probability of excessive weight gain even after controlling for socioeconomic and demographical characteristics. -Statistically insignificant relationship between infant birth weight and number of fast food restaurants across all groups.</p>



<p><i>Obesity and the built environment: Does the density of neighborhood fast-food outlets matter?</i>, Li, 2009 -Cross-Sectional, Multilevel Logistic Model (42)</p>	<p>N = 1,221 randomly sampled adults aged 50-75</p>	<p>-US -Randomly sampled U.S. census block groups in Portland, Oregon's Urban Growth Boundary.</p>	<p>-Commercial business data were purchased via infoUSA, and the data were then compiled using Standard Industrial Classification (SIC) codes.</p>	<p>-Number of fast food restaurants was divided by area to obtain a density measure of fast food outlets; the densities were then standardized, and neighborhoods in upper quartile were classified as high density.</p>	<p>-Measured Residential Density, Land Use mix, eating self-efficacy, physical activity, and fruit/vegetable intake.</p>	<p>-Height and weight were measured in in-person assessments, data used to calculate BMI</p>	<p>-Accounted for median household income, percentage of black/Hispanic residents.</p>	<p>-Increased density of neighborhood fast food outlets was associated with unhealthy lifestyles, poorer psychosocial profiles, and increased obesity risk among adults.</p>
<p><i>Childhood obesity and community food environments in Alabama's Black Belt region.</i>, Li, 2015 -Cross-Sectional, Multilevel regression models (43)</p>	<p>N = 613 children (in Grades Kindergarten-5<sup>th</sup>) living in a county in the Black Belt Region</p>	<p>-US -Black Belt Region in the state of Alabama</p>	<p>-Obtained food outlet information from Yellow Book, did not mention an explicit definition.</p>	<p>-Measured distance from residential address to nearest fast food restaurant. -Determined the probability that the child patronizes a certain store. Calculated a Food Environment Score (FES)</p>	<p>-Included data on convenience stores, supermarkets, and restaurants.</p>	<p>-Both self-reported and measured heights and weights used to calculate BMI.</p>	<p>-Considered percentage of African American, median household income.</p>	<p>-No significant relationship between index for fast food restaurants and obese/overweight status. Index for convenience stores is positively related to obesity, index of supermarket is negatively related with obesity. -Lower income communities have poorer food environments around them.</p>
<p><i>Weight Status and Restaurant Availability. A Multilevel Analysis.</i> Mehta, 2008 -Cross-Sectional, Two-level hierarchical regression models (44)</p>	<p>N = 714,054 individuals age 18 or older participating in BRFSS study 2002-2006</p>	<p>-US -544 counties across the US</p>	<p>-Restaurants classified as either fast food restaurants or full-service restaurants based on previous studies.</p>	<p>-Calculated restaurant density as number of fast food restaurants per 10,000 individuals</p>	<p>-Measured density of full-service restaurants.</p>	<p>-Self-reported heights and weights used to calculate the BMI of individuals.</p>	<p>-Accounted for a variety of SES factors, such as race, household income, percentage of adults with a high school diploma.</p>	<p>-Fast food restaurant density and a higher ratio of fast food to full-service restaurants is associated with higher individual weight status, while a higher density of full-service restaurants is associated with lower weight status. -Area-level restaurant can potentially be associated with risks of obesity.</p>
<p><i>Neighborhood Food Environment, Diet, and Obesity Among Los Angeles County Adults, 2011</i>, Mejia, 2015 -Cross-Sectional, Logistic Regression, Negative Binomial Regression, Least Squares Regression (45)</p>	<p>N = 5,185 from Los Angeles County Healthy Survey (LACHS)</p>	<p>-US -random participants selected from throughout Los Angeles County</p>	<p>-Food outlet information obtained from InfoUSA 2009, classified according to North American Industry Classification System (NAICS)</p>	<p>- Number of fast food outlets was counted in a buffer of 0.25, 0.5, 1.0, 1.5, and 3.0 miles around each respondent's residential address</p>	<p>-Number of convenience stores, small food stores, grocery stores, and supermarkets</p>	<p>-Obesity defined as BMI &gt; 30 kg/m<sup>2</sup>, Overweight defined as BMI &gt; 25 kg/m<sup>2</sup>. All measurements self-reported - Intake of fruit, vegetables, fast food, sugar-sweetened beverages</p>	<p>-Did not study effect of SES</p>	<p>- No evidence found that local food environment influences BMI or prevalence of obesity. -No associations found between BMI and fast food outlets, small food stores, midsize grocery stores, and supermarkets.</p>
<p><i>Child body mass index, obesity, and proximity to fast food restaurants</i>, Mellor, 2011 -Cross-Sectional Analysis, logistic regression/ordinary least squares models (46)</p>	<p>N = 2023 students 3<sup>rd</sup>, 6<sup>th</sup>, and 7<sup>th</sup> grade participating in an effort to collect height and weight of students.</p>	<p>-US -Virginia -Medium-sized public school district located in the "urban-fringe of a large city."</p>	<p>-Food outlet data obtained from Division of Food and Environmental Services at the Virginia Department of Health. -Classified fast food as major chain restaurants (McDonalds, Burger King, etc..) and limited service restaurants</p>	<p>-Number of fast food restaurants within 1/10, ¼, ½, and 1 mile of the student's home.</p>	<p>-Availability of full-service restaurants, percent Black/Hispanic, percent free lunch at the school, and average standardized reading scores.</p>	<p>-Height and weight were measured by trained personnel. -BMI was calculated from these measurements, rates of obesity calculated based on CDC standards.</p>	<p>-Accounted for SES through property values and rental analysis.</p>	<p>-Students who resided within 1/10 or ¼ of a mile had significantly higher BMI's even after controlling for socioeconomic factors. -Proximity of full-service restaurants did not have significant relations with BMI. -Students residing in homes with higher values (higher SES) were significantly less likely to be obese and had significantly lower BMI's.</p>

<p><i>The food environment and adult obesity in US metropolitan areas</i>, Michimi, 2015 -Cross-Sectional, Multilevel logistic regression (47)</p>	<p>N = 300, 933 adults in BRFSS (Behavioral Risk Factor Surveillance System)</p>	<p>-US - 186 MMSA (Metropolitan/Micropolitan statistical areas) throughout the US</p>	<p>-Concentration of food service workers; North American Industry Classification System (NAICS)</p>	<p>-Location Quotients(LQ's) corresponding to number of paid food service employees in a region.</p>	<p>-LQ's with respect to Supermarkets, Convenience Stores, Full Service-Restaurants, Fast Food Restaurants, and Snack/ Coffee Shops</p>	<p>-BMI of participants in BRFSS data using self-reported measurements - Obesity defined as BMI&gt;30 kg/m<sup>2</sup> - Odds Ratio of obesity with respect to LQ's</p>	<p>-Did not study effect of SES</p>	<p>-In urban settings, populations served by more full-service restaurants and supermarkets are less likely to be obese, while populations served by more fast food restaurants and convenience store workers are more likely to be obese. - Greater statistically significant Odds Ratio of obesity for those adults living in MMSA's with greater share of fast food restaurants and convenience stores than supermarkets, snack/ coffee shops, and full-service restaurants</p>
<p><i>Obesity prevalence and the local food environment</i>, Morland, 2009 -Cross-Sectional, Mixed model analysis (48)</p>	<p>N = 1,295 individuals who responded to a random digit dialed phone survey.</p>	<p>-US -Forsyth County, North Carolina -City of Jackson, Mississippi</p>	<p>-Obtained restaurant data from local Department of Environmental Health and state Department of Agriculture. -Classified fast food restaurants according to NAICS codes.</p>	<p>-Network distances were calculated between the nearest supermarket/ fast food restaurants. -Also coded census tracts based on the presence of more than one type of fast food restaurant.</p>	<p>-Measured presence of supermarkets, convenience stores, full-service restaurants.</p>	<p>-Self-Reported heights and weights used to calculate BMI.</p>	<p>-Incorporated Race/Ethnicity, Education, and Employment status.</p>	<p>-After adjustment for individual-level effects, higher prevalence of obesity was observed in areas with more than one franchised fast food restaurant. -higher prevalence of obesity in areas of convenience stores and at least one independent grocery store.</p>
<p><i>Built Environment and Weight Disparities Among Children in High- and Low-Income Towns</i>, Oreskovic, 2009 -Cross-Sectional, Clustered logistic regression analysis (49)</p>	<p>N = 6,680 children seen at Partners HealthCare outpatient affiliate between January 1<sup>st</sup>/ December 31<sup>st</sup>, 2006</p>	<p>-US -Eastern Massachusetts</p>	<p>-Fast food data obtained from Business Analyst, defined as a franchised vendor, ability to purchase food without a wait staff, and sale of both food and beverage.</p>	<p>-Density of fast food restaurants within 400-meter buffer around patient's home. -Calculated distance to the nearest fast food restaurant.</p>	<p>-Calculated density of subway stations, bicycle paths, and sidewalk area per 400 m buffer.</p>	<p>-Heights and weights were measured during visit to healthcare facility. -BMI percentile was used to determine weight status.</p>	<p>-Stratified towns into Highest Income Quartile (HIQ) and Lowest Income Quartile (LIQ).</p>	<p>-Low income towns had greater density of fast food restaurants and higher rates of overweight/obesity. -For LIQ children, after adjusting for age/gender/ race/town, density of fast food restaurants was significantly positively associated with obesity while distance to nearest fast food restaurant was inversely associated with obesity. -Overall, LIQ children had more consistent associations between weight status and the built environment.</p>
<p><i>Obesity and the Built Environment Among Massachusetts Children</i>, Oreskovic, 2009 -Cross-Sectional, Bivariate/ multivariate analysis, multilevel regression analysis (50)</p>	<p>N = 21,008 children aged 2-18 years old who visited Partners HealthCare between January 1<sup>st</sup> and December 31, 2006</p>	<p>-US -Eastern Massachusetts</p>	<p>-Defined fast food restaurants as a franchised food vendor, ability to purchase food in the absence of waiters/ waitresses, and the sale of both food and beverages.</p>	<p>-Calculated the density of fast-food restaurants in a 400-meter buffer around each patient's home address. -Also calculated distance to the nearest fast food restaurant.</p>	<p>-Density of subway stations, bicycle paths within a 400-meter buffer around patient's home address.</p>	<p>-Heights and weights were measured during visit to healthcare facility. -BMI percentile was used to determine weight status.</p>	<p>-Used crime and income data to account for social environment.</p>	<p>-After accounting for sociodemographic factors, only the presence of subway stations within 400 meters was significantly inversely associated with being overweight for children. -Study pointed to points to the large effects of sociodemographic factors.</p>
<p><i>Multiple pathways from the neighborhood food ... analysis in the CARDIA study</i>, Richardson, 2015 -Retrospective longitudinal, SEM (Structural Equation Modeling) (51)</p>	<p>N = 5114, participants involved in CARDIA (Coronary Artery Risk Development in Young Adults)</p>	<p>-US - Birmingham, AL, Chicago, IL, Minneapolis, MN, Oakland, CA -3 km Euclidian buffer around each respondent's home location</p>	<p>-Standard Industrial Classification Codes</p>	<p>-Number of fast food restaurants within 3 km buffer measured at various stages throughout 20-year period</p>	<p>- Number of supermarkets</p>	<p>-BMI of participants, measured at examinations during CARDIA study</p>	<p>-SES derived at census tract level; created a 4 level variable: upwardly mobile, downwardly mobile, stable low, stable high</p>	<p>-Greater number of fast food restaurants indirectly associated with higher BMI through greater consumption; however, association did not change in magnitude/ significance over 20-year period. - Overall pattern: over time, neighborhood socioeconomic disadvantage associated with greater density of restaurants and food stores.</p>

<p><i>Is there a robust relationship between neighbourhood food environment and childhood obesity in the USA?</i>, Shier, 2012 -Longitudinal, Ordinary Least Squares Regression (52)</p>	<p>N = 9,610 children enrolled in a longitudinal study (ECLS-K) from kindergarten to 8<sup>th</sup> grade</p>	<p>-US -2970 census tracts across 45 states in the US</p>	<p>-Food outlet data classified based on NAICS</p>	<p>-Calculated the number of fast food outlets per 1000 living in a census tract</p>	<p>-Physical Food Environment Index (PFEI) and Retail Food Environment Index (RFEI). -Whether or not a census tract contains various combinations of supermarkets, convenience stores, and grocery stores, Index of street connectivity</p>	<p>-Height and weighted were measured in a standardized way through the ECLS-K study -Calculated BMI percentiles in 8<sup>th</sup> grade, and change in BMI percentile from 5<sup>th</sup> to 8<sup>th</sup> grade</p>	<p>-Included median household income</p>	<p>-No consistent evidence was found to indicate a positive relationship between fast food availability and BMI or a negative relationship between number of grocery stores and BMI</p>
<p><i>Body mass index in elementary school children, metropolitan area food prices and food outlet density</i>, Sturm, 2005 -Cross-Sectional, Least-Squares Regression (53)</p>	<p>N = 13,282 children between kindergarten and 3<sup>rd</sup> grade participating in Early Childhood Longitudinal Study (ECLS)</p>	<p>-US</p>	<p>-Obtained fast food restaurant information from U.S. Census Bureau, classified data according to NAICS 1997.</p>	<p>-Determined per-capita number of fast food restaurants in the residence zip codes.</p>	<p>-Measured price indices of groceries. -Also used per-capita number of grocery stores, convenience stores, full-service restaurants.</p>	<p>-Heights and weights were measured all at once during examinations. -BMI calculated from measured heights and weights.</p>	<p>-Accounted and controlled for educational level, real family income.</p>	<p>-No significant effect of fast food outlet density on BMI. -Lower vegetable prices associated with lower BMI in children</p>
<p><i>A multi-level analysis showing associations between school neighborhood and child body mass index</i>, Wasserman, 2014 -Cross-Sectional, multilevel correlational analysis (54)</p>	<p>N = 12118 boys and girls and age 4-12, 2008-2009</p>	<p>-US -Kansas City metropolitan area</p>	<p>-Did not mention a specific definition for "fast food."</p>	<p>-Number of fast food restaurants that fall within a 0.5 mile radius of a school, calculated the density of fast food restaurants.</p>	<p>-Sex, Race/Ethnicity, density of convenience stores, grocery stores, fitness facilities, and parks.</p>	<p>-Standardized Health screenings conducted by medical students, measured height and weight of participants -Calculated BMIp</p>	<p>-Examined effect of school-level SES</p>	<p>-Significant positive association between number of fast food restaurants and BMIp in school neighborhoods. - Most obesogenic neighborhoods associated with lower school-level SES</p>
<p><i>Built environment and obesity by urbanicity in the U.S.</i>, Xu, 2015 -Cross-Sectional, Multi-Level Modeling (MLM) (55)</p>	<p>N = 328, 156 from BRFSS 2012</p>	<p>-US -observations from BRFSS in the 48 contiguous states and Washington D.C.</p>	<p>- Fast food as defined in 2012 County Business Patterns (CBP)</p>	<p>- Ratio of fast food to full-service restaurants numbers at the county level, data extracted from 2012 County Business Patterns (CBP)</p>	<p>-Poverty rate, racial-ethnic heterogeneity, walkability, urbanicity</p>	<p>- Obesity Rate (OBR), derived from self-reported data in BRFSS. BMI &gt; 30 kg/m<sup>2</sup> -Physical Inactivity Rate (PIR)</p>	<p>-Did not study effect of SES</p>	<p>-Higher ratio of fast food restaurants to full-service restaurants is associated with obesity most strongly in areas with modern urbanicity. -Significant association found between built environment variables and physical inactivity/obesity when controlling for individual and neighborhood characteristics/ attributes.</p>
<p><i>GIS-based analysis of obesity and the built environment in the US</i>, Xu, 2015 -Cross-Sectional, Geographic Weighted Regression (GWR) (56)</p>	<p>N = 3, 109 counties</p>	<p>-US -Spatial distribution of obesity vs. food environment throughout the US</p>	<p>-Food environment data obtained from 5-year U.S. Economic Census</p>	<p>- Food environment represented by a fast-food/ full-service restaurant ratio.</p>	<p>-Street connectivity, Walkability, poverty rate, ethnic heterogeneity</p>	<p>-Obesity rate calculated from Diabetes Interactive Atlases, self-reported measurements</p>	<p>-Poverty rate strongly associated with obesity in most counties</p>	<p>- Ratio of fast-food/full-service restaurants is strongly and positively correlated with obesity rate in the Northeast; however, this variable does not have much effect throughout the rest of the country. - In most counties, street connectivity, and walk score played a role in obesity; however, contribution of these variables to obesity varies spatially.</p>

<p><i>Implications of fast food restaurant concentration for preschool-aged childhood obesity</i>, Newman, 2014 -Cross-Sectional, Hierarchical Regression Analysis (57)</p>	<p>N = 2718 U.S. counties</p>	<p>-US</p>	<p>-Fast food definition obtained from U.S. Census Bureau, County Business Patterns, 2008</p>	<p>-Relative prevalence of fast food restaurants determined as per capita number of fast food restaurants</p>	<p>-Level of urbanization (rural/urban), economic environment</p>	<p>-Preschool obesity rate obtained from CDC analysis of height and weight data from the Pediatric Nutrition Surveillance System (PedNSS)</p>	<p>-Studied effects of persistent poverty present vs. no persistent poverty present</p>	<p>-No Significant association between prevalence of fast food restaurants per capita and preschool childhood obesity rates in rural communities. - In More urbanized communities, relationship between prevalence of fast food restaurants and childhood obesity rate is significant. -Relationship between availability of fast food restaurants is significant when persistent poverty and high urbanization are present.</p>
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Table 1: Compilation of studies and extracted data.

Studies with at least one significant association between the fast food environment and higher rates of obesity/overweight	Studies reporting no significant associations or only indirect associations between the fast food environment and higher rates of obesity/overweight
N=20	N=14
Michimi 2015	Richardson 2015
Xu 2015	Laxy 2015
Xu 2015*	Mejia 2015
Feichtner 2015	Li 2015
Alviola IV 2014	Boone-Heinonen 2013
Newman 2014	Hattori 2013
Kruger 2014	Shier 2012
Wasserman 2014	Langellier 2012
Dubowitz 2012	Koleilat 2012
Lhila 2011	Hickson 2011
Block 2011	Harris 2011
Ahern 2011	Howard 2011
Mellor 2011	Oreskovic 2009*
Bodor 2010	Sturn 2005
Dunn 2010	
Inagami 2009	
Oreskovic 2009 Morland 2009	
Li 2009	
Mehta 2008	
*indicates multiple studies performed by same author in the same year	

Table 2: Summary of associations between the fast food environment and rates of obesity in us studies.

studies used BMI to measure the outcomes of the population, the included studies were split in terms of how they obtained height and weight measurements. A total of 29 studies (63%) obtained height and weight data of participants in a standardized manner (for example, height and weight measurements were taken during a clinic visit by trained professionals). A total of 17 studies (37%) obtained height and weight data from self-reported measurements.

### Fast food access studies categorized by geographic location and scale

A majority of studies included in this review were performed in urban locations or were performed in both urban and rural locations. Only one study was performed solely in a rural location; this study was conducted in rural China [21]. The scale of the included studies varied significantly, ranging from studies performed on entire countries [20] to studies examining Metropolitan Statistical Areas (MSA) to studies

Studies with at least one significant association between the fast food environment and higher rates of obesity/overweight	Studies reporting no significant associations or only indirect associations between the fast food environment and higher rates of obesity/overweight
N=4	N=6
Hollands 2014	Griffiths 2014
Hollands 2013	Larsen 2014
Chiang 2011	Du 2014* (negative association)
Fraser 2010	Buck 2013
	Fraser 2012
	Crawford 2008

Table 3: Summary of associations between the fast food environment and rates of obesity in non- us studies.

examining individual cities and neighbourhoods [42-47]. The most commonly used scale in the included studies were the county level (or a similar measure, such as MSA) and the city level.

### Characterization of the fast food environment

The included studies also differed significantly in the way the fast food environment was characterized. A majority (n=21, 62%) of the studies performed in the US utilized a similar definition for fast food based on Standard Industrial Classification (SIC) codes, the North American Industrial Classification System (NAICS), or the US Census Bureau's County Business Patterns (CBP) [48-51]. Two included studies did not explicitly mention a definition for fast food restaurants [20,43,52-54]. The remainder of studies in the US (n=13, 38%) utilized their own definition of fast food restaurants, often loosely based on standards defined by local public health departments. These studies categorized restaurants as fast food restaurants based on characteristics such as the type of utensils offered, whether a customer receives their food before or after they pay, and the type of foods served. In addition, several included studies used popular franchised fast food restaurants, such as McDonald's, Burger King, Subway, KFC, and Taco Bell, as a proxy for the fast food environment. Studies performed outside the US displayed an even greater heterogeneity in the definitions of fast food utilized. A significant portion (n=4, 40%) of studies performed outside the US utilized their own definitions of fast food; similar to the studies performed in the US, these definitions were based on the manner of service, the type of food served, and the use of franchised Western fast food restaurants as proxies to represent the fast food environment. The remainder (n=6, 60%) of studies performed outside the US utilized a definition of fast food based on local public health departments or public data sources, such as Larsen 2014, which defined fast food based on Toronto Healthy Environments Inspection System (THEIS).



To describe the fast food environment, several different methodologies were used; the most commonly utilized methods included densities, proximities, ratios, and indexes used to characterize the food environment. The majority of studies (n=31, 67%) utilized a measure of the density of fast food restaurants. There was some variability, however, within the density measurements; some studies calculated the number of fast food restaurants within a circular buffer of fixed distances around a reference point (such as a residential location or school), while other studies calculated the relative prevalence of fast food restaurants by finding the number of fast food restaurants per fixed unit of population. The next most common measure (n=6, 13%) of describing the food environment utilized was a proximity measure; studies utilizing a proximity measure often measured the distance from a reference point (such as a residential location or a school) to the nearest fast food restaurants. Some studies (n=4, 9%) used indices to characterize the food environment; a commonly utilized measure was some form of the Retail Food Environment Index (RFEI). Finally, only two studies utilized a ratio measure to characterize the food environment; these studies characterized the food environment based on ratios of fast food restaurants to other types of restaurants. A total of three studies [25,26,50] characterized the fast food environment based on both density and proximity measures.

Several studies further described the food environment by incorporating measures of food outlets other than fast food restaurants. A majority of studies (n=33, 72%) included other food outlets in addition to fast food restaurants in their studies [51-53]. The most commonly included food outlets were full-service restaurants, convenience stores, grocery stores, supermarkets, outdoor food stalls, and cafes. Several studies [16,49,50,52,54,55] also examined the built environment beyond solely food, studying factors like street connectivity, number of bicycle paths, and the number of subway stations.

#### **Associations found between the fast food environment and obesity: US Studies**

One of the 34 included studies that were performed within the US, 20 studies (59%) found at least one significant association between the fast food environment and higher rates of obesity/overweight or excessive weight gain [41]. Generally, these significant associations were strongest in metropolitan/urban areas with higher rates of deprivation. The associations found were varied in nature. Xu et al. [56] found strongest associations between the fast food restaurant and high rates of obesity in North-eastern US. Xu et al. [55] found the strongest associations in areas with higher urban city measures. Newman et al. [57] found associations between the fast food environment and higher rates of obesity only in urban areas and areas with persistent poverty, but not in rural areas. Ahern et al. [12] found that the significant relationship between a more prevalent fast food restaurant and higher rates of obesity only existed in metropolitan areas. Inagami et al. [35] found the strongest associations for residents who don't have access to cars. Oreskovic et al. [50] found the strongest associations for individuals of the Lowest Income Quartile (LIQ). The remaining 14 studies (41%) found no significant association or only indirect associations between the fast food environment and rates of obesity/overweight. Once again, the conclusions presented by the studies that found no significant association were varied in nature; for example, Hickson et al. [31] found no association between the availability of fast food and BMI, but the study found that greater availability of fast food was significantly associated with higher energy intake in certain study populations. Finally, although some of the studies found no significant relationship between fast food availability

and BMI, they found significant relationships between the availability of other food outlets and BMI; for example, Koleilat et al. and Langelier [36,38] both found a significant association between the presence of convenience/corner stores and higher BMIs, but found no significant relationship with regards to the availability of fast food restaurants. In terms of study design, four (12%) longitudinal studies were performed in the US, while 30 (88%) cross-sectional studies were performed in the US. A total of three (75%) longitudinal studies performed in the US found no significant association or only indirect associations between the fast food environment and rates of obesity/overweight. Only one (25%) longitudinal study performed in the US found at least one significant association between the fast food environment and higher rates of obesity/overweight. Amongst the 30 cross-sectional studies performed in the US, 11 (37%) studies found no significant association or only indirect associations between the fast food environment and rates of obesity/overweight; 19 (63%) studies found at least one significant association between the fast food environment and higher rates of obesity/overweight. Finally, of the 5 studies performed studying US schools, three (60%) studies found no significant association or only indirect associations between the fast food environment and rates of obesity/overweight, while two (40%) found at least one significant association between the fast food environment and higher rates of obesity/overweight.

#### **Associations found between the fast food environment and obesity: Studies performed outside the US**

Amongst the 10 included studies that were performed in countries outside the US, a total of four (40%) studies found at least one significant association between the fast food environment and higher rates of obesity/overweight. Similar to the studies performed within the US, the strongest associations were found in urban/metropolitan areas. Also, similar to the studies within the US, the associations found were varied in nature. For example, Fraser and Edwards [25], found that within the UK, a significant positive association between fast food availability and obesity rates only when using density measures (no significant association found while using proximity measures). Chiang et al. [18], a study performed in Taiwan, only found a significant positive association existed in boys, but not girls. A total of six (60%) studies reported no significant association or only indirect associations between the fast food environment and rates of obesity/overweight. Interestingly in the final study performed in rural China [21], a significant negative relationship was found between the fast food environment and BMI. No such relationship was found elsewhere. Similar to the US studies, although some of the studies found no significant relationship between fast food availability and BMI, they found significant relationships between the availability of other food outlets and BMI. For example, Larsen et al. [39], performed in Canada, found no association between the fast food environment, but found a significant negative association between "healthy food outlets" and obesity.

In terms of study design, only one (10%) study was longitudinal, while the remaining nine (90%) studies were cross-sectional. Du et al [21], a longitudinal study performed in rural China, found no significant association between the fast food environment and BMI for men, and found a significant negative association between the fast food environment and BMI for women (not found elsewhere). Amongst the remaining nine cross-sectional studies, four (44%) studies found at least one significant association between the fast food environment and higher rates of obesity/overweight, while five (56%) studies found no significant association or only indirect associations between the fast

food environment and rates of obesity/overweight. Finally, of the three studies performed studying the fast food environment surrounding schools, two (67%) studies found no significant association between the fast food environment and rates of obesity/overweight, while one (33%) study found at least one significant association between the fast food environment and higher rates of obesity/overweight.

### Associations found between the fast food environment and SES: US studies

A majority of included studies conducted in the US incorporated various measures of socioeconomic status (SES). In many of the studies, SES measures served as controls to accurately study the fast food environment and its relationship to obesity/overweight rates without confounding variables. However, 21 (62%) studies further examined the relationship between SES measures and the fast food environment. All of these studies demonstrated similar findings: lower SES was associated with a higher density of fast food restaurants and convenience stores, an unfavourable retail environment, poorer food environments, higher consumption of junk foods, and higher obesity rates. Higher SES was associated with a "healthier" food environment and lower obesity rates. In addition, when a significant positive association was found between the fast food environment and rates of obesity/overweight, the association was often strongest in areas with low SES (persistent poverty, higher levels of deprivation, etc.). Examples of such studies include (24,54,57). Interestingly, the SES findings were consistent across US studies that found no significant relationship between the fast food environment and rates of obesity/overweight and studies that found at least one significant association between the fast food environment and higher rates of obesity/overweight. For example, although Laxy et al. [40] found no direct associations between the fast food environment and obesity, this study found that neighbourhood economic hardship was associated with an unfavourable retail environment.

### Associations found between the fast food environment and SES: Studies performed outside the US.

Similarly, a majority of included studies conducted outside the US incorporated various measures of SES, primarily as a controlled variable. However, five (50%) studies further examined the relationship between SES measures and the fast food environment. The findings were similar to the findings of the studies performed in the US: lower SES was associated with a larger number of food outlets, higher rates of obesity, higher consumption of junk food, higher fat intakes, and higher densities of fast food outlets. Higher SES was associated with lower obesity rates and lower concentrations of fast food restaurants. Similar to US studies, these findings were present across all the studies that included SES, even those that found no direct associations between the fast food environment and obesity; for example, Fraser et al. [26] found no consistent associations between the fast food environment and rates of obesity, but found that higher levels of deprivation were associated with greater numbers of food outlets.

## Discussion

Many factors contribute to the development of obesity, including lifestyle factors, genetics, consumption of "specific foods and beverages, physical activity, alcohol use, television watching, and smoking habits" [58]. This review sought to specifically compare the relationship between the fast food environment and obesity in the US and other countries throughout the world. Associations found between the fast food environment and obesity: US vs. abroad.

## Limitations

Amongst the studies conducted in the US included in our review, 59% found at least one significant association between the fast food environment and higher rates of obesity/overweight, or excessive weight gain, while 41% found no significant association or only indirect associations between the fast food environment and rates of obesity/overweight. Of the included studies conducted outside the US, 40% found at least one significant association between the fast food environment and higher rates of obesity/overweight, while 60% found no significant association or only indirect associations between the fast food environment and rates of obesity/overweight. The studies performed in the US and countries outside the US both demonstrated largely mixed results in terms of the relationship between the fast food environment and obesity. In both the US and non-US studies, when associations were present between the fast food environment and rates of obesity/overweight, the associations were strongest in urban areas and populations with lower SES. Thus, the fast food environment may be associated with higher rates of obesity in areas with lower SES and higher concentrations of ethnic minorities in both the US and countries other than the US. However, as a whole, similar to a review performed by Fleischhacker et al. [59], we find no consistent associations between the fast food environment and measures of obesity/overweight. There are several limitations to our approach. First, the vast majority (89%) of included studies, both US and non-US, were cross-sectional in design. The cross-sectional nature of the included studies in both the US and non-US categories greatly limit our ability to draw definitive conclusions about the relationship between the fast-food environment and rates of obesity/overweight. In addition, there was a significant amount of heterogeneity in various essential components of the included studies, such as the study population, scale of the study, methods of measuring the fast food environment (density, proximity), assessment of other food outlets (Examples: convenience stores, supermarkets), and assessment of BMIs in the study population (self-reported vs. standardized exams). The majority of included studies were performed in metropolitan areas; more studies must be performed in rural areas, in both the US and outside the US, to fully understand the role that the fast food environment. Also, a majority of included studies examined various types of food outlets in addition to fast food, such as convenience stores, sit-down restaurants, and supermarkets. As Fleischhacker et al. [59] points out, it may be necessary to strike a balance between solely examining the associations between the fast food environment and obesity along with examining fast food outlets as a part of the total food environment. Finally, in the non-US category, there were only two non - "Western" countries included: Taiwan and China. More studies must be performed in non - "Western" countries to fully understand the role that the fast food environment plays as a potential risk factor for the development of obesity across cultures. There is a wide range of countries included in the non-US category, complicating the interpretation and comparison of associations found between the fast food environment and rates of obesity in US vs. non-US category. Overall, the vast differences present in methodology across included studies performed in both the US and non-US categories strongly limit our ability to draw conclusions about the association between the fast food environment and rates of overweight/obesity.

### Associations found between SES and Fast Food Environment: US vs. Abroad

In the included studies in both the US and non-US groups, there were strong associations between socioeconomic status (SES) and the fast food environment. In nearly all of the included US and non-

US studies that examined SES, it was found that areas with lower SES were associated with unfavourable fast food environments, with higher concentrations of fast food restaurants, higher consumption of junk food, and higher obesity rates when compared to areas with higher SES. While there were inconsistent results in the association between the fast food environment and rates of obesity/overweight, lower SES was strongly associated with higher fast food densities and closer proximity to fast food restaurants, especially in urban areas. These findings were consistent across both US and non-US studies. Our findings are in agreement with the review performed by Fleischhacker et al. [59] and several recent studies [60,61] that have affirmed the presence of an unfavourable food environment and higher obesity risks in areas with lower incomes and SES. Several explanations have been posed for this phenomenon, including disproportionate marketing towards children in majority black communities/rural areas/middle-income communities along with other economic factors and social processes [59,62]. Based on the results of our study, the association between low SES and an unfavourable fast food environment is consistently present in both the US and non-US studies. Once again, there were several limitations to our approach. Included studies used a wide range of conditions to define SES, including education, race, personal income, levels of poverty, and median neighbourhood income. As discussed previously, there were also great variations in the measures used to study the fast food environment. Future studies examining SES and the fast food environment must use more comprehensive, uniform methods to define SES and the fast food environment.

### Policy Implications in the US

The food environment has come under increasing scrutiny as a potential factor for the development of obesity, and there have been several proposed policy initiatives specifically targeting the fast food environment in the US. Based on the mixed nature of the associations found between the fast food environment and rates of obesity overall in addition to the primarily cross-sectional design of the studies, we find it difficult to justify policy initiatives targeting the fast food environment as a corrective measure to reduce rates of obesity/overweight based on the current literature. More longitudinal studies must be performed with uniform definitions of the fast food environment, study populations, measures of access, and the inclusion of other food outlets in order to more accurately devise policy initiatives that may or may not target the fast food environment. Our conclusions are in agreement with the review performed by Fleischhacker et al. [59].

Relevant to our discussion of policy is the “Los Angeles Fast-Food Ban” introduced in 2007. The ordinance passed by the city of Los Angeles (LA), US is a zoning regulation intending to reduce the prevalence of fast food restaurants in south LA by preventing the expansion or opening of stand-alone fast food restaurants [11]. A study by Sturm and Hattori examined the effects of the so-called fast food ban, and found that there was no significant change in the composition of the food environment, with similar rates of new fast food restaurants in south LA compared to the rest of LA [11]. Overall, the study concluded that the Los Angeles fast-food ban has been ineffective so far, due in large part to the limited focus of the ordinance and the possible limited relationship between the fast food environment and obesity/diet [11].

With the inconsistent associations found between the fast food environment and rates of obesity/overweight in our review along with the limited positive outcomes of initiatives such as the LA fast-food ban, we propose alternative policy measures. While the prevalence of obesity remains high in youth and adult populations in the US, recent research

has shown that in the youth populations across the US, the prevalence of obesity among adolescents age 12-17 of high socioeconomic-status has actually begun to decrease, while the prevalence of obesity among adolescents of lower socioeconomic status has continued to increase [63]. Frederick et al. suggests that interventions targeted towards lower SES youth will be particularly effective in helping to alleviate the burden of obesity in the US [63]. Targeted initiatives promoting increased physical activity, increased educational attainment, and healthier lifestyles in lower SES populations will be particularly important in decreasing the obesity epidemic in the US [60,63].

### Conclusions

Our review sought to compare the relationship between the fast food environment and rates of obesity/overweight in the US and countries outside the US. A total of 46 studies were included in our final review. Based on the results of our review, the findings were largely similar between US and non-US studies; in both groups, there were inconsistent associations between the fast food environment and rates of obesity/overweight. However, in terms of SES, our findings were consistent across both US and non-US studies; lower SES was consistently associated with unfavourable fast food environments, with higher concentrations of fast food restaurants, higher consumption of junk food, and higher obesity rates. The large variance in methodology and study design across both US and non-US studies potentially limits the conclusions of our study. More longitudinal research must be performed with consistent methodology in order to better understand the role of the fast food environment in the development of obesity. Until then, no definite conclusions regarding the role of the fast food environment in the development of obesity can be drawn.

### Conflicts of Interest

No conflicts of interest declared.

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