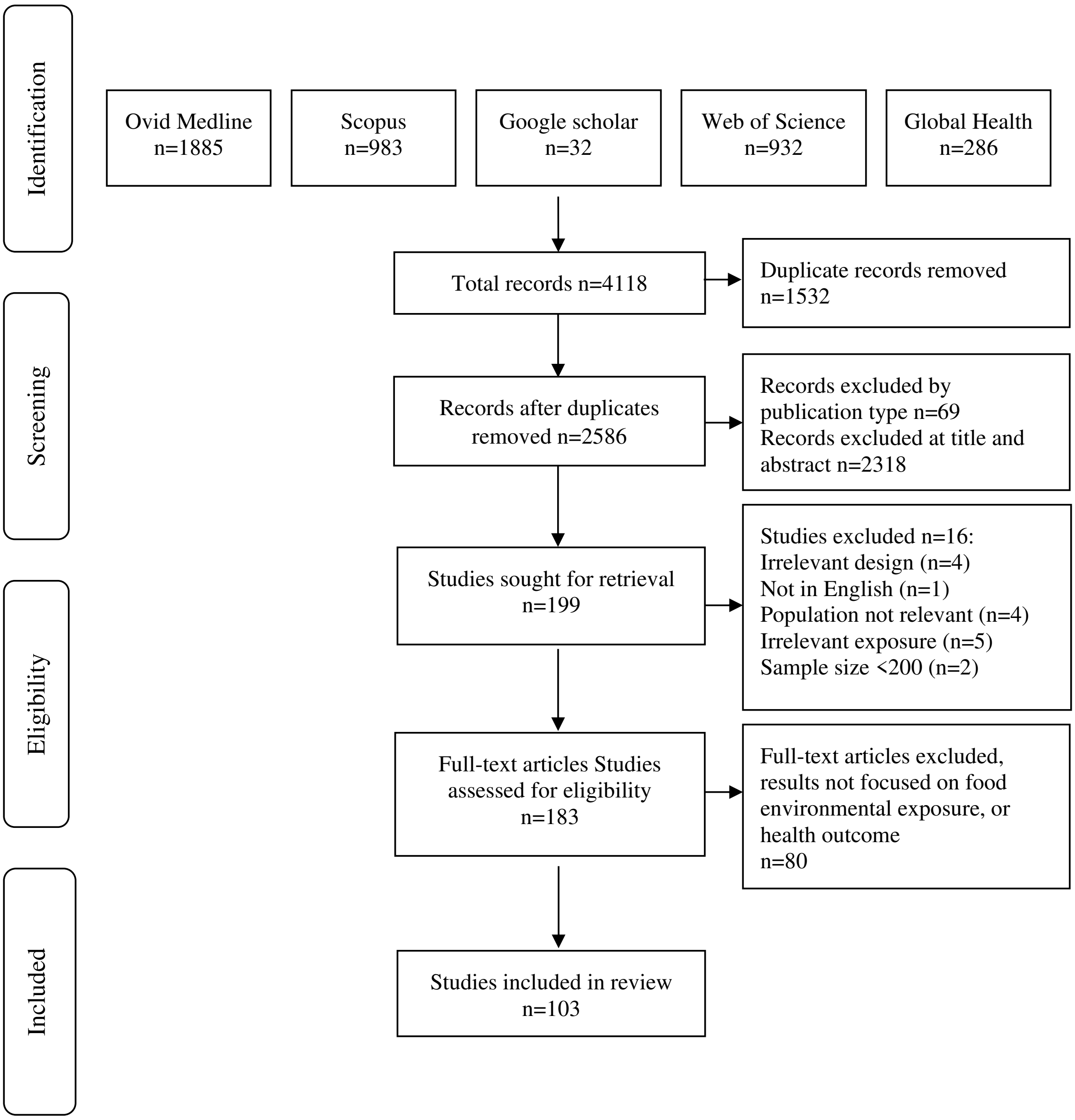
The Food Environment and Obesity: A Systematic Review and Meta-analysis

Supplementary Material

Contents

1. PRISMA Flow Diagram

Figure S1. PRISMA Flow Diagram



2. Eligibility criteria

Table S1. Eligibility criteria for publications relevant to the review using PICO

Population	General adult population, excluding populations with comorbidities.
Intervention/ exposure	Assessment of the retail food environments at any geographical level (e.g., census tract area, postal code, county, city, etc)
Control	Not applicable/areas with no food environment
Primary Outcomes	Obesity related outcomes (e.g., BMI, obesity prevalence, adiposity, etc.)

3. Risk of bias

Table S2. Risk of bias and quality criteria assessment for reviewed studies

Criterion	Meeting criteria (Score 1)	Not meeting criteria (Score 0)
Population	Population was randomly selected, and proper sampling methods were undertaken to select a representative population according to the study's aims.	Population was selected using telephone surveys.
Outcome (BMI)	Measured weight and height or validated data.	Self-reported or non-validated data used.
Exposure (food environment)	> 2 types of food establishments were studied.	≤ 2 types of food establishments were studied
Food outlet data source	Validated or trustworthy source (e.g., up-to-date government database) used or ground truthing was undertaken).	Data were not validated.
Spatial analysis method	≥ 2 methods were employed.	Only one method.
Physical activity (PA)	PA or walkability was considered in the model.	Neither PA nor walkability considered.
Study design	Longitudinal studies.	Cross-sectional or ecological design
Statistical method	Use of Moran's I, multilevel analysis, geographic weighted regression analysis or any other method that considered space or clustering as an important variable of influence.	Linear regression methods which do not consider space or clustering.
Data temporality	Health and food outlet data were from same year.	Health and food outlet data varied in collection time.

4. General characteristics of reviewed studies

Table S3. General characteristics and descriptive summary of reviewed studies

Reference	Country	Sample population	Physical activity consideration	Statistical Method	Significant findings
Cross-sectional studies					
Abbott et al., 2014	Australia	1,819	Yes	Linear regression model	Yes
Adachi-Mejia 2017	USA	2,025	Yes	Multiple regression models	Mixed
Ahern et al., 2011	USA	USA population	Yes	Linear regression	Yes
Albalawi et al., 2020	UK	456,079	No	Multiple linear regressions	No
Backes et al., 2019	Brazil	1,096	No	Multilevel Poisson regression models (with robust standard error)	No
Bodor et al., 2010	USA	3,925	Yes	Hierarchical linear models	Yes
Burgoine 2017	UK	9,702	Yes	Multiple linear regression	Yes
Burgoine 2018	UK	51,361	Yes	Multivariable linear and binomial logistic regression	Yes
Cerin et al., 2011	USA	274	Yes	GLM with binomial variance and logit link functions	Yes
Chaparro et al., 2017	USA	1,041	No	Multilevel logistic regression	No
Chen et al., 2010	USA	844,187	No	OLS spatial diagnostic test on regression residual of non-spatial model	Yes
Chen et al., 2013	USA	3,550	Yes	OLS	Yes
Chen et al., 2016	USA	25,023	No	Multilevel	Yes
Chen et al., 2019	USA	20,897	Yes	Ordinary least squares linear regression (evaluated by Moran's I index) global ordinary least squares regression local geographically weighted regression	Yes
Chen et al., 2020	USA	20,897	No	Path analysis	Yes

Reference	Country	Sample population	Physical activity consideration	Statistical Method	Significant findings
Christian et al., 2012	USA	121	Yes	Multivariate logistic regression	No
Conroy et al., 2018	USA	102,906	Yes	multivariable linear regression multivariable multinomial logistic regression	No
Cooksey-Stowers et al., 2017	USA	3,108	Yes	OLS	Yes
Crawford et al., 2008	Canada	684	Yes	Bivariate logistic regression	No
Dake et al., 2016	Ghana	657	Yes	Multilevel	Yes
Drewnowski et al., 2012	USA	1,304	No	Modified Poisson regression	No
Drewnowski et al., 2014a	USA-France	9,291	No	Modified Poisson regression w/ robust error variance	No
Dunn et al., 2012	USA	1,019	No	Probit regression	Yes
Fan et al., 2014	USA	403,305	No	Multilevel regression models	Yes
Frankenfeld et al., 2015	USA	USA population	No	Linear regression	Yes
Fuller et al., 2013	USA	1,440	Yes	Bivariate linear regression	No
Gartin 2012	Paraguay	126	No	Linear regression no GIS analysis	No
Ghosh-Dastidar et al., 2014	USA	1,214	No	Multivariate logistic regression	Yes
Hanibuchi et al., 2011	Japan	39,765	No	Multiple linear regression logistic regression	Yes
Hattori et al., 2013	USA	97,678	Yes	Negative binomial regression OLS and logistic regression	Yes
Hobbs 2017	UK	4,723	No	Single-level linear regression linear multilevel	No
Hobbs et al., 2019	UK	22,889	No	Binary logistic regression	No
Hobbs et al., 2019	UK	7,544	No	Structural equation modelling	No
Hollands et al., 2013	Canada	1,269 geographic areas	Yes	OLS and spatial auto-regressive error	Yes

Reference	Country	Sample population	Physical activity consideration	Statistical Method	Significant findings
Hollands et al., 2014	Canada	84,341	Yes	Multivariable regression analyses	Yes
Hosler et al., 2009	USA	Columbia and Greene counties in NY	No	Bivariate correlations	No
Inagami et al., 2009	USA	2,156	No	Multilevel modelling	Yes
Jeffery et al., 2006	USA	1,033	Yes	Logistic regression	No
Jilcott et al., 2011	USA	USA population	Yes	Multilevel linear models	Yes
Kruger et al., 2014	USA	1,345	No	Stepwise linear regressions	Yes
Laxy et al., 2015	USA	1,570	Yes	Multivariate linear and logistic regression	No
Li et al., 2008	USA	1,221	Yes	Linear and logistic regression	No
Li et al., 2009b	USA	1,145	Yes	Multilevel Poisson regression	Yes
Li et al., 2009c	USA	1,145	Yes	Multilevel	Yes
Liese 2017	USA	459	Yes	Multivariable/hierarchical linear regression	Yes
Lopez 2007	USA	15,358	No	Multilevel logistic regression	Yes
Macdonald et al., 2011	Scotland	991	No	Multilevel	Yes
Mackenbach 2019	Belgium France Hungary Netherlands and the United Kingdom.	5,076	No	Logistic and linear regressions	No
Mackenbach 2019	Netherlands	2,812	No	Linear and multinomial logistic regression	Yes
Maddock 2004	USA	USA population	Yes	Logistic regression and multinomial regression	Yes
Mason 2018	UK	40,1435	Yes	Multilevel linear regression	Yes

Reference	Country	Sample population	Physical activity consideration	Statistical Method	Significant findings
Mazidi and Speakman 2017	USA	2,996 counties. 3,138 counties USA population~ 170 million adults	Yes	Linear regression	No
Mehta and Chang 2008	USA	876,091	Yes	Bivariate correlation hierarchical multiple regression	Yes
Mejia et al., 2015	USA	5,185	Yes	Multilevel analysis Two-level hierarchic regression models	Yes
Mendes et al., 2013	Brazil	3,404	No	Negative binomial	Yes
Michimi and Wimberly 2010	USA	1,477,828	No	Poisson regression model in a single level	No
Michimi and Wimberly 2015	USA	300,933	No	Latent class analysis	Yes
Morland et al., 2006	USA	10,763	Yes	Multilevel logistic regression	Yes
Murphy 2017	Australia	3,218	No	Generalised estimating equations	Yes
Murphy 2018	Australia	3,141	Yes	Generalized estimating equations models	Yes
Mylona 2020	USA	20,927	Yes	Multivariate logistic regression	Yes
Oexle et al., 2015	USA	838	No	Multilevel logistic regression	Yes
Oka et al., 2013	USA	5,485	Yes	Multilevel modelling binomial regression	Yes
Patel et al., 2017	India	1,782	Yes	Logistic regression	Yes
Pearce et al., 2009	New Zealand	12,529	No	Multinomial Logistic regression	No
Pineda et al., 2021	Mexico	37,969	Yes	Multilevel linear regression	Yes
Polsky et al., 2016	Canada	10,199	Yes	logistic regression stratified linear regression	Yes
Polsky et al., 2016	Canada	10,199	Yes	Multilevel modelling	No

Reference	Country	Sample population	Physical activity consideration	Statistical Method	Significant findings
Pouliou and Elliott 2010	Canada	115,548	Yes	Two-level logistic regression multilevel	Yes
Prince et al., 2012	Canada	4,727	Yes	Logistic and linear regression	Yes
Pruchno et al., 2014	USA	5,688	No	Multivariate analysis	No
Richardson et al., 2015	USA	5,114	Yes	Binomial multivariate multilevel model	Yes
Rundle et al., 2009	USA	13,102	Yes	Multilevel structural equation	Yes
Salois 2012	USA	3,051 counties	Yes	Structural equation model	Yes
Singleton et al., 2016	USA	3,135	No	Linear regression	Yes
Slack et al., 2014	USA	3,109 counties	Yes	Multilevel analysis	Yes
Spence et al., 2009	Canada	2,900	No	Robust regression MM estimator regression	Yes
Stark et al., 2013	USA	48,482	Yes	OLS spatial regression	No
Tung et al., 2016	USA	267	Yes	Linear regression	No
Viola et al., 2013	USA	48,014	Yes	Weighted logistic regression models	Yes
Walker 2020	Canada	8,076	Yes	Logistic regression	Yes
Wang et al., 2007	USA	7,595	Yes	Multilevel Pearson correlation coefficients	Yes
Xu and Wang 2015	USA	328,156	Yes	Bayesian ecologic approach for spatial prediction	Yes
Yan et al., 2015	USA	3,041	No	Multilevel	No
Yenerall 2017	USA	784	No	Logistic regression model	No
Zhang 2019	USA	8,365	No	Generalised linear regression and logistic regression	No
Zhang 2020	China	170,872	Yes	Five-level logistic regression models	Yes
Zick et al., 2009	USA	898,387	Yes	Multilevel Logistic model	Yes
Jaime et al., 2011	Brazil	2,122	Yes	Correlation analyses Pearson	No

Reference	Country	Sample population	Physical activity consideration	Statistical Method	Significant findings
				correlation coefficient	
Longitudinal studies					
Block et al., 2011a	USA	3,113	No	Cross-classified multilevel model	No
Boone-Heinonen et al., 2013	USA	4,092	Yes	Regression with fixed effects for individuals	Yes
Burgoine et al., 2011	England	893	Yes	Correlation ANOVA and Chi-square analysis	No
Burgoine et al., 2016	UK	2,039	Yes	Linear and logistic regression	Yes
Carroll 2020	Australia	2,253	Yes	Spearman rank correlation latent variable growth models	Yes
Du et al., 2014	China	24,396	Yes	Random intercept-slope growth model	Yes
Dubowitz et al., 2012	USA	60,775	Yes	Logistic regression multivariate regression models with random effects	Yes
Gibson et al., 2011	USA	27,825	Yes	OLS	Yes
Hobbs 2019	UK	8,864	No	Multilevel linear regression	No
Jilcott Pitts et al., 2015	USA	205	No	Multiple linear and logistic regression	No
Meyer et al., 2015	USA	14,397	Yes	OLS logistic regression	No
Rummo 2017	USA	12,174	Yes	Instrumental-variables regression	No
Xu et al., 2013	China	28,063	Yes	Bayesian hierarchical regressions multilevel	Yes
Zenk 2017	USA	219	No	Hierarchical linear regression	No

GLM: General linear model, OLS: ordinary least squares regression, ANOVA: analysis of variance

Table S4. Food environment characteristics and methods of the reviewed studies

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
Abbott et al., 2014	Suburbs	Green grocers, supermarkets, FF	Density	NA	NA
Adachi-Mejia 2017	Neighbourhood	FF, restaurant, GS, supermarket	Density and proximity	1 km street-network	Government and commercial
Ahern et al., 2011	County	Direct-to-consumer farms, GS, restaurants, FF, CS	Density	NA	Government
Albalawi 2020	Postcode district (PD)	FF, restaurants, delivery, takeaways, pubs, and cafes	Density	Postcode district	Government and Commercial databases
Backes 2019	residential address	Supermarkets, GC, CS	Density	400m radius buffer around residential locations	Systematic survey
Block et al., 2011a	CTA	FF, restaurants, bakeries/coffee shops, supermarkets, GS, CS	Proximity (driving time)	NA	Government, Yellow pages, Commercial
Bodor et al., 2010	CTA	Supermarkets, medium food stores, small food stores, CS, general merchandise stores, FF	Density	2km	Government
Boone-Heinonen et al., 2013	Census block group	FF, supermarkets, CS	Proximity	1km Euclidean	Commercial
Burgoine 2017	Residential address	Supermarkets	Proximity	Street network proximity	Government
Burgoine 2018	Residential address	FF	%	1-mile straight-line radius (circular) residential address	Government
Burgoine et al., 2011	LSOA	FF, supermarkets, greengrocer, CS, pizza delivery, takeaway	Density	NA	Yellow pages
Burgoine et al., 2016	residential and work address	FF, supermarkets	Density	1-mile straight-line radius (circular) buffers, cantered on home and work addresses	Government
Carroll 2020	Census collection districts	FF; RFEI	Density, RFEI	1600m road-network proximity buffers from participants' residence	Government and commercial databases

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
Cerin et al., 2011	CTA	FF, CS, restaurants, gas/non gas food marts	Density, proximity, diversity	1km residential, 1km network	Government, Yellow Pages, online business, directories, and ground-truthing
Chaparro et al., 2017	CTA	FF, CS, LS	Density	NA	Government
Chen et al., 2010	County	Chain grocers	Density	1-mile	Government
Chen et al., 2013	CTA	Restaurants, FF	Density, proximity	0·5 mile	Government
Chen et al., 2016	County, food desert tract	Supermarkets, GS, clubs and supercentres, CS, specialty food stores, pharmacies, restaurants	Density	NA	Government
Chen 2019	CTA	mRFEI	mRFEI	None	Government
Chen 2020	CTA	mRFEI	mRFEI	None	Government
Christian, 2012	CTA	Supermarkets, CS, FV markets, limited-service restaurants	Density	0·50 miles Euclidian	Government
Conroy 2018	Census block group	REI, RFEI	REI, RFEI	1·6 km pedestrian network	Government and commercial databases
Crawford et al., 2008	State	FF chains	Proximity, density	2km	Yellow pages, commercial/online
Crawford et al., 2008	Residential address	FF	Density, proximity	2km	Government
Dake et al., 2016	Enumeration areas	Out-of-home cooked food, CS, FV	Density	NA	Ground truthing
Drewnowski et al., 2012	County and block group code	Supermarkets	Network proximity (3 types, driving)	NA	Field work
Drewnowski et al., 2014a	County	Supermarkets	Network proximity	Buffers cantered on each study participant's residence·	Government
Du et al., 2014	Neighbourhood	FF, indoor restaurants, and	Density	NA	Community questionnaire

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
		fixed outdoor food stalls			, community leader
Dubowitz et al., 2012	Tract and metropolitan statistical area	GS, supermarkets, FF	Density	0·75, 1·5, and 3·0 miles	Yellow pages, commercial
Dunn et al., 2012	CTA	FF	Density	1, 3 miles	Ground-truthing
Fan et al., 2014	Census block group, CTA, zip code, 1 km buffer around residential address.	GS, CS, restaurants	Density	1km	Commercial
Frankenfeld et al., 2015	Block group	FF, CS and pharmacies, GS, and specialty food stores	Ratio unhealthy: healthy food outlets, k-mean cluster	NA	Commercial
Fuller et al., 2013	CTA	Primary food stores	Road network proximity	NA	Commercial and participant survey
Gartin, 2012	Census block group	Open-air markets, CS, supermarkets	Proximity	0·5-1 miles	Ground-truthing
Ghosh-Dastidar et al., 2014	CTA	Supermarkets, specialty grocery stores, discount grocery stores, supercentres, meat/seafood markets, wholesale clubs	Network proximity	NA	Geocoded from participant's interview
Gibson, 2011	Zip code	GS, CS, restaurants	Density	NA	Government
Hanibuchi et al., 2011	Block	CS, FF, supermarkets	Radial proximity based on street network	500m	Yellow pages
Hattori et al., 2013	Residential address	FF, restaurants, CS, small food stores, GS, supermarkets	Density, Euclidian proximity within walking proximity	0·25, 0·5, 1-, 1·5-, and 3-miles circular buffers	Commercial
Hobbs 2017	Residential address	Supermarkets, takeaways, CS	Density	800m and 2000m) residential address; LSOA (km^2)	Government and commercial databases

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
Hobbs 2019	Residential postcode	FF, LS, CS, and restaurants	Density	2km	Commercial database
Hobbs 2019	Residential postcode	FF	Density	2km radial buffers around home postcode	Commercial database
Hobbs 2019	Cluster of food outlets	FF, LS, restaurants, CS, independent supermarkets, specialty, café	Density	1600m Euclidean radial buffer	National database
Hollands et al., 2013	Forward sortation area	FF, coffee outlets, restaurants	Density	NA	Commercial
Hollands et al., 2014	Forward sortation area	FF, restaurants	Density	NA	Commercial
Hosler, 2009	Census block group	Food stores, farmer's markets	Density, Euclidian proximity	NA	Research centre
Inagami et al., 2009	CTA	FF	Density	NA	Government
Jaime et al., 2011	Sub-municipality	Supermarket, GS, FV, FF chains	Density	NA	Government and commercial
Jeffery et al., 2006	Not defined	FF, restaurants	Proximity, density, frequency	Radio of 0·5 miles, 1 mile and 2 miles (home and work addresses)	Government and commercial
Jilcott et al., 2011	County	Farmers' markets, GS, supermarkets, supercentres	Density	NA	Government
Jilcott Pitts et al., 2015	County	Farmers' market	Network proximity	NA	Ground truthing
Kruger et al., 2014	County	FF	Proximity	NA	Yellow pages and internet
Laxy et al., 2015	Neighbourhood	FF, CS, supermarkets	Network proximity	NA	Commercial
Li et al., 2008	Census block group	FF	Density	NA	Commercial
Li et al., 2009b	Census block group	FF	Density	NA	Government and commercial
Li et al., 2009c	Census block group	FF	Density	NA	Government and commercial
Liese 2017	Residential address	Supermarkets, supercentre, or warehouse club	Proximity	None	Ground-truthing survey and government

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
Lopez, 2007	Zip code	Supermarkets, FF, general retail	Density	NA	Government and commercial
Macdonald et al., 2011	Postal code	Supermarkets, independent food stores and chain outlets, FV	Network Proximity	500m and 1000m	Government
Mackenbach 2019	Neighbourhood	FF	Spatial access	300m Euclidean buffer around selected residential neighbourhoods	Commercial database
Mackenbach 2019	Residential address	FF	Spatial access	300m Euclidean buffers around participants' home addresses	Commercial database
Maddock, 2004	State	FF	Square miles per food outlet	NA	Yellow pages and online verification
Mason 2018	Residential address	FF	Street-network Proximity	500m, 500–999m, 1000–1999m, 2000m from residential address	National database
Mazidi and Speakman, 2017	County	FF and restaurants	Density	NA	Government
Mehta and Chang, 2008	County	FF	Density	NA	Government
Mejia et al., 2015	Neighbourhood	FF, CS, small food stores, GS, supermarkets.	Density, Euclidian proximity	0·25, 0·5, 1, 1·5, and 3 miles	Commercial
Mendes et al., 2013	Postal code	Supermarkets, hypermarkets	Presence, health vulnerability index	NA	Commercial
Meyer et al., 2015	Neighbourhood	CS, coops/natural food stores, specialty markets, supermarkets, GS, FF, food stances/cafeterias, restaurants	Density	3km	Commercial
Michimi and Wimberly, 2010	County	Supermarkets and supercentres other grocery stores (except convenience stores), and warehouse clubs	Euclidian proximity	NA	Government

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
Michimi and Wimberly, 2015	County	Supermarkets, snack/coffee shops, restaurants, FF, CS	Factor analysis	NA	Government
Morland et al., 2006	CTA	Supermarkets, grocery stores, or smaller non–corporate-owned food stores, CS, restaurants, FF, and limited-service restaurant	Density	NA	Government
Murphy 2017	Residential address	Supermarkets	Density, proximity	800, 1000, 1600, 2000 and 3000m network	Government, commercial, and ground truthing
Murphy 2018	Residential address	FF, supermarkets	Density, proximity	800m, 1000m, 1600m, 2000m, and 3000m network	Government and commercial
Mylona 2020	Residential address	FF	kernel Density	3·1 km	Commercial database
Oexle et al., 2015	County	FF	Count, proximity	1 mile	Ground truthing
Oka et al., 2013	CTA	Food markets, CS, grocers, restaurants, pizza stores, gyms	Principal component analysis	NA	Government
Patel et al., 2017	census enumeration blocks	FF, restaurants	Density	1-km	Ground truthing
Pearce et al., 2009	Census mesh block	Multinational/local FF	Travel proximity	NA	Yellow pages
Pineda et al.., 2021	CTA	FF, restaurant, CS, supermarkets	Density	NA	Government and ground truthing
Polsky et al., 2016	Census block group	FF, restaurants	Absolute density, relative density	720m along the street network	Commercial
Polsky et al., 2016	Dissemination blocks	Restaurants	Absolute and relative Density	720m	Commercial
Pouliou and Elliott, 2010	Postal code	FF, CS, GS, supermarkets	Density	1km	Government
Prince et al., 2012	Neighbourhood	GS, CS, specialty food stores, FF, restaurants	Density	NA	Another study

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
Pruchno et al., 2014	CTA	FF, store fronts, supermarkets, GS, CS	Density	NA	Government
Richardson et al., 2015	Residential address	FF, restaurants, supermarkets, CS	Density	3 and 8km Euclidean	Commercial
Rummo 2017	Residential address	FF, restaurants, CS, GS, supermarkets	percentage of CS, GS, and S out of sum of them, percentage of FF and FSR out of the sum of them	1-km street network proximity from respondents' residences	Commercial database
Rundle et al., 2009	Network buffer around residential address	Supermarkets, FV markets, FF, pizzerias, bakeries, and candy and nut stores	Density	805m network	Commercial
Salois, 2012	County	Restaurants, FF, supermarkets, GS, gas-based CS, no-gas CS, super centre/warehouse club stores, farmers' markets	Density	NA	Government
Singleton et al., 2016	County	GS, CS, farmer's markets, supercentres, supermarkets, FF, restaurants	Density	NA	Government
Slack et al., 2014	County/food desert tract	FF	Density	NA	Government
Spence et al., 2009	Postal code	Supermarkets, FF, specialty food stores, CS	Count, ratio, Retail Food Environment Index (RFEI)	800m and 1600m	Government and commercial
Stark et al., 2013	Zip code	GS, supermarkets, national/local FF, pizza restaurants, CS, Food outlets were categorized, bodegas, bakeries, candy and nut stores, meat markets, restaurants, GS, fish markets and specialty food stores	Density, relative concentration (proportion), diversity	NA	Commercial
Tung et al., 2016	Neighbourhood	GS	Euclidian Proximity	NA	Self-reported

Reference	Geographic unit of observation	Store type	Spatial food store measure	Buffer size	Food outlet source
Viola et al., 2013	Postal code	FF, pizzerias, supermarkets	Density, Network Proximity	¼ miles	Commercial
Walker 2020	Residential postcode	FF, restaurants, pubs to liquor stores, markets	ratio (FF/FSR, pubs/liquor stores); Count (markets)	500m	Ground-truthing survey
Wang et al., 2007	Census tracts and/or block groups	FF, food retail stores	Density, Euclidian Proximity	0·5 miles	Government and commercial
Xu and Wang, 2015	County	FF and restaurants	Ratio FF:Restaurants	NA	Government
Xu et al., 2013	Street committee	FF, restaurants	Density	720m street network	Government
Yan et al., 2015	County	Supercentres, GS, CS, specialized food stores	Density	NA	Government
Yenerall 2017	Residential address	GS	accessibility (network Proximity)	None	National database
Zenk 2017	Census block group	CS, small GS, large GS, liquor stores	availability (Count)	0·5-mile radial buffer around participants' census block centroid	Ground-truthing survey
Zhang 2019	CTA	mRFEI	mRFEI	0·5 miles	Commercial database
Zhang 2020	Subdistrict/town	FF, restaurants, small GS, LS	Density	NA	National database
Zick et al., 2009	Census block group	Healthy grocery stores, CS, restaurants, FF, multiple retail food options	Density, diversity, and design	NA	Government and commercial

CS: convenience store, FF: fast-food outlet, FV: fruit and vegetable store, GS: grocery store, LS: liquor store, RFEI: retail food environment index, mRFEI: modified retail food environment index. NA: not available/not applicable

5. Risk of bias assessment

Table S5. Risk of bias and quality assessment of reviewed studies

Reference	Population sampling	Outcome	Exposure (food environment)	Food outlet data source	Spatial analysis method	PA	Study design	Statistical Method	Data temporality/ time match	Score
Abbott et al., 2014	Low	High	Low	High	High	High	High	High	High	2
Adachi-Mejia et al., 2017	High	High	Low	Low	Low	Low	High	High	High	4
Ahern et al., 2011	Low	High	Low	High	High	Low	High	High	High	3
Albalawi 2020	High	Low	Low	Low	High	High	High	High	High	3
Backes 2019	Low	High	Low	Low	High	High	High	High	Low	4
Block et al., 2011a	Low	Low	Low	High	High	High	Low	Low	Low	6
Bodor et al., 2010	High	High	Low	Low	High	High	High	High	Low	3
Boone-Heinonen et al., 2013	Low	Low	Low	High	High	Low	Low	High	Low	6
Burgoine 2017	Low	Low	High	Low	High	Low	High	High	High	3
Burgoine 2018	Low	Low	Low	Low	High	Low	High	High	High	4
Burgoine et al., 2011	Low	High	Low	High	High	Low	Low	High	Low	5
Burgoine et al., 2016	Low	Low	High	Low	Low	High	High	High	Low	5
Carroll 2020	Low	Low	Low	Low	Low	Low	Low	High	Low	7
Cerin et al., 2011	Low	High	Low	Low	Low	Low	High	Low	High	6
Chaparro et al., 2017	Low	High	High	High	Low	High	High	Low	Low	4
Chen et al., 2010	Low	High	High	Low	High	High	High	Low	High	3
Chen et al., 2013	High	High	High	Low	Low	Low	High	Low	Low	5
Chen et al., 2016	Low	High	High	High	High	High	High	Low	High	2
Chen et al., 2019	High	Low	Low	Low	High	High	High	Low	High	4
Chen et al., 2020	High	Low	High	Low	High	High	High	High	High	2

Reference	Population sampling	Outcome	Exposure (food environment)	Food outlet data source	Spatial analysis method	PA	Study design	Statistical Method	Data temporality/ time match	Score
Christian, 2012	High	High	Low	Low	High	High	High	High	Low	3
Conroy 2018	High	High	Low	Low	High	High	High	High	High	2
Cooksey-Stowers et al., 2017	Low	High	Low	High	Low	Low	High	High	Low	5
Crawford et al., 2008	High	High	High	High	High	Low	High	High	High	1
Dake et al., 2016	High	Low	Low	High	Low	Low	High	Low	Low	6
Drewnowski et al., 2014b	High	High	High	Low	High	High	High	Low	Low	3
Drewnowski, 2012	High	High	High	Low	High	High	High	High	Low	2
Du et al., 2014	Low	Low	Low	High	Low	Low	Low	High	High	6
Dubowitz et al., 2012	Low	Low	Low	Low	High	Low	Low	High	High	6
Dunn et al., 2012	Low	High	High	Low	High	High	High	Low	Low	4
Fan et al., 2014	Low	High	Low	High	High	High	High	High	High	2
Frankenfeld et al., 2015	Low	High	Low	High	High	High	High	High	High	2
Fuller et al., 2013	High	High	High	Low	High	Low	High	Low	Low	4
Gartin, 2012	High	Low	Low	Low	High	High	High	High	Low	4
Ghosh-Dastidar et al., 2014	Low	Low	Low	Low	Low	High	High	High	Low	6
Gibson, 2011	Low	Low	Low	Low	High	High	High	High	Low	5
Hanibuchi et al., 2011	Low	High	Low	High	High	High	High	High	High	2
Hattori et al., 2013	Low	High	Low	High	Low	Low	High	Low	High	5
Hobbs 2017	High	High	Low	Low	Low	High	High	High	Unclear	3
Hobbs 2019	High	High	Low	Low	High	High	Low	Low	High	4
Hobbs 2019	High	High	High	Low	High	High	High	High	High	1
Hobbs 2019	High	High	High	Low	High	High	High	High	Unclear	1

Reference	Population sampling	Outcome	Exposure (food environment)	Food outlet data source	Spatial analysis method	PA	Study design	Statistical Method	Data temporality/ time match	Score
Hollands et al., 2013	High	High	Low	Low	High	Low	High	Low	Low	5
Hollands et al., 2014	Low	High	High	Low	High	Low	High	Low	Low	5
Hosler, 2009	Low	High	High	Low	High	High	High	High	High	2
Inagami et al., 2009	Low	High	High	Low	High	High	High	Low	High	3
Jaime et al., 2011	Low	High	Low	Low	High	Low	High	High	Low	5
Jeffery et al., 2006	Low	High	High	High	Low	Low	High	High	High	3
Jilcott et al., 2011	Low	High	Low	Low	High	Low	High	Low	High	5
Jilcott Pitts et al., 2015	High	High	High	Low	Low	High	High	High	Low	3
Kruger et al., 2014	High	High	High	High	High	High	High	High	High	0
Laxy et al., 2015	Low	Low	Low	High	Low	Low	High	High	Low	6
Li et al., 2008	Low	High	High	High	High	Low	High	Low	Low	4
Li et al., 2009c	Low	High	High	High	High	Low	High	Low	Low	4
Li et al., 2009c	Low	High	High	High	High	Low	High	Low	Low	4
Liese 2017	High	Low	Low	Low	High	Low	High	High	Low	4
Lopez, 2007	Low	High	Low	High	High	High	High	Low	High	3
Macdonald et al., 2011	Low	High	Low	Low	High	High	High	High	High	3
Mackenbach 2019	High	High	High	Low	Low	High	High	Low	High	3
Mackenbach 2019	High	High	High	Low	High	High	High	High	Low	2
Maddock, 2004	Low	High	High	High	High	Low	High	Low	High	3
Mason 2018	High	Low	High	Low	High	Low	High	High	Unclear	2
Mazidi and Speakman, 2017	Low	High	High	Low	Low	Low	High	High	Low	5
Mehta and Chang, 2008	Low	High	High	High	High	High	High	High	Low	2

Reference	Population sampling	Outcome	Exposure (food environment)	Food outlet data source	Spatial analysis method	PA	Study design	Statistical Method	Data temporality/ time match	Score
Mejia et al., 2015	High	High	Low	Low	Low	Low	High	High	High	4
Mendes et al., 2013	High	High	High	High	High	High	High	High	High	0
Meyer et al., 2015	High	Low	Low	High	High	Low	Low	High	High	4
Michimi and Wimberly, 2010	High	High	Low	High	High	High	High	High	Low	2
Michimi and Wimberly, 2015	High	High	Low	Low	High	High	High	Low	Low	4
Morland et al., 2006	Low	Low	Low	High	High	Low	High	Low	High	5
Murphy 2017	High	High	High	Low	High	High	High	Low	Low	3
Murphy 2018	High	High	High	Low	High	Low	High	Low	Unclear	2
Mylona 2020	High	Low	High	Low	High	Low	High	Low	Unclear	3
Oexle et al., 2015	High	High	High	Low	Low	High	High	High	High	2
Oka et al., 2013	Low	Low	Low	High	High	Low	High	Low	High	5
Patel et al., 2017	Low	Low	High	Low	Low	Low	High	High	High	5
Pearce et al., 2009	Low	Low	High	High	High	High	High	Low	High	3
Pineda et al., 2021	Low	Low	Low	Low	Low	Low	High	Low	High	7
Polsky 2016	High	High	Low	Low	Low	Low	High	High	High	3
Polsky et al., 2016	Low	Low	High	High	High	Low	High	High	High	3
Pouliou and Elliott, 2010	Low	High	Low	High	High	Low	High	High	High	3
Prince et al., 2012	Low	High	Low	High	High	Low	High	Low	High	4
Pruchno et al., 2014	High	High	Low	High	High	High	High	Low	Low	3
Richardson et al., 2015	High	Low	High	High	High	Low	Low	Low	Low	5
Rummo 2017	High	Low	Low	Low	High	Low	Low	High	Low	5
Rundle et al., 2009	Low	Low	Low	High	High	Low	High	Low	High	5

Reference	Population sampling	Outcome	Exposure (food environment)	Food outlet data source	Spatial analysis method	PA	Study design	Statistical Method	Data temporality/ time match	Score
Salois, 2012	Low	High	Low	High	High	Low	High	High	Low	4
Singleton et al., 2016	High	High	Low	Low	Low	High	High	High	High	
Slack et al., 2014	Low	High	High	High	High	Low	High	Low	High	3
Spence et al., 2009	High	High	Low	High	Low	High	High	High	High	2
Stark et al., 2013	High	High	Low	High	Low	Low	High	Low	Low	5
Tung et al., 2016	High	Low	High	High	High	Low	High	High	Low	3
Viola et al., 2013	High	High	Low	High	Low	Low	High	Low	Low	5
Walker 2020	High	Low	Low	Low	Low	Low	High	Low	Unclear	5
Wang et al., 2007	Low	High	Low	High	Low	Low	High	Low	High	5
Xu and Wang, 2015	Low	High	High	High	High	Low	High	Low	Low	4
Xu et al., 2013	High	High	High	Low	Low	Low	Low	Low	Low	6
Yan et al., 2015	High	High	Low	High	High	High	High	High	High	1
Yenerall 2017	Low	High	High	Low	High	High	High	High	Unclear	2
Zenk 2017	High	Low	Low	Low	High	High	Low	High	Low	5
Zhang 2019	High	Low	Low	Low	High	High	High	High	High	3
Zhang 2020	High	Low	Low	Low	High	Low	High	High	Low	4
Zick et al., 2009	High	High	Low	High	Low	Low	High	Low	High	4

A high score represents a lower risk of bias while a low score indicates a higher risk of bias. The maximum possible score was 9.

6. Food outlet density and proximity and its association with BMI

Figure S2. Fast-food outlet density and proximity and its association with BMI

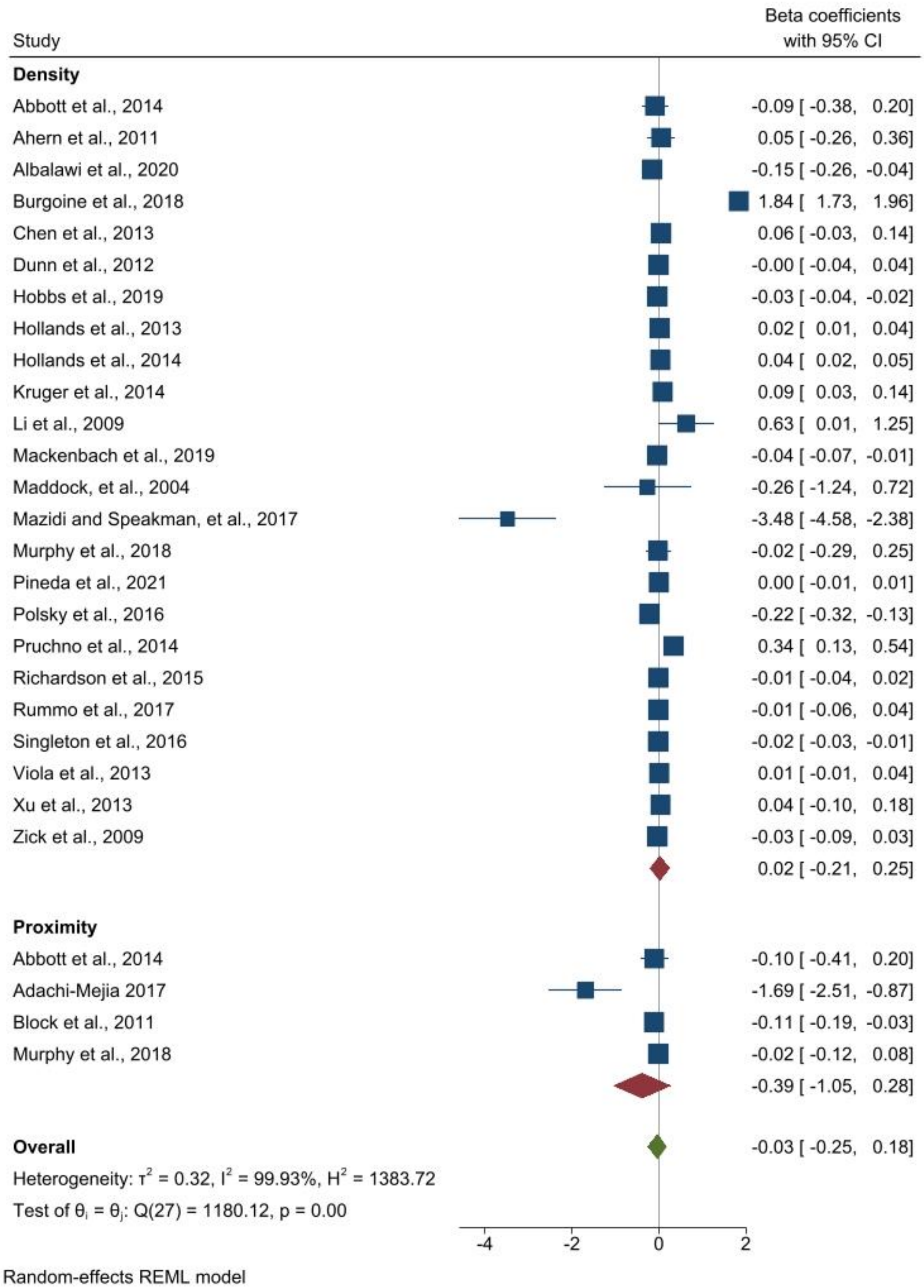


Figure S3. Restaurant density and its association with BMI.

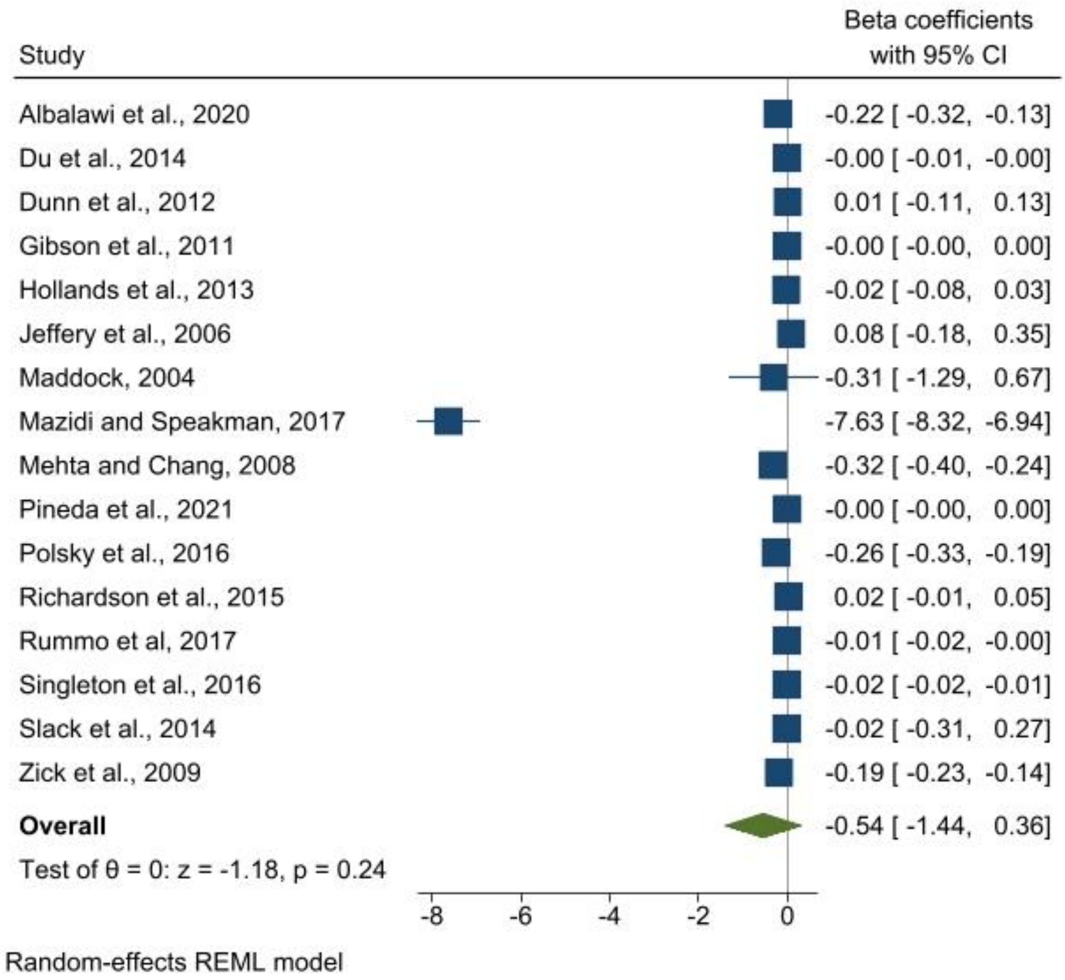


Figure S4. Convenience store density and proximity and its association with BMI.

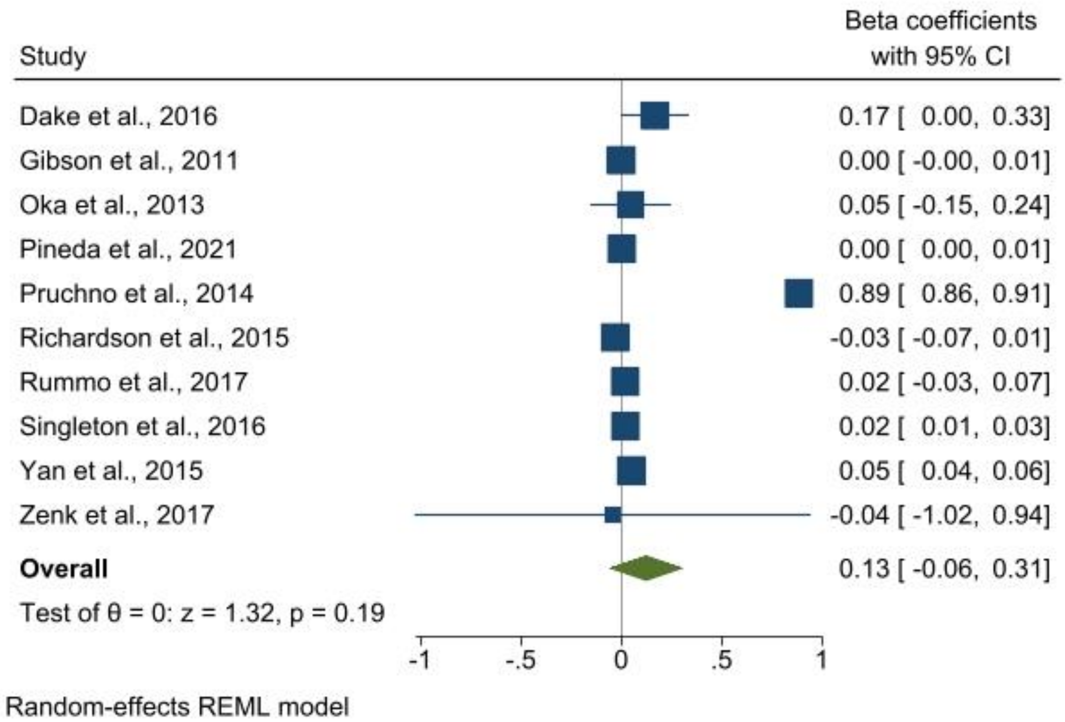


Figure S5. Supermarket density and proximity and its association with BMI.

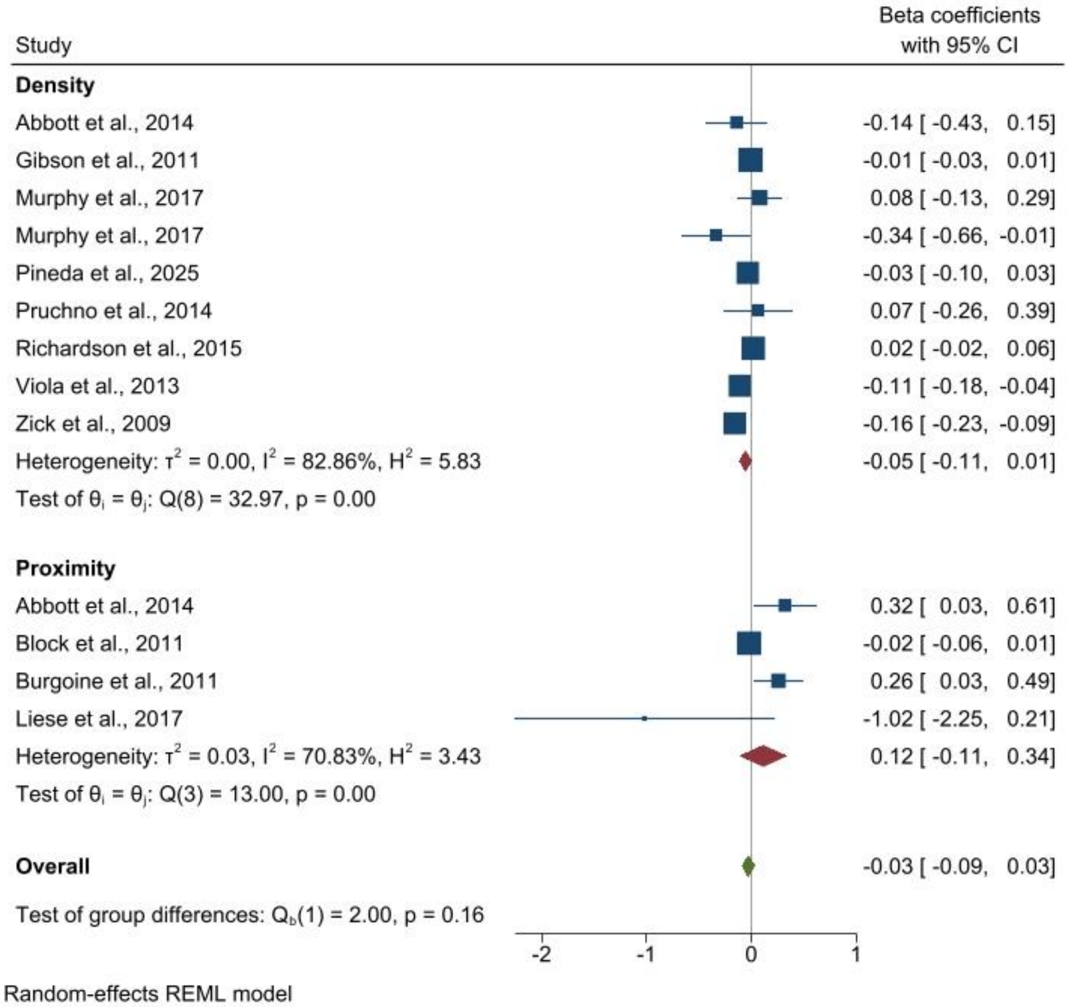


Figure S6. Fruit and vegetable store density and its association with BMI.

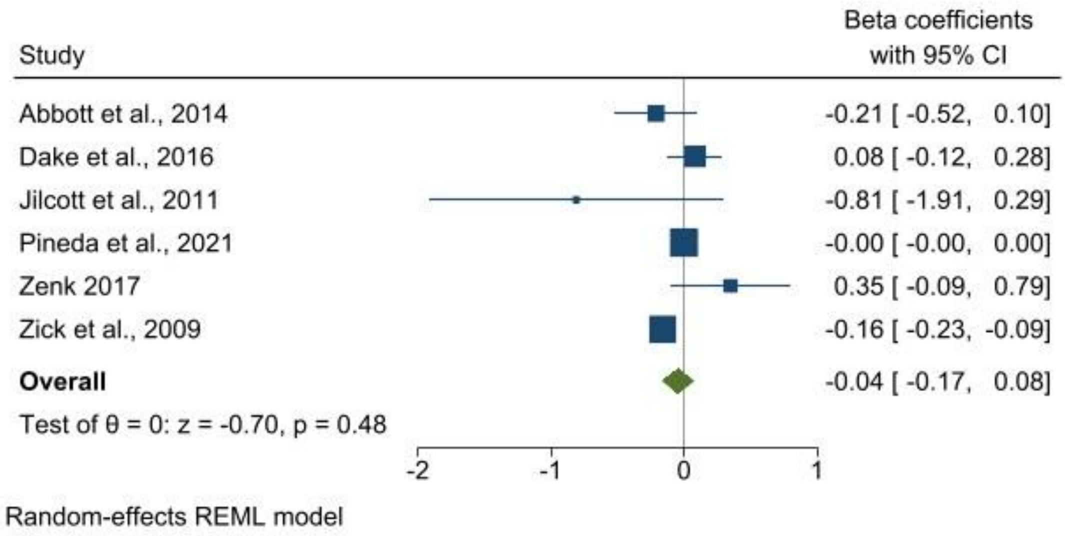


Figure S7. Retail food environment index (RFEI) and its association with BMI.