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# BMJ Open

## Neighborhood effects on obesity: a scoping review of longitudinal study designs

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# NEIGHBORHOOD EFFECTS ON OBESITY: A SCOPING REVIEW OF LONGITUDINAL STUDY DESIGNS

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Obesity, neighborhood effect, longitudinal design, scoping review

## ABSTRACT

### Introduction

Neighborhood effect research on obesity took off in the early 2000s, and was composed of mostly cross-sectional observational studies interested in various characteristics of the built environment and the socioeconomic environment. To limit biases related to self-selection and life course exposures, many researchers now apply longitudinal designs in their studies. Until now, no review has specifically and exclusively examined longitudinal studies or the specific designs of these studies. In this review, we intend to answer the following research question: How are the temporal measurements of contextual exposure and obesity outcomes integrated into longitudinal studies that explore how neighborhood-level built and socioeconomic environments impact adult obesity?

### Methods and Analysis

A systematic search strategy was designed to address the research question, and to collect all possible publications relevant to this field from three scientific citation index databases. The eligible studies reported results on adults, included exposure that was limited to neighborhood characteristics at the sub-municipal level, included an outcome limited to obesity proxies (OP), and reported a design with at least two exposure measurements or two outcome measurements.

### Discussion and Conclusion

This scoping review identified 66 studies that fit the eligibility criteria. A wide variety of neighborhood characteristics were also measured, making it difficult to draw general conclusions about associations between neighborhood exposure and obesity. We applied a typology that classified studies by whether exposure and outcome were measured as varying or fixed. Using this typology, we found that 32 studies reported both neighborhood exposure and obesity outcomes that were varying in time, 28 reported varying outcomes but fixed exposures, and six had fixed outcomes and varying exposures. This typology illustrates the variety of longitudinal designs that were used in the selected studies. In conclusion, we make recommendations on how to better report longitudinal designs and facilitate comparisons between studies.

## ARTICLE SUMMARY

Strengths and limitations of this study:

- To our knowledge, this is the first review of longitudinal designs of neighborhood effect studies on obesity.
- This study proposes a typology to that classifies longitudinal studies by their design.
- The descriptive nature of a scoping review excludes quantitative analyses of the results.
- This scoping review excludes studies on children, which limits its scope but increases the homogeneity of the results.

## 1. BACKGROUND

Before the emergence of ecological models for weight change [1-3], obesity was mostly considered an individual responsibility. Efforts to combat the obesity epidemic were therefore focused on trying to influence the behaviors of individuals to either reduce their caloric intake or increase their caloric expenditure, or both. But such public health interventions did not have the expected results [4]. Worldwide, adult populations have shown increasing rates of obesity prevalence, although a slower rate has been observed in high-income countries [5, 6]. In children, trends in obesity prevalence have plateaued in high-income countries but are steadily increasing in East and South Asia [7].

Due to the mitigated success from the interventions that focused on individuals, some researchers expanded their focus by including the contextual factors in the causal web that may lead to obesity. Among the many levels of contextual factors, those related to neighborhoods quickly became aspects of interest for reasons both theoretical and practical. The observational theory that being overweight is heterogeneously geographically distributed on the neighborhood scale is a strong incentive for researchers to focus on the contextual influences that occur close to one's residence [8]. Also, the increase in obesity prevalence correlates over time with strong global contextual changes. A number of these changes include trade liberalization, economic growth and rapid urbanization, which impact the shape and dynamics of neighborhoods [9]. Among the more practical reasons for focusing on the neighborhood level is the hypothesis that the home environment is relatively easier to influence compared to the global food market or industrialization. Moreover, in some countries, local and national governments have the legislative and regulatory powers to plan neighborhoods. They are also responsible for health policies and services, which act as incentives for the government to lower health care costs and increase well-being by using contextual interventions.

Neighborhood effect research on obesity grew in popularity in the early 2000's [10], consisting of mostly cross-sectional observational studies. These studies were focused on various characteristics of the built environment (e.g. dwelling density, street connectivity, land use mix, food availability) and the socioeconomic environment (e.g. deprivation, safety, social cohesion) and their effect on different obesity proxies (OP) (e.g. BMI (Body Mass Index), weight, waist circumference). The last two decades saw the publication of a substantial number of such studies [10-19]. As of today, recent literature reviews specifically interested in the neighborhood level have identified urban sprawl (positively) and land use mix (negatively) to be associated with weight, only in North America [10] [14]. But authors have also reported methodological challenges, such as self-selection bias and the

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3 lack of life course exposure, and have suggested improving neighborhood effect studies by using  
4 longitudinal designs (i.e. using repeated measures of outcome and/or exposure) in order to move  
5 towards causality models [10, 14, 20].  
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9 Self-selection is a bias that can be introduced when individual residential localization choices are  
10 related to individual obesity outcomes [21, 22]. For instance, people who enjoy physical activity  
11 might prefer residential neighborhoods where many opportunities for such activities exist. People  
12 who enjoy traveling by car might prefer car-friendly neighborhoods compared to those who prefer  
13 walking [23]. These preferences and behaviors are often associated with obesity outcomes, but the  
14 time sequence between residential choice and weight gain cannot be disentangled in cross-sectional  
15 studies. In addition to the temporal sequence problem, cross-sectional studies have a limited  
16 capacity to examine the cumulative effect of neighborhood exposure on an individual [21, 24, 25].  
17 An unhealthy obesity status can be the result of a very gradual weight gain. This potentially long  
18 latency combined with the effect of frequent residential moving is not captured by the current  
19 studies on neighborhood exposure [24, 26].  
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26 The ability of longitudinal studies to control for self-selection bias and life course exposure depends  
27 in part on their design; i.e. how outcome and exposure measurements are considered in time.  
28 Additionally, although some reviews of neighborhood effects on obesity did include a section  
29 dedicated to longitudinal studies, no review was specifically devoted to longitudinal studies or to  
30 the specific designs that were used.  
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## 35 **2. RESEARCH QUESTION AND OBJECTIVES**

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37 This scoping review was specifically designed to answer the following research question: How are  
38 the temporal measurements of contextual exposure and obesity outcomes integrated into  
39 longitudinal studies that explore how neighborhood-level built and socioeconomic environments  
40 impact adult obesity?  
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45 To address this research question, the specific objectives of this review were to:

- 46  
47 1. detail the number of studies investigating longitudinal neighborhood effects on obesity  
48 status and to describe their general characteristics;
- 49  
50 2. describe and classify the study designs used to investigate longitudinal neighborhood  
51 effects on obesity status;
- 52  
53 3. carry out a qualitative overview of the associations between neighborhood exposure and  
54 obesity status among studies that apply a longitudinal design.  
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### 3. MATERIALS AND METHODS

We decided to use a scoping review approach because the large number of study designs that were used in the literature makes it difficult and irrelevant to sum and compare results quantitatively [27]. Methods for this review are described in greater detail in the protocol [28]. A concise description of the methods is provided in the following sections.

#### 3.1 Systematic search strategy

A systematic search strategy was designed to reflect the research question as closely as possible and to collect all possible studies relevant to this field of research while screening for the eligibility criteria described in Table 1.

*Table 1 Eligibility criteria for selection of publications. Modified from the PICO (Population, Intervention, Comparison, Outcome) framework [27].*

<b>Criteria</b>	<b>Description</b>
<b>Population</b>	<i>Eligible study populations were composed of adults between 18 and 65 years of age. At least two OPs and/or neighborhood characteristics must have been measured during adulthood (18 to 65 years old); other measurements may be collected in childhood, youth or older age.</i>
<b>Exposure</b>	<i>Exposure was measured by any indicator of neighborhood socioeconomic and/or built environment, where neighborhood is defined as an administratively delimited geographic area enclosing the participant's residence, a buffer-delimited area around the participant's residence, or a perceived area delimited by the participant. The geographic area must have been defined at the neighborhood level, which is smaller than a municipal area.</i>
<b>Outcome</b>	<i>The term "obesity" is generally used to refer to the accumulation of body fat and can be measured in numerous ways. Eligible studies were those reporting measured or self-reported OP such as total body weight, BMI, waist circumference, waist/hip ratio and/or skin fold thickness (with no specific thresholds). In this review, any study considering obesity status as an outcome was included.</i>
<b>Study Design</b>	<i>The studies must have included a longitudinal perspective in the measurement of the exposure and/or outcome. For example, studies applying the following designs were considered longitudinal: case-control studies and cohort studies, where exposure is measured at different points in time or classified as a pattern over time; or experimental or quasi-experimental schemes, where participants are exposed to different living environments over time. Cross-sectional and ecological studies were systematically excluded. Study designs that focused only on life course changes in obesity status without measuring contextual exposure were not included in this review.</i>

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3 A search strategy was drafted by an experienced librarian (Frédéric Bergeron) and completed by  
4 the research team. The final search strategy involved identifying five keywords specifically related  
5 to the research question and articulated using Boolean operators:  
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8 Outcome terms AND longitudinal design terms AND (geographic context terms AND (social  
9 environment exposure terms OR physical environment exposure terms)).  
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12 This research strategy was modified to fit the search terms specific to three scientific citation index  
13 databases: *Embase*, *Web of Science* and *PubMed*. The full search strategy for PubMed is presented  
14 as an example in Supplementary file 1. Only peer-reviewed literature that was published in  
15 referenced journals in English were considered. The search was performed in February 2018 for  
16 scientific papers published before 01/01/2018.  
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### 20 21 **3.2 Screening and Eligibility**

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23 The selection process was performed independently by two investigators (LL and SP). Kappa  
24 correlation was calculated to assess the inter-investigator agreement for selecting articles according  
25 to the title and abstract. Disagreements were resolved by attempting to reach a consensus between  
26 the two investigators. When a consensus could not be reached, a third observer (AL) was consulted  
27 to make a final decision. Most of the articles excluded at this point were ecological studies, studies  
28 with exposures measured at a scale other than the neighborhood, and studies with outcomes that  
29 were not obesity status. Pertinent articles from the reference list of included papers were also added  
30 to the screened records.  
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### 36 37 **3.3 Charting**

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39 The charting process was conducted according to the steps described in the previously published  
40 protocol [28]. The construction of the chart also includes an iterative procedure of improvement, in  
41 order to consider other types of longitudinal designs that were not expected prior to the charting.  
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44 In its final form, the charting table contained the following information, extracted by one  
45 investigator (LL):  
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- 48 • Basic characteristics (year published, country of data collection, target population, type of  
49 outcome measure, exposure measure [type and neighborhood unit])
- 50 • Longitudinal characteristics (number of outcome measures, number of exposure measures,  
51 residential mobility of the population, change in neighborhood characteristics, typology of  
52 study designs)
- 53 • Direction and statistical significance of reported associations  
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Results were synthesized by grouping studies according to their basic and longitudinal characteristics and then summarizing their overall findings by analysing the reported associations.

## 4. RESULTS

### 4.1 Publication selection

Citations collected from the database searches were managed using Endnote X7.5. Duplicates were deleted. A flowchart of the selection process is presented in **Error! Reference source not found.** From the 12,757 identified studies, after screening for relevant titles, abstracts and full manuscripts, 66 articles that fitted the eligibility criteria were selected [29-94]. Summary characteristics are shown in Table 2 and complete characteristics of the studies are shown in Supplementary file 2.

[Figure 1]

### 4.2 Basic characteristics

#### 4.2.1 Year published

[Figure 2]

The selected studies were published over a relatively short time span, with the earliest publication in 2005 (**Error! Reference source not found.**). A general increasing pattern was observed, with a greater number of studies published each year. A particularly notable increase was observed for the last year of the review period (20 papers in 2017).

#### 4.2.2 Countries of Origin

Among the selected articles, the studied populations were not particularly diverse. The majority of studies were from North America (79%, n= 52), and more specifically from the United States (74%, n=37). Of the non-American study populations, seven (11%) were European, two (3%) were from Asia and five (8%) were Australian.

#### 4.2.3 Target Population

We focused on adult populations, who have more stable weight status patterns than children. Thus the selection criteria were set to include only studies in which two measurements were collected for OPs and/or neighborhood exposure during adulthood (18-65 years old). The majority of studies (n=33) examined non-specific adult populations. Six studies examined young adults (generally younger than 35 years old), while seven other studies were focused on older adults (generally older than 45 years old). Fourteen studies also chose specific sub-groups of the adult population that are

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3 susceptible to a differentiated neighborhood effect compared to the general adult population  
4 (women, African-American women, people with diabetes and migrants). Fourteen studies stratified  
5 their results for gender, four for race, and two for urban/rural places of residence.  
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#### 8 4.2.4 Outcome Measures 9

10 The studies presented in this review were selected for outcomes associated with obesity. BMI was  
11 used as an outcome by 76% (n=50) of the studies, while waist circumference (or a ratio associated  
12 to waist and hip circumference) was used by 8% (n=5) of the studies. The remainder (17%, n=11)  
13 used weight or more than one type of measure as outcomes. Only one study included measurements  
14 of subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) [63].  
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Table 2 Distribution of the included studies, their overall findings and design characteristics

Characteristics	Included studies		Overall study findings				
	n	%	Null n	Mixed n	Expected n	Inverse n	% studies with expected findings
<b>All</b>	<b>66</b>	<b>100%</b>	34	6	25	1	38%
<b>Outcome</b>							
BMI	50	76%	24	5	20	1	40%
BMI and waist circumference	7	11%	6	1	.	.	.
Waist circumference	5	8%	2	.	3	.	60%
Weight	3	5%	2	.	1	.	33%
Adipose tissue volume	1	2%	.	.	1	.	100%
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Type of attribute</b>							
Built environment	32	49%	20	3	8	1	25%
Socioeconomic	30	46%	12	2	16	.	53%
Both	4	6%	2	1	1	.	25%
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Geographic unit</b>							
Census limits	25	38%	10	3	12	.	48%
Euclidean Buffer	13	20%	8	.	4	1	31%
Other	10	15%	8	1	1	.	10%
Administrative limits	9	14%	5	.	4	.	44%
Network buffer	7	11%	3	2	2	.	29%
Self-reported	2	3%	.	.	2	.	100%
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Residential mobility</b>							
Stayers and movers	46	70%	22	5	18	1	39%
Stayers	12	18%	7	.	5	.	42%
Stratified	6	9%	3	1	2	.	33%
Movers	2	3%	2	.	.	.	.
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Change in neighborhood characteristics</b>							
No	38	58%	16	3	19	.	50%
Yes	28	42%	18	3	6	1	21%
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Typology</b>							
Varying Outcome-Varying Exposure	32	49%	20	3	8	1	25%
Varying Outcome-Fixed Exposure	28	42%	12	3	13	.	46%
Fixed Outcome-Varying Exposure	6	9%	2	.	4	.	67%
<b>All</b>	<b>66</b>	<b>100%</b>					

#### 4.2.5 Exposure Measurements

Each of the studies that were included was classified according to the primary exposure that was examined. About half the studies fell into the built environment category (49%, n=32) and slightly fewer fell into the socioeconomic indicators category (46%, n=30). A small proportion of studies

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3 included both types (6%, n=4). Table 3 shows all associations measured in all included studies  
4 (n=483) and groups them into indicator categories. Food environment indicators appeared most  
5 often (46%, n=223), followed by area deprivation (14%, n=66), green spaces (8%, n=40),  
6 socioeconomic composite index (7%, n=34), and perceived environment indicators (5%, n=25). The  
7 indicators used were widely varied in all the categories. For example, some food environment  
8 indicators focused on assessing healthy food environments, such as grocery store and supermarket  
9 densities [29, 62], and others focused on fast-food restaurant and convenience store densities [65,  
10 90]. For composite indexes, authors applied an array of indexing methods, from preexisting indexes  
11 [50, 77, 84], to summing different indicators [42, 70, 80] or using principal component analyses  
12 [45, 54, 74, 75, 89, 95].  
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Table 3 Number of associations measured in selected studies and percent of statistically significant associations by indicator type

Indicator type	Associations N (% of all associations in study)	Statistically significant associations N (% by indicator type)
Food environment	223 (46.2%)	53 (23.8%)
Deprivation	66 (13.7%)	18 (27.3%)
Green space	40 (8.3%)	8 (20.0%)
Composite index socioeconomic	34 (7.0%)	21 (61.8%)
Perceived environment	25 (5.2%)	4 (16.0%)
Security	25 (5.2%)	2 (8.0%)
Physical activity establishment	16 (3.3%)	4 (25.0%)
Walkability	11 (2.3%)	2 (18.2%)
Composite index built environment	10 (2.1%)	5 (50.0%)
Land use	9 (1.9%)	2 (22.2%)
Transportation infrastructure	6 (1.2%)	4 (66.7%)
Density	5 (1.0%)	2 (40.0%)
Racial composition	4 (0.8%)	2 (50.0%)
Distance to landmark	2 (0.4%)	2 (100.0%)
Other	2 (0.4%)	2 (100.0%)
Foreclosure	2 (0.4%)	1 (50.0%)
Sprawl	2 (0.4%)	0 (0.0%)
Prevalence of health behavior	1 (0.2%)	1 (100.0%)
<b>All</b>	<b>483</b>	<b>133</b>

There was also a large amount of variability in the choice of neighborhood units that were used to calculate exposure. The neighborhood areas most often used were those defined by census limits (n=25, 38%), but quite a few studies relied on measurements such as Euclidean distance (n=13, 20%) or network distance (n=7, 11%), with a radius ranging from 100 m to 5 km around the individual's residence. Only two studies (2%) asked participants for a self-reported neighborhood area, and one study defined a neighborhood as a participant's activity space, including non-residential neighborhood exposure.

### 4.3 Longitudinal Characteristics

The included studies applied longitudinal designs, meaning that more than one measurement of neighborhood exposure or outcome in time was applied. Although all of the studies fit under the general definition of a longitudinal design, a few characteristics related to repeated measures and time allowed them to be categorized into subgroups.

#### 4.3.1 Number of Outcome Measurements

There was wide variation in the number of outcomes measured among the selected studies. Six studies included only one outcome measurement, of which most were interventions or community trials. Thirty studies included two outcome measurements and 30 others included three or more different measurements. Among those, Laraia [62], who studied the impact of food environment on weight change in a population of patients who were clinically followed for diabetes, reported a median of 17 BMI measurements for the patients enrolled, with these measurements ranging from 10 to 27. This study reported the highest number of outcome measurements of all the studies selected for this review.

#### 4.3.2 Number of Exposure Measurements

Neighborhood exposure measurements are more difficult to set in time than outcome measurements because they involve both the geographic location of the participants (generally in the form of an address, postal code or census area) and the contextual characteristics of their neighborhood (e.g. walkability, safety, greenness). Researchers can collect both pieces of information simultaneously or at different times. For example, Richardson [79] collected crime data from the city of Pittsburgh up to two years before the baseline year and also at the time of address collection from the participants in order to assess long term neighborhood exposure and its effect on BMI. Other studies did not simultaneously collect participant addresses and examine neighborhood characteristics simply because no neighborhood data were available at the baseline year. For example, Wasfi [88] linked the 2012 Walkscore data to address records from 1994-1995 since historical Walkscore data were available for that same period.

Studies including only one neighborhood exposure measurement were the most common (n=29), followed by studies including two measurements (n=17). The highest number of exposure assessments was reported by Murray and co-authors [71], who used a 20-year residential history questionnaire to assess the influence of poverty on BMI. They interpolated census-tract poverty for every month between three US censuses for every participant.

#### 4.3.3 Residential Mobility

The residential mobility of participants is another characteristic related to time, as changes in residential location can contribute to changes in exposure to contexts. The vast majority (n=52, 79%) of the studies included both participants who still remained at the same residence at the time of the follow-up (stayers) and participants who had changed residences (movers). Six studies (9%) that included both stayers and movers in their sample presented a stratified analysis for residential



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3 mobility status. A few studies (n=12, 18%) included samples composed of participants who stayed  
4 in the same neighborhood for the entire duration of the follow-up period. Only two studies (3%) had  
5 samples composed of only people who moved during the follow-up period (movers).  
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#### 8 4.3.4 Change in Neighborhood Characteristics 9

10 Another important characteristic linked to the longitudinal designs we examined is whether or not  
11 neighborhood context was considered a time-varying quantity. That is, regardless of whether or not  
12 participants changed their residential location, did the studies examine how the characteristics of the  
13 neighborhood changed over time? Less than half of the studies (n=28) considered the temporal  
14 changes in neighborhood context. There were several reasons that were provided for not measuring  
15 changes in neighborhood characteristics when two residential location measurements were  
16 collected. These reasons included the absence of historical data, such as the Walkscore® [39, 88],  
17 or the availability of data at only one time during the follow-up period, such as through a census or  
18 land survey [45, 56, 74, 75].  
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#### 25 4.3.5 Typology of Study Designs 26

27 After examining the selected studies, we identified a three-category typology based on how  
28 outcomes and exposures were considered, related to time: time-varying outcome and fixed exposure  
29 studies (VO-FE), fixed outcome and time-varying exposure studies (FO-VE), and time-varying  
30 outcome and time-varying exposure studies (VO-VE).  
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34 In reality, both obesity and neighborhood exposures are time-varying. However, while planning a  
35 longitudinal study, the researchers considered their research questions and the data that were  
36 available in order to decide whether their statistical model should be based on fixed or time-varying  
37 outcomes and exposures. Outcomes and exposures were considered fixed when only one of these  
38 two measurements was collected. The outcome was considered time-varying when repeated  
39 measurements of OP were reported. The context was considered time-varying when either or both  
40 the geographical localization of participants and the neighborhood characteristics were repeatedly  
41 measured over time. The fixed outcome and fixed exposure design (FO-FE) was implicitly excluded  
42 from this review, since according to the eligibility criteria, no longitudinal studies applied this type  
43 of design.  
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51 Of the 28 studies using a VO-FE design (time-varying outcomes and fixed exposure), 18 only  
52 collected two measurements for the outcome using a typical baseline and follow-up design. Other  
53 studies used up to seven outcome measurements [44]. In general, the sole contextual measurement  
54 from these studies was synchronized with baseline outcome measurements, but Auchincloss [31]  
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synchronized a contextual measurement with the third of four clinical assessments of BMI in order to measure the impact of perceived walkability and food environment [31].

The most prevalent type of design was the VO-VE type with time-varying outcomes and time-varying exposures, which included 32 studies. Of those, 27 had the same number of outcome and exposure measurements (either geographical localization or context characteristics). Hirsch [54], for example, used a US sample to measure BMI, waist circumference, geographical location and contextual characteristics at five points in time to examine the association between built environment and obesity. Twenty-four studies measured the characteristics of context and their changes over time while the others examined participant residential mobility to yield changes in exposure.

The FO-VE (fixed outcome and time-varying exposure) design was the least prevalent type of study. Six authors used this type of design, two of them in randomized social experiments from the Moving to Opportunity (MTO) study [42, 43] and two others were focused on neighborhood poverty trajectories [44, 45].

#### 4.4 Qualitative Synthesis of Results

Although the objective of this review was mainly to examine longitudinal designs, a qualitative synthesis of the associations is presented to summarize the results obtained from the selected studies.

For each study, all associations were qualified based on statistical significance (at a level of 5%) and expected direction (as defined by the author). For studies using multiple models, results from the final and fully adjusted models were used. For articles measuring more than one association (n=46), an aggregated indicator was created to qualify the overall study findings, based on the criteria from two previous reviews [96, 97], and is presented in Table 4.

*Table 4 Criteria used to define overall study findings based on the associations measured*

<b>Overall study findings</b>	<b>Statistical significance reported</b>	<b>Direction reported</b>
<b>Null</b>	Less than 50% statistically significant associations	Inverse or expected
<b>Mixed</b>	50% statistically significant associations	Inverse or expected
<b>Expected</b>	More than 50% statistically significant associations	Expected
<b>Inverse</b>	More than 50% statistically significant associations	Inverse

Table 2 summarizes the overall findings of the reviewed studies according to their different characteristics. Of all the papers included in the review (n=66), 52% (n=34) reported a majority of non-significant associations and 39% (n=26) reported a majority of significant associations in the

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3 expected or inverse direction. The results were mixed for 9% of the papers, as they did not indicate  
4 a majority of significant, non-significant associations or inverse of the expected result.  
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7 When considering basic characteristics, studies that used waist circumference as an outcome  
8 measure, studies that measured socioeconomic neighborhood exposure and studies with fixed  
9 outcomes and varying exposure resulted in more than 50% of aggregated associations that were  
10 statistically significant in the expected direction. Categories with fewer than five studies were not  
11 considered for this analysis, as presented in Table 2.  
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15 Table 3 shows the results of the 483 disaggregated associations grouped by indicator type. Overall  
16 composite indexes of the socioeconomic environment and indicators of transportation infrastructure  
17 revealed more than 50% of the statistically significant associations, all in the expected direction.  
18 Groups of indicators with fewer than five associations were not considered for this analysis.  
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## 25 **5. DISCUSSION**

### 26 **5.1 Main findings**

#### 27 **5.1.1 Basic Characteristics**

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29 We conducted a systematic search of the scientific literature that examined associations between  
30 neighborhood characteristics and obesity outcomes and found 66 papers. These papers included  
31 some form of longitudinal design with repeated measures of outcome and/or repeated measures of  
32 exposure. Most of the papers that were selected for our review were published very recently. This  
33 rapid increase in the number of papers published in this area of research reflects a more general  
34 trend in studies about neighborhood effect on health as observed by Oakes [98], who in 2005, also  
35 revealed a substantial increase in such publications. However, this trend may also be due to the  
36 overall accelerated pace of publications that has been observed across most scientific domains [99].  
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45 There have been many calls to improve the research on neighborhood effect on health over the last  
46 20 years [10, 17, 20, 22, 98, 100]. In addition to the longitudinal designs, which were the main  
47 focus of this review, we found that the more common suggestions for design improvement  
48 (conducting more studies on population subgroups, using adequate OPs, better identifying and  
49 defining neighborhoods) were taken into account in at least a few of the studies among the 66 that  
50 were selected.  
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3 Ding and Gebel [20] suggested that conducting more studies focused on populations outside the  
4 United States and on population groups such as women and ethnic minorities is a potential way to  
5 improve overall neighborhood effect research. Although most studies used samples from WEIRD  
6 populations (Western, Educated, Industrialized, Rich and Democratic [101]), a few studies that  
7 were included in this review focused on specific groups defined by gender, race, age or immigration  
8 status.  
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13 We also found that most of the studies selected BMI as an OP. Some authors have suggested that  
14 BMI does not accurately reflect the distribution of fat mass throughout the body, a factor that is  
15 hypothesized to have a substantial impact on the risk of cardiovascular disease and insulin  
16 resistance [102]. The use of waist circumference measurements is recommended at the individual  
17 level [103, 104], but this information is rarely available at the population level.  
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22 The studies in this review used diverse indicators to describe contextual exposure. The large variety  
23 of indicators in these studies makes it difficult to compare studies and draw conclusions for each  
24 type of indicator. Mackenbach [10], in a review of studies examining the association between built  
25 environment and weight, made a similar observation for both cross-sectional and longitudinal  
26 studies. However, in our review, we observed that this was not the case for food environment and  
27 socioeconomic indexes. These two categories combined amounted to nearly half the associations  
28 measured in the selected studies. The popularity of food environment indicators suggests that  
29 research on diet-related behaviors attracts more interest among the scientific community than  
30 physical activity and its determinants [105]. This may be because food availability data can be more  
31 easily collected than data on opportunities to participate in physical activity. Or perhaps because  
32 researchers observe the synchronicity between the changes in global food systems and the onset of  
33 the obesity epidemic to be an indication that the food environment could be the main influence for  
34 global weight gain [106]. The long history of literature linking socioeconomic status and  
35 cardiovascular risk factors [98, 107, 108] and the availability of historical socioeconomic data in  
36 national censuses may have also motivated numerous researchers to examine socioeconomic  
37 indexes. When we looked specifically at the indicators examined in these two prevailing categories  
38 (food environment and socioeconomic indexes), there was a wide diversity of indicators within the  
39 categories that made it difficult to compare studies.  
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### 50 51 5.1.2 Longitudinal Characteristics

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53 As the main focus of this review, we first summarized how exposures and outcomes were set in  
54 time by applying a typology comprising three categories according to the longitudinal nature of the  
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3 exposures and the outcomes. Using this typology allowed us to identify two key points: what the  
4 studies measured and what biases they attempted to address.  
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7 Studies with fixed exposure and varying outcomes (FE-VO) are generally designed to control for  
8 selection bias. Recording participant OP at an initial baseline exam, follow-up, and sometimes in  
9 between, limits the possibility that OP differences between individuals were only due to their OP  
10 prior to starting the study. This is an important improvement from cross-sectional studies. Some  
11 studies in this review reported contrasting results between cross-sectional and longitudinal data.  
12 Albrecht et al. [29] observed associations between the baseline waist circumferences and  
13 neighborhood food resources. However, they found no associations when using the changes in  
14 waistline circumference. Lee et al. [63] observed inconsistent results for the cross-sectional and  
15 longitudinal associations between intersection density, food store density and green space and  
16 visceral adipose tissue.  
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23 Fixed outcome and varying exposure (FO-VE) studies are designed to examine life course changes  
24 in neighborhood exposure or changes in neighborhood characteristics. As early as 2001, Diez Roux  
25 [22] recognized the importance of examining “the cumulative or interacting effects of neighborhood  
26 environments measured at different times over the life course, the effects of duration of exposure to  
27 certain neighborhood conditions, the effects of changes over time in neighborhood characteristics,  
28 and the impact of moving from one neighborhood to another.” Our review found that every aspect  
29 of the longitudinal neighborhood effect that was suggested by Diez Roux has been the focus of at  
30 least one of the selected studies.  
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36 The VO-VE design, which was applied in the largest number of studies in this review, controls both  
37 for selection bias and life course exposure. For example, Burdette et al. [42] examined both  
38 temporal sequencing and life course and showed using a growth curve model that in a population of  
39 adolescents from the United States, those who lived in more disadvantaged neighborhoods at the  
40 baseline gained weight at a faster rate than those from a less disadvantaged neighborhood. Leonard  
41 et al. [64] demonstrated that the conditions of neighborhood change was related to changes in  
42 weight only among those who did not move from their neighborhood, thus controlling for self-  
43 selection bias and life course changes in neighborhood exposure.  
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50 The “fixed-varying” typology highlights the numerous research questions in the selected studies.  
51 Some studies posed research questions with particularities beyond the scope of this review, such as  
52 mediating behaviors or individual characteristics. But we could list at least six research questions  
53 directly related to neighborhood effect on obesity with some degree of longitudinal variation:  
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- What is the effect of neighborhood characteristics on OP change?
- What is the effect of neighborhood characteristics on OP trajectory?
- What is the effect of neighborhood characteristics change on OP change?
- What is the effect of moving to another neighborhood on OP?
- What is the effect of neighborhood trajectory on OP?
- What is the effect of a neighborhood intervention on obesity?

Each one of these questions is pertinent and illustrates one particular aspect of obesity and neighborhood evolution. However, the longitudinal characteristics added even more variety to the diverse neighborhood indicators, neighborhood definitions and OPs previously described, which makes it more difficult to draw meaningful conclusions that may be helpful for intervention design.

### 5.1.3 Qualitative Synthesis of Results

Although this was not the main focus of our review, we found no strong evidence on neighborhood effects on obesity in the longitudinal studies. Only 25 studies (38%) yielded statistically significant results in the expected direction. However, this does not necessarily indicate that neighborhood context has no effect, but that the specific characteristics of the neighborhood and how they are measured is important.

In terms of contextual measures, we found that studies reporting socioeconomic indicators of context yielded the majority of significant associations whereas studies on the built environment yielded the majority of non-significant association (Table 2). This may be because contextual socioeconomic indicators do in fact have a stronger effect on obesity or that associations with socioeconomic indicators are biased by more closely correlated individual socioeconomic indicators that are difficult to control for. This adds to the general findings from literature reviews that these results are generally equivocal. Black and Macinko [17] observed that economic resources and physical activity features of the neighborhood are significantly associated with obesity, while the associations between income inequality and racial composition were mixed, and food availability associations were inconsistent. Leal and Chaix [109] Fireported associations that were remarkably to reasonably consistent in all four categories (sociodemographic environment, physical environment, services and social interaction). Mackenbach [10] reported mixed results for the physical environment.

When considering the obesity outcome measurement, our review shows that studies using waist circumference, although few in number, yielded more statistically significant associations than studies using only BMI. This could be explained by the fact that the distribution of fat may be

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3 differentially influenced by lifestyle choices induced by neighborhood characteristics (i.e. increase  
4 in muscular mass or decrease in visceral fat versus subcutaneous fat) [102, 110-112] or that the  
5 studies using waistline measurements could have characteristics (number of participants, follow-up  
6 length, measurement quality,...) which could be associated with more statistical associations in the  
7 expected direction.  
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11 Finally, the type of design, whether using fixed or varying outcomes and exposures, did not seem to  
12 influence the significance or the direction of the association between the neighborhood exposure  
13 and the obesity outcome. Studies with fixed outcomes and varying exposure (FO-VE) did yield  
14 more statistically significant results than other types of longitudinal designs, but no definitive  
15 conclusions can be drawn due to the small number of studies. More studies of this type could  
16 contribute to better knowledge about neighborhood effects on obesity, but authors of such studies  
17 should be aware that there is less control over self-selection bias when the follow-up period is short  
18 or the exposure is not randomized.  
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## 25 **5.2 Strengths and Weaknesses**

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27 We reviewed studies that were selected through a comprehensive research strategy. We also  
28 included a few papers that were cited in relevant publications. The selection criteria were designed  
29 to focus on observational studies. In strictly following the search strategy, we included some  
30 experimental and trial studies that appeared in our search results [41, 47, 57, 67, 94]. However these  
31 results could not be considered as a comprehensive appreciation of experimental schemes, and  
32 could therefore be the topic of a review paper of their own [113].  
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37 A person's weight status can vary greatly over their life course, with some periods and determinants  
38 playing more critical roles in the potential development of obesity [25, 114]. Therefore, although  
39 some authors have suggested that neighborhood effects are stronger when considering trajectories  
40 that include childhood, we have decided to limit this scoping review to measuring obesity in adults  
41 [115], for uniformity. This restriction likely limited the number of eligible publications and reduced  
42 the number of longitudinal designs to examine, but it also reduced the heterogeneity among the  
43 selected studies and likely facilitated greater comparability among them, considering that OP cut-  
44 off values are different for adults and children. [116].  
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50 We also chose to limit our review to studies that focused on residential neighborhoods, despite  
51 research showing that they are not the only source of contextual exposure in a population [100].  
52 Accessibility to GPS technologies have allowed a number of studies to examine activity-space and  
53 better account for the environmental exposure of individuals. This environmental exposure includes  
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3 the daily mobility of participants who are exposed to neighborhoods around their home, around  
4 their workplace, or other destinations related to their activities. One study [58] in our review found  
5 that accounting for activity-space and the time spent in different neighborhoods does influence the  
6 impact on obesity risk. Extending neighborhood effect research beyond residential environments  
7 could help draw a more complete picture of how neighborhoods and obesity status interact in time  
8 and space.  
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### 12 13 **5.3 Unanswered Questions**

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15 Better understanding longitudinal designs used in studies on neighborhood effect on obesity  
16 prompts questions that can not be answered in this review. The most obvious one would be whether  
17 quantitative analysis of the results of longitudinal studies can be applied. Restricting the reviews to  
18 a specific category of indicators, such as the food environment or socioeconomic index or a specific  
19 type of design, could possibly provide enough homogeneity to perform such analyses. This would  
20 facilitate a quality analysis among studies, which was not possible in this review. Appraising  
21 statistical models, the length of follow-up periods?, the number of measurements and population  
22 size would be helpful for not only selecting studies for a systematic review, but also for suggesting  
23 quality standards for future longitudinal studies.  
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### 30 31 **5.4 Implications for Future Research**

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33 One of the biggest challenges in conducting this review was the general difficulty in identifying the  
34 longitudinal characteristics in the selected studies. This reflects the challenging task of identifying  
35 and reporting every aspect of a study that can be influenced by time, and the difficulty in connecting  
36 these longitudinal characteristics with a specific research question. One of the most obvious  
37 examples is the residential mobility status of a population. In some articles, a group's choice to  
38 move or to stay in the same location was made clear, and was sometimes even stated in the  
39 publication's title [62, 64, 94] or research question [75]. But other authors neglected to mention the  
40 mobility status of their population or gave very little information about this factor, making it  
41 difficult to interpret the study's results and their meaning. Similarly, some publications provided  
42 very few details about changes in neighborhood characteristics or the time that neighborhood  
43 characteristic measurements were collected. Therefore, we suggest that future studies on  
44 longitudinal characteristics of neighborhood effects should report the following items whenever  
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- **Mobility status:** specify whether participants moved residential locations during the follow-up period, stayed in the same residential location or whether the sample contains both types of mobility statuses.
- **Time of residential location measurement:** Report time (date or wave) at which the residential neighborhood of participants was localized;
- **Time of neighborhood characteristics measurements:** Report time at which the data describing neighborhood characteristics were collected. Specify if neighborhood characteristics vary in time (multiple neighborhood characteristic measurements).

The availability of data describing exposures or outcomes is an important obstacle when conducting quality longitudinal studies. Acquiring access to repeated measures of BMI or waist circumference that are linked to high-quality retrospective neighborhood measurements is highly challenging outside large-scale initiatives. Even with access to this information, capturing measurements that are more representative of neighborhoods, such as the perceived neighborhood or activity space, is a challenging task. It is worth considering the use of new technologies such as GPS data from mobile phones, geo-located data from social media, satellite imaging [72] and administrative open data as they become more available to researchers [117, 118].

## 6. CONCLUSION

Our scoping review, aimed at characterizing the designs of longitudinal studies examining neighborhood effects on obesity, identified 66 studies that fit our eligibility criteria. Overall, these longitudinal study designs were mostly intended to control for self-selection bias, although a fair number of studies also took life course exposure into consideration. The studies were very diverse in terms of the questions asked, indicators used and designs proposed, which limited the potential for conducting quantitative reviews of the results. On the other hand, the populations that were studied lacked diversity, suggesting that future studies should expand their interest to those outside WEIRD (Western, Educated, Industrialized, Rich and Democratic) populations. Additionally, we have proposed improvements for reporting longitudinal characteristics that could help authors design future longitudinal studies.

The diversified longitudinal study designs examined in this review reveal the intricate pathways in which the neighborhood and obesity may interact with time. Identifying these pathways is indispensable in the discussion about causality. However, at this time, they also compound the overwhelming diversity of neighborhood effect designs, which is an issue that has been identified as

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3 potentially hindering researchers from uncovering information that may prove useful for clinical or  
4 urban practices.  
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8  
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## 15 16 17 **8. COMPETING INTEREST STATEMENT**

18 A.T and L.B. have received research funding from Johnson & Johnson Medical Companies as well  
19 as Medtronic for studies unrelated to this manuscript.  
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## 22 23 **9. PATIENT AND PUBLIC INVOLVEMENT**

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25 Patients or the public were not involved in the design, or conduct, or reporting, or dissemination of  
26 our research.  
27  
28

## 29 30 **10. AUTHOR CONTRIBUTIONS**

31 Laurence Letarte designed this study, acquired, analyzed and interpreted the data and wrote the  
32 article. Sonia Pomerleau participated in data acquisition and contributed important intellectual  
33 content to the article. André Tchernof and Laurent Biertho revised the article and contributed  
34 important intellectual content. Alexandre Lebel participated in the study design, data interpretation,  
35 and revised the article and contributed important intellectual content. Owen Waygood participated  
36 in the study design, revised the article and contributed important intellectual content.  
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43  
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45 design and update the systematic search strategy.  
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47

## 48 49 **12. DATA AVAILABILITY STATEMENT**

50 All data relevant to the study are included in the article or uploaded as supplementary information  
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### 13. REFERENCES

1. Glass, T.A. and M.J. McAtee, *Behavioral science at the crossroads in public health: extending horizons, envisioning the future*. Soc Sci Med, 2006. **62**(7): p. 1650-71.
2. Kumanyika, S.K., L. Parker, and L.J. Sim, *Bridging the evidence gap in obesity prevention: a framework to inform decision making*. 2010: National Academies Press.
3. Swinburn, B., G. Egger, and F. Raza, *Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity*. Preventive medicine, 1999. **29**(6): p. 563-570.
4. Gotay, C.C., et al., *Updating the Canadian obesity maps: an epidemic in progress*. Can J Public Health, 2013. **104**(1): p. e64-e68.
5. Collaboration, N.R.F., *Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19· 2 million participants*. The Lancet, 2016. **387**(10026): p. 1377-1396.
6. Ng, M., et al., *Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013*. Lancet, 2014. **384**(9945): p. 766-81.
7. Abarca-Gómez, L., et al., *Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128· 9 million children, adolescents, and adults*. The Lancet, 2017. **390**(10113): p. 2627-2642.
8. Lebel, A., et al., *The Geography of Overweight in Quebec: A Multilevel Perspective*. Can J Public Health, 2009. **100**(1): p. 18-23.
9. Malik, V.S., W.C. Willett, and F.B. Hu, *Global obesity: trends, risk factors and policy implications*. Nature Reviews Endocrinology, 2013. **9**(1): p. 13-27.
10. Mackenbach, J.D., et al., *Obesogenic environments: a systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project*. BMC Public Health, 2014. **14**.
11. Papas, M.A., et al., *The built environment and obesity*. Epidemiologic Reviews, 2007. **29**: p. 129-143.
12. Booth, K.M., M.M. Pinkston, and W.S.C. Poston, *Obesity and the built environment*. Journal of the American Dietetic Association, 2005. **105**(5): p. S110-S117.
13. Feng, J., et al., *The built environment and obesity: A systematic review of the epidemiologic evidence*. Health & Place, 2010. **16**(2): p. 175-190.
14. Garfinkel-Castro, A., et al., *The Built Environment and Obesity*, in *Metabolic Syndrome: A Comprehensive Textbook*, R.S. Ahima, Editor. 2016. p. 275-286.
15. Durand, C.P., et al., *A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning*. Obesity Reviews, 2011. **12**(501): p. e173-e182.
16. Casagrande, S.S., et al., *Built Environment and Health Behaviors Among African Americans A Systematic Review*. American Journal of Preventive Medicine, 2009. **36**(2): p. 174-181.
17. Black, J.L. and J. Macinko, *Neighborhoods and obesity*. Nutrition Reviews, 2008. **66**(1): p. 2-20.
18. Lachowycz, K. and A.P. Jones, *Greenspace and obesity: a systematic review of the evidence*. Obesity Reviews, 2011. **12**(501): p. e183-e189.
19. Lovasi, G.S., et al., *Built Environments and Obesity in Disadvantaged Populations*. Epidemiologic Reviews, 2009. **31**(1): p. 7-20.
20. Ding, D. and K. Gebel, *Built environment, physical activity, and obesity: What have we learned from reviewing the literature?* Health & Place, 2012. **18**(1): p. 100-105.

21. Merlo, J., *Contextual influences on the individual life course: Building a research framework for social epidemiology*. Psychosocial Intervention, 2011. **20**(1): p. 109-118.
22. Diez Roux, A.V., *Investigating neighborhood and area effects on health*. American journal of public health, 2001. **91**(11): p. 1783-1789.
23. Kitamura, R., P.L. Mokhtarian, and L. Laidet, *A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area*. Transportation, 1997. **24**(2): p. 125-158.
24. Wheeler, D.C. and C.A. Calder, *Sociospatial Epidemiology: Residential History Analysis*, in *Handbook of Spatial Epidemiology*, A.B. Lawson, et al., Editors. 2016, CRC Press.
25. Ben-Shlomo, Y. and D. Kuh, *A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives*. Int J Epidemiol, 2002. **31**(2): p. 285-93.
26. Boscoe, F.P., *The use of residential history in environmental health studies*, in *Geospatial Analysis of Environmental Health*. 2011, Springer. p. 93-110.
27. Arksey, H. and L. O'Malley, *Scoping studies: towards a methodological framework*. International journal of social research methodology, 2005. **8**(1): p. 19-32.
28. Letarte, L., et al., *Longitudinal designs to study neighbourhood effects on the development of obesity: a scoping review protocol*. BMJ open, 2018. **8**(1): p. e017704.
29. Albrecht, S.S., et al., *Change in waist circumference with longer time in the United States among Hispanic and Chinese immigrants: the modifying role of the neighborhood built environment*. Ann Epidemiol, 2015. **25**(10): p. 767-72.e2.
30. Arcaya, M., et al., *Effects of proximate foreclosed properties on individuals' weight gain in Massachusetts, 1987-2008*. American journal of public health, 2013. **103**(9): p. e50-56.
31. Auchincloss, A.H., et al., *Neighborhood Health-Promoting Resources and Obesity Risk (the Multi-Ethnic Study of Atherosclerosis)*. Obesity, 2012.
32. Auerbach, B.J., et al., *Factors associated with maintenance of body mass index in the Jackson Heart Study: A prospective cohort study secondary analysis*. Preventive Medicine, 2017. **100**: p. 95-100.
33. Barrientos-Gutierrez, T., et al., *Neighborhood Physical Environment and Changes in Body Mass Index: Results From the Multi-Ethnic Study of Atherosclerosis*. Am J Epidemiol, 2017. **186**(11): p. 1237-1245.
34. Berry, T.R., et al., *Changes in BMI over 6 years: the role of demographic and neighborhood characteristics*. International Journal of Obesity, 2010. **34**(8): p. 1275-1283.
35. Berry, T.R., et al., *A longitudinal and cross-sectional examination of the relationship between reasons for choosing a neighbourhood, physical activity and body mass index*. International Journal of Behavioral Nutrition and Physical Activity, 2010. **7**.
36. Block, J.P., et al., *Proximity to food establishments and body mass index in the Framingham Heart Study offspring cohort over 30 years*. Am J Epidemiol, 2011. **174**(10): p. 1108-14.
37. Blok, D.J., et al., *Changes in smoking, sports participation and overweight: Does neighborhood prevalence matter?* Health & Place, 2013. **23**: p. 33-38.
38. Boone-Heinonen, J., et al., *The Neighborhood Energy Balance Equation: Does Neighborhood Food Retail Environment plus Physical Activity Environment = Obesity? The CARDIA Study*. Plos One, 2013. **8**(12).
39. Braun, L.M., et al., *Walkability and cardiometabolic risk factors: Cross-sectional and longitudinal associations from the Multi-Ethnic Study of Atherosclerosis*. Health & Place, 2016. **39**: p. 9-17.
40. Braun, L.M., et al., *Changes in walking, body mass index, and cardiometabolic risk factors following residential relocation: Longitudinal results from the CARDIA study*. J Transp Health, 2016. **3**(4): p. 426-439.

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2  
3 41. Brown, B.B., et al., *Transit Use, Physical Activity, and Body Mass Index Changes: Objective Measures Associated With Complete Street Light-Rail Construction*. American Journal of Public Health, 2015. **105**(7): p. 1468-1474.
- 4  
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6 42. Burdette, A.M. and B.L. Needham, *Neighborhood environment and body mass index trajectories from adolescence to adulthood*. J Adolesc Health, 2012. **50**(1): p. 30-7.
- 7  
8 43. Christine, P.J., et al., *Exposure to Neighborhood Foreclosures and Changes in Cardiometabolic Health: Results From MESA*. American Journal of Epidemiology, 2017. **185**(2): p. 106-114.
- 9  
10  
11 44. Colchero, M.A. and D. Bishai, *Effect of neighborhood exposures on changes in weight among women in Cebu, Philippines (1983-2002)*. American Journal of Epidemiology, 2008. **167**(5): p. 615-623.
- 12  
13  
14 45. Coogan, P.F., et al., *Neighborhood Socioeconomic Status in Relation to 10-Year Weight Gain in the Black Women's Health Study*. Obesity, 2010. **18**(10): p. 2064-2065.
- 15  
16 46. Coogan, P.F., et al., *Longitudinal assessment of urban form and weight gain in African-American women*. Am J Prev Med, 2011. **40**(4): p. 411-8.
- 17  
18 47. Cummins, S., E. Flint, and S.A. Matthews, *New Neighborhood Grocery Store Increased Awareness Of Food Access But Did Not Alter Dietary Habits Or Obesity*. Health Affairs, 2014. **33**(2): p. 283-291.
- 19  
20  
21 48. Do, D.P. and C. Zheng, *A marginal structural modeling strategy investigating short and long-term exposure to neighborhood poverty on BMI among US black and white adults*. Health & Place, 2017. **46**: p. 201-209.
- 22  
23  
24 49. Eid, J., et al., *Fat city: Questioning the relationship between urban sprawl and obesity*. Journal of Urban Economics, 2008. **63**(2): p. 385-404.
- 25  
26  
27 50. Feng, X.Q. and A. Wilson, *Getting Bigger, Quicker? Gendered Socioeconomic Trajectories in Body Mass Index across the Adult Lifecourse: A Longitudinal Study of 21,403 Australians*. Plos One, 2015. **10**(10).
- 28  
29  
30 51. Gebel, K., et al., *Mismatch between perceived and objectively assessed neighborhood walkability attributes: Prospective relationships with walking and weight gain*. Health & Place, 2011. **17**(2): p. 519-524.
- 31  
32  
33 52. Gibson, D.M., *The neighborhood food environment and adult weight status: estimates from longitudinal data*. Am J Public Health, 2011. **101**(1): p. 71-8.
- 34  
35  
36 53. Halonen, J.I., et al., *Green and Blue Areas as Predictors of Overweight and Obesity in an 8-Year Follow-Up Study*. Obesity, 2014. **22**(8): p. 1910-1917.
- 37  
38 54. Hirsch, J.A., et al., *Built environment change and change in BMI and waist circumference: Multi-ethnic Study of Atherosclerosis*. Obesity (Silver Spring), 2014. **22**(11): p. 2450-7.
- 39  
40 55. Jones, M. and J. Huh, *Toward a multidimensional understanding of residential neighborhood: a latent profile analysis of Los Angeles neighborhoods and longitudinal adult excess weight*. Health Place, 2014. **27**: p. 134-41.
- 41  
42  
43 56. Joost, S., et al., *Persistent spatial clusters of high body mass index in a Swiss urban population as revealed by the 5-year GeoCoLaus longitudinal study*. BMJ Open, 2016. **6**(1): p. e010145.
- 44  
45  
46 57. Kapinos, K.A., O. Yakusheva, and D. Eisenberg, *Obesogenic environmental influences on young adults: Evidence from college dormitory assignments*. Economics & Human Biology, 2014. **12**: p. 98-109.
- 47  
48  
49 58. Kimbro, R.T., G. Sharp, and J.T. Denney, *Home and away: Area socioeconomic disadvantage and obesity risk*. Health Place, 2017. **44**: p. 94-102.
- 50  
51  
52 59. Kwarteng, J.L., et al., *Independent Effects of Neighborhood Poverty and Psychosocial Stress on Obesity Over Time*. Journal of Urban Health, 2017. **94**(6): p. 791-802.
- 53  
54 60. Kwarteng, J.L., et al., *NEIGHBOURHOOD POVERTY, PERCEIVED DISCRIMINATION AND CENTRAL ADIPOSITY IN THE USA: INDEPENDENT ASSOCIATIONS IN A REPEATED MEASURES ANALYSIS*. J Biosoc Sci, 2016. **48**(6): p. 709-22.
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61. Lamb, K.E., et al., *Associations between major chain fast-food outlet availability and change in body mass index: a longitudinal observational study of women from Victoria, Australia*. *Bmj Open*, 2017. **7**(10).
62. Laraia, B.A., et al., *Food Environment and Weight Change: Does Residential Mobility Matter?: The Diabetes Study of Northern California (DISTANCE)*. *Am J Epidemiol*, 2017. **185**(9): p. 743-750.
63. Lee, J.J., et al., *Association of built environment characteristics with adiposity and glycaemic measures*. *Obesity Science & Practice*, 2017. **3**(3): p. 333-341.
64. Leonard, T., et al., *Do neighborhoods matter differently for movers and non-movers? Analysis of weight gain in the longitudinal dallas heart study*. *Health & Place*, 2017. **44**: p. 52-60.
65. Li, F., et al., *Built Environment and 1-Year Change in Weight and Waist Circumference in Middle-Aged and Older Adults*. *American Journal of Epidemiology*, 2009. **169**(4): p. 401-408.
66. Lippert, A.M., et al., *Associations of Continuity and Change in Early Neighborhood Poverty With Adult Cardiometabolic Biomarkers in the United States: Results From the National Longitudinal Study of Adolescent to Adult Health, 1995-2008*. *Am J Epidemiol*, 2017: p. 1-12.
67. Ludwig, J., et al., *Neighborhoods, obesity, and diabetes--a randomized social experiment*. *N Engl J Med*, 2011. **365**(16): p. 1509-19.
68. Mendez, D.D., et al., *Neighborhood factors and six-month weight change among overweight individuals in a weight loss intervention*. *Prev Med Rep*, 2016. **4**: p. 569-573.
69. Meyer, K.A., et al., *Combined measure of neighborhood food and physical activity environments and weight-related outcomes: The CARDIA study*. *Health & Place*, 2015. **33**: p. 9-18.
70. Mujahid, M.S., et al., *Cross-sectional and longitudinal associations of BMI with socioeconomic characteristics*. *Obesity Research*, 2005. **13**(8): p. 1412-1421.
71. Murray, E.T., et al., *Trajectories of neighborhood poverty and associations with subclinical atherosclerosis and associated risk factors: the multi-ethnic study of atherosclerosis*. *American journal of epidemiology*, 2010. **171**(10): p. 1099-1108.
72. Picavet, H.S., et al., *Greener living environment healthier people?: Exploring green space, physical activity and health in the Doetinchem Cohort Study*. *Prev Med*, 2016. **89**: p. 7-14.
73. Pitts, S.B.J., et al., *Examining the Association between Intervention-Related Changes in Diet, Physical Activity, and Weight as Moderated by the Food and Physical Activity Environments among Rural, Southern Adults*. *Journal of the Academy of Nutrition and Dietetics*, 2017. **117**(10): p. 1618-1627.
74. Powell-Wiley, T.M., et al., *Neighborhood-level socioeconomic deprivation predicts weight gain in a multi-ethnic population: longitudinal data from the Dallas Heart Study*. *Prev Med*, 2014. **66**: p. 22-7.
75. Powell-Wiley, T.M., et al., *Change in Neighborhood Socioeconomic Status and Weight Gain Dallas Heart Study*. *American Journal of Preventive Medicine*, 2015. **49**(1): p. 72-79.
76. Powell-Wiley, T.M., et al., *Associations of Neighborhood Crime and Safety and With Changes in Body Mass Index and Waist Circumference The Multi-Ethnic Study of Atherosclerosis*. *American Journal of Epidemiology*, 2017. **186**(3): p. 280-288.
77. Rachele, J.N., et al., *Neighborhood socioeconomic disadvantage and body mass index among residentially stable mid-older aged adults: Findings from the HABITAT multilevel longitudinal study*. *Prev Med*, 2017. **105**: p. 271-274.
78. Richardson, A.S., et al., *Multiple pathways from the neighborhood food environment to increased body mass index through dietary behaviors: A structural equation-based analysis in the CARDIA study*. *Health & Place*, 2015. **36**: p. 74-87.

- 1
- 2
- 3 79. Richardson, A.S., et al., *Pathways through which higher neighborhood crime is*
- 4 *longitudinally associated with greater body mass index*. International Journal of Behavioral
- 5 Nutrition and Physical Activity, 2017. **14**.
- 6 80. Ruel, E., et al., *Neighborhood effects on BMI trends: examining BMI trajectories for Black*
- 7 *and White women*. Health Place, 2010. **16**(2): p. 191-8.
- 8 81. Rummo, P.E., et al., *Does unmeasured confounding influence associations between the*
- 9 *retail food environment and body mass index over time? The Coronary Artery Risk*
- 10 *Development in Young Adults (CARDIA) study*. International Journal of Epidemiology,
- 11 2017. **46**(5): p. 1456-1464.
- 12 82. Sarkar, C., J. Gallacher, and C. Webster, *Built environment configuration and change in*
- 13 *body mass index: the Caerphilly Prospective Study (CaPS)*. Health Place, 2013. **19**: p. 33-
- 14 44.
- 15 83. Sheehan, C.M., et al., *Long-term neighborhood poverty trajectories and obesity in a sample*
- 16 *of california mothers*. Health Place, 2017. **46**: p. 49-57.
- 17 84. Stafford, M., et al., *Deprivation and the Development of Obesity A Multilevel, Longitudinal*
- 18 *Study in England*. American Journal of Preventive Medicine, 2010. **39**(2): p. 130-139.
- 19 85. Stoddard, P.J., et al., *Neighborhood Deprivation and Change in BMI Among Adults With*
- 20 *Type 2 Diabetes*. Diabetes Care, 2013. **36**(5): p. 1200-1208.
- 21 86. Sugiyama, T., et al., *Residential proximity to urban centres, local-area walkability and*
- 22 *change in waist circumference among Australian adults*. Prev Med, 2016. **93**: p. 39-45.
- 23 87. Sund, E.R., A. Jones, and K. Midthjell, *Individual, family, and area predictors of BMI and*
- 24 *BMI change in an adult Norwegian population: Findings from the HUNT study*. Social
- 25 Science and Medicine, 2010. **70**(8): p. 1194-1202.
- 26 88. Wasfi, R.A., et al., *Neighborhood Walkability and Body Mass Index Trajectories:*
- 27 *Longitudinal Study of Canadians*. Am J Public Health, 2016. **106**(5): p. 934-40.
- 28 89. Xiao, Q., et al., *Neighborhood Socioeconomic Deprivation and Weight Change in a Large*
- 29 *US Cohort*. American Journal of Preventive Medicine, 2017. **52**(6): p. E173-E181.
- 30 90. Xu, H., S.E. Short, and T. Liu, *Dynamic relations between fast-food restaurant and body*
- 31 *weight status: a longitudinal and multilevel analysis of Chinese adults*. J Epidemiol
- 32 Community Health, 2013. **67**(3): p. 271-9.
- 33 91. Zenk, S.N., et al., *Longitudinal Associations Between Observed and Perceived*
- 34 *Neighborhood Food Availability and Body Mass Index in a Multiethnic Urban Sample*.
- 35 Health Educ Behav, 2017. **44**(1): p. 41-51.
- 36 92. Zenk, S.N., et al., *Geographic Accessibility Of Food Outlets Not Associated With Body*
- 37 *Mass Index Change Among Veterans, 2009-14*. Health Affairs, 2017. **36**(8): p. 1433-1442.
- 38 93. Zhang, Y.T., et al., *Is a reduction in distance to nearest supermarket associated with BMI*
- 39 *change among type 2 diabetes patients?* Health & Place, 2016. **40**: p. 15-20.
- 40 94. Zhao, Z.X., R. Kaestner, and X. Xu, *Spatial mobility and environmental effects on obesity*.
- 41 Economics & Human Biology, 2014. **14**: p. 128-140.
- 42 95. Rummo, P.E., et al., *Fast food price, diet behavior, and cardiometabolic health:*
- 43 *Differential associations by neighborhood SES and neighborhood fast food restaurant*
- 44 *availability in the CARDIA study*. Health Place, 2015. **35**: p. 128-35.
- 45 96. Ding, D., et al., *Neighborhood environment and physical activity among youth a review*.
- 46 Am J Prev Med, 2011. **41**(4): p. 442-55.
- 47 97. Brown, V., M. Moodie, and R. Carter, *Evidence for associations between traffic calming*
- 48 *and safety and active transport or obesity: A scoping review*. Journal of Transport &
- 49 Health, 2017. **7**: p. 23-37.
- 50 98. Oakes, J.M., et al., *Twenty Years of Neighborhood Effect Research: An Assessment*. Curr
- 51 Epidemiol Rep, 2015. **2**(1): p. 80-87.
- 52 99. Unesco and F. Schlegel, *UNESCO science report: towards 2030*. 2015: UNESCO Publ.
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

- 1  
2  
3 100. Perchoux, C., et al., *Residential buffer, perceived neighborhood, and individual activity space: New refinements in the definition of exposure areas - The RECORD Cohort Study*. Health Place, 2016. **40**: p. 116-22.
- 4  
5  
6 101. Henrich, J., S.J. Heine, and A. Norenzayan, *The weirdest people in the world?* Behavioral and Brain Sciences, 2010. **33**(2-3): p. 61-+.
- 7  
8 102. Tchernof, A. and J.P. Despres, *PATHOPHYSIOLOGY OF HUMAN VISCERAL OBESITY: AN UPDATE*. Physiological Reviews, 2013. **93**(1): p. 359-404.
- 9  
10 103. World Health Organization, *Obesity: preventing and managing the global epidemic*. 2000.
- 11 104. Despres, J.-P., et al., *Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease*. Arteriosclerosis, Thrombosis, and Vascular Biology, 1990. **10**(4): p. 497-511.
- 12  
13  
14 105. Rodgers, A., et al., *Prevalence trends tell us what did not precipitate the US obesity epidemic*. Lancet Public Health, 2018. **3**(4): p. e162-e163.
- 15  
16 106. Swinburn, B.A., et al., *The global obesity pandemic: shaped by global drivers and local environments*. The Lancet, 2011. **378**(9793): p. 804-814.
- 17  
18 107. Kaplan, G.A. and J.E. Keil, *Socioeconomic factors and cardiovascular disease: a review of the literature*. Circulation, 1993. **88**(4): p. 1973-1998.
- 19  
20 108. Suglia, S.F., et al., *Why the Neighborhood Social Environment Is Critical in Obesity Prevention*. Journal of Urban Health-Bulletin of the New York Academy of Medicine, 2016. **93**(1): p. 206-212.
- 21  
22  
23 109. Leal, C.C., B., *The influence of geographic life environments on cardiometabolic risk factors: a systematic review, a methodological assessment and a research agenda*. Obes Rev, 2011. **12**(3): p. 217-30.
- 24  
25  
26 110. Arsenault, B.J., et al., *Visceral adipose tissue accumulation, cardiorespiratory fitness, and features of the metabolic syndrome*. Archives of internal medicine, 2007. **167**(14): p. 1518-1525.
- 27  
28  
29 111. Despres, J.P., *Obesity and Cardiovascular Disease: Weight Loss Is Not the Only Target*. Canadian Journal of Cardiology, 2015. **31**(2).
- 30  
31  
32 112. Vissers, D., et al., *The effect of exercise on visceral adipose tissue in overweight adults: a systematic review and meta-analysis*. PloS one, 2013. **8**(2): p. e56415.
- 33  
34  
35 113. Mayne, S.L., A.H. Auchincloss, and Y.L. Michael, *Impact of policy and built environment changes on obesity-related outcomes: a systematic review of naturally occurring experiments*. Obesity reviews : an official journal of the International Association for the Study of Obesity, 2015. **16**(5): p. 362-375.
- 36  
37  
38 114. Ziyab, A.H., et al., *Developmental trajectories of Body Mass Index from infancy to 18 years of age: prenatal determinants and health consequences*. Journal of Epidemiology and Community Health, 2014. **68**(10): p. 934-941.
- 39  
40  
41 115. Glass, T.A. and U. Bilal, *Are neighborhoods causal? Complications arising from the 'stickiness' of ZNA*. Social Science & Medicine, 2016.
- 42  
43  
44 116. Ogden, C.L. and K.M. Flegal, *Changes in terminology for childhood overweight and obesity*. Age, 2010. **12**(12).
- 45  
46  
47 117. Kwan, M.-P., *The Limits of the Neighborhood Effect: Contextual Uncertainties in Geographic, Environmental Health, and Social Science Research*. Annals of the American Association of Geographers, 2018: p. 1-9.
- 48  
49  
50 118. Ohmer, M.L., et al., *Measures for Community and Neighborhood Research*. 2018: SAGE Publications.
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## 52 14.LEGENDS

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55 Figure 1 Flowchart of the article selection process

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Figure 2 Publication year of selected longitudinal studies of neighborhood effect on obesity

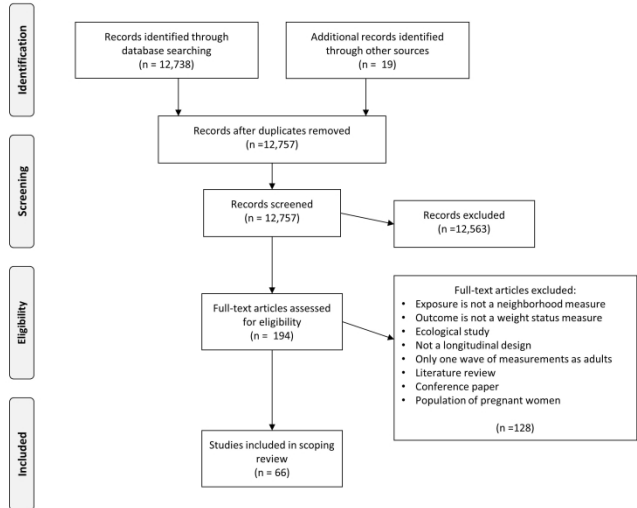
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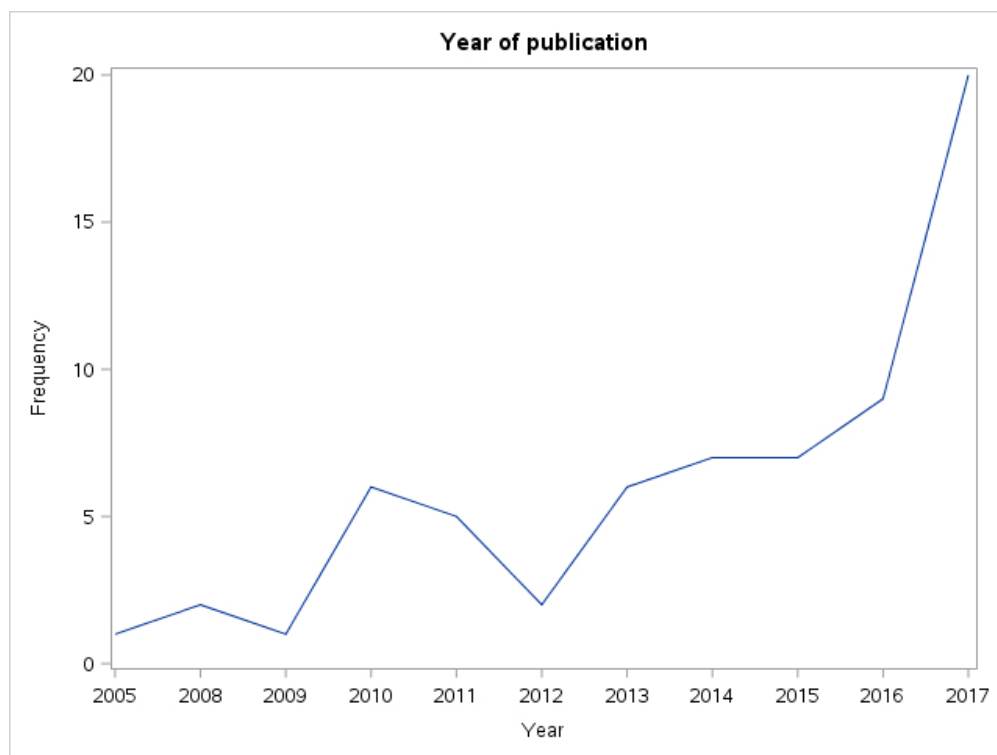
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Flowchart of the article selection process

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### SUPPLEMENTARY FILE TABLE OF CONTENT

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## SUPPLEMENTARY FILE 1 : SAMPLE SEARCH STRATEGY

Outcome terms AND longitudinal design terms AND (geographic context terms AND (social environment exposure terms OR physical environment exposure terms ) )

<b>Terms</b>	<b>Type*</b>
<b>Outcome</b>	
1 Obesity	MeSH:noexp, TIAB
2 Obesity, Morbid	MeSH
3 Body Mass Index	MeSH, TIAB
4 BMI	TIAB
5 Overweight	MeSH:noexp, TIAB
6 Weight	TIAB
7 Adiposity	TIAB
<b>Longitudinal design</b>	
8 Cohort studies	MeSH
9 Prospective studies	MeSH
10 Cohort*	TIAB
11 Follow up	TIAB
12 Longitudinal	TIAB
13 Retrospective	TIAB
14 Life course	TIAB
15 Randomized	TIAB
16 Change	TIAB
17 Experimental	TIAB
18 History	TIAB
<b>Geographic context</b>	
19 Environment	MeSH:noexp
20 Residence characteristics	MeSH:noexp
21 Neighborhood*	TIAB
22 Neighbourhood*	TIAB
23 Catchment Area (Health)	MeSH
24 Residential	TIAB
25 Residence	TIAB
26 Context	TIAB
27 Composition	TIAB
28 Urban	TIAB
<b>Social environment exposure</b>	
29 Sociological Factors	MeSH:noexp, TIAB
30 Socioeconomic Factors	MeSH
31 Low-income	TIAB
32 Education	TIAB
33 Poverty	TIAB
34 Socioeconomic	TIAB
35 Income	TIAB
36 Social conditions	TIAB
<b>Physical environment exposure</b>	

37	Environment Design	MeSH
38	City Planning	MeSH, TIAB
39	Food service	MeSH
40	Urban planning	TIAB
41	Built Environment	TIAB
42	Physical environment	TIAB
43	Urban form	TIAB
44	Obesogenic environment	TIAB

\*“Type” refers to the tags complementing search terms in queries. “MeSH” (Medical Subject Heading) terms will be searched in the controlled vocabulary assigned by U.S National Library of medicine to index scientific articles in its database. “MeSH:noexp” terms have the same function as MeSH, except that the search will be limited to the exact term not including subordinate terms generally linked to MeSH terms. “TIAB” terms will be searched in the title and abstract of the citations.

## SUPPLEMENTARY FILE 2 : CHARACTERISTICS OF SELECTED STUDIES

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Result (summary)	Statistically significant associations by indicator type
Albrecht, 2015 [1]	United States	Migrants	Waist circumference	Euclidean Buffer	1	5	Both	No	Null	Food environment 0/4 Walkability 0/2 Physical activity establishment 0/2
Arcaya, 2013 [2]	United States	Adults	BMI	Euclidean Buffer	3.8	3.8	Both	Yes	Expected	Foreclosure 1/1
Auchincloss, 2012 [3]	United States	Older adults	BMI	Self-reported	1	4	Both	No	Expected	À préciser
Auerbach, 2017 [4]	United States	African American women	BMI	Self-reported	1	2	Both	No	Expected	Physical activity establishment 1/1 Food environment 0/1 Security 1/1
Barrientos-Gutierrez, 2017 [5]	United States	Older adults	BMI	Euclidean Buffer	4	5	Both	Yes	Null	Food environment 0/2 Physical activity establishment 0/1 Walkability 0/1
Berry, 2010 [6]	Canada	Adults	BMI	Census limits	1	2	Both	No	Mixed	Composite index socioeconomic 1/1 Walkability 0/1
Berry, 2010 [7]	Canada	Adults	BMI	Administrative limits	1	2	Stayers	No	Null	Composite index socioeconomic 0/1 Walkability 0/1
Block, 2011 [8]	United States	Adults	BMI	Other	7	7	Both	Yes	Null	Food environment 5/36
Blok, 2013 [9]	Netherlands	Adults	BMI	Administrative limits	1	2	Both	No	Expected	Prevalence of health behavior 1/1
Boone-Heinonen, 2013 [10]	United States	Young adults	BMI	Euclidean Buffer	4	4	Both	Yes	Null	Food environment 1/3 Density 0/1 Deprivation 1/1 Physical activity establishment 0/2
Braun, 2016 [11]	United States	Older adults	Waist circumference	Other	2	2	Movers	No	Null	Walkability 0/1
Braun, 2016 [12]	United States	Young adults	BMI and waist ratio	Other	2	2	Movers	Yes	Null	Walkability 0/1



Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Result (summary)	Statistically significant associations by indicator type
Brown, 2015 [13]	United States	Adults	BMI	Euclidean Buffer	2	2	Stayers	Yes	Expected	Transportation infrastructure 1/1
Burdette, 2012 [14]	United States	Young adults	BMI	Other	1	3	Both	No	Null	Composite index socioeconomic 1/1 Perceived environment 0/2
Christine, 2017 [15]	United States	Adults	BMI	Euclidean Buffer	2	2	Both	Yes	Null	Foreclosure 0/1
Colchero, 2008 [16]	Philippines	Women	BMI	Administrative limits	1	7	Both	No	Expected	Other 1/1 Density 1/1
Coogan, 2010 [17]	United States	African american women	BMI	Administrative limits	6	6	Both	No	Expected	Composite socioeconomic index 2/2
Coogan, 2011 [18]	United States	African american women	BMI	Network buffer	3	4	Both	No	Expected	Composite index built environment 2/2
Cummins, 2014 [19]	United States	Adults	BMI	Administrative limits	2	2	Stayers	Yes	Null	Food environment 0/1
Do, 2017 [20]	United States	Adults	BMI	Administrative limits	6	6	Both	Yes	Null	Deprivation 4/32
Eid, 2008 [21]	United States	Young adults	BMI	Euclidean Buffer	4.1	4.1	Both	No	Null	Sprawl 0/2 Mixed use 0/2
Feng, 2015 [22]	Australia	Adults	BMI	Census limits	1	2.9	Stayers	No	Expected	Composite index socioeconomic 1/1
Gebel, 2011 [23]	Australia	Adults	BMI	Other	1	2	Stayers	No	Expected	Perceived environment 1/1
Gibson, 2011 [24]	United States	Adults	BMI	Administrative limits	3.3	3.3	Both	Yes	Null	Food environment 4/10
Halonen, 2014 [25]	Finland	Profession	BMI	Other	2	2	Stratified	No	Null	Blue and green area 3/8
Hirsch, 2014 [26]	United States	Older adults	BMI and waist ratio	Euclidean Buffer	5	5	Both	Yes	Null	Composite built environment 2/6
Jones, 2014 [27]	United States	Adults	BMI and waist ratio	Census limits	1	2	Both	No	Mixed	Composite index socioeconomic 1/2
Joost, 2016 [28]	Switzerland	Adults	BMI	Census limits	2	2	Both	No	Expected	Deprivation 1/1

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Result (summary)	Statistically significant associations by indicator type
Kapinos, 2014 [29]	United States	Students	BMI	Other	1	2	Both	No	Null	Food environment ¼ Physical activity establishment 2/2
Kimbro, 2017 [30]	United States	Adults	BMI	Census limits	2	2	Both	Yes	Null	Deprivation 0/2 Food environment 0/6
Kwarteng, 2017 [31]	United States	Adults	Waist circumference	Census limits	1	2	Both	No	Expected	Deprivation 1/1
Kwarteng, 2016 [32]	United States	Adults	Waist circumference	Census limits	1	2	Both	No	Expected	Deprivation 1/1
Lamb, 2017 [33]	Australia	Women	BMI	Network buffer	2	3	Stayers	Yes	Null	Food environment 0/1
Laraia, 2017[34]	United States	Diabetes	BMI	Census limits	5	17	Stratified	Yes	Mixed	Food environment 2/4 Transportation 1/1
Lee, 2017 [35]	United States	Adults	Other	Census limits	1	2	Both	No	Expected	Greenspace 1/1 Inverse Land use 0/1 Food environment 5/5
Leonard, 2017 [36]	United States	Adults	BMI	Euclidean Buffer	2	2	Stratified	Yes	Expected	Composite index socioeconomic 3/3
Li, 2009 [37]	United States	Older adults	BMI and waist ratio	Census limits	1	2	Both	No	Null	Food environment 0/1 Walkability 0/1
Lippert, 2017 [38]	United States	Young adults	BMI and waist ratio	Census limits	2	1	Both	Yes	Null	Deprivation 3/12
Ludwig, 2011 [39]	United States	Women	BMI	Census limits	2	1	Both	No	Expected	Deprivation 1/1
Mendez, 2016 [40]	United States	Participants in weightloss program	Weight	Census limits	1	2	Both	No	Null	Food environment 0/2 Racial composition 1/1 Deprivation 0/4
Meyer, 2015 [41]	United States	Adults	BMI	Network buffer	4	4	Both	Yes	Mixed	Composite index built environment 1/2
Mujahid, 2005 [42]	United States	Older adults	BMI	Census limits	1	4	Both	No	Null	Composite index socioeconomic 0/4
Murray, 2010 [43]	United States	Older adults	BMI	Census limits	20	1	Both	Yes	Expected	Deprivation 1/1
Picavet, 2016 [44]	Netherlands	Adults	BMI	Euclidean Buffer	4	4	Both	Yes	Inverse	Green space 0/30

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Result (summary)	Statistically significant associations by indicator type
Pitts, 2017 [45]	United States	rural adults	Weight	Other	1	2	Both	No	Null	Food environment 1/10 Physical activity establishment 0/6 Walkability 0/1 Security 0/1 Perceived 0/1
Powell-Wiley, 2014 [46]	United States	Adults	Weight	Census limits	2	2	Stayers	No	Expected	Composite index socioeconomic 1/2
Powell-Wiley, 2015 [47]	United States	Adults	BMI	Census limits	2	2	Stratified	No	Expected	Composite index socioeconomic 3/3
Powell-Wiley, 2017 [48]	United States	Older adults	BMI and waist ratio	Other	5	5	Both	Yes	Null	Perceived environment 2/18 Security 0/18
Rachele, 2017 [49]	Australia	Older adults	BMI	Census limits	1	4	Stayers	No	Null	Composite index socioeconomic 0/2
Richardson, 2015 [50]	United States	Adults	BMI	Other	3	3	Both	Yes	Mixed	Food environment ½
Richardson, 2017 [51]	United States	African american	BMI	Euclidean Buffer	1	1	Both	Yes	Expected	Perceived environment 1/1 Security 1/1
Ruel, 2010 [52]	United States	Women	BMI	Census limits	1	4	Both	No	Null	Composite index socioeconomic 0/1 Racial composition 0/1
Rummo, 2017 [53]	United States	Adults	BMI	Network buffer	6	6	Both	Yes	Null	Food environment 2/7
Sarkar, 2013 [54]	United Kingdom	Older adults	BMI	Network buffer	1	3	Both	No	Mixed	Land use 2/6 Green space 0/1 Physical activity establishment 1/1 Transportation infrastructure 2/4 Other 1/1 Density 1/1
Sheehan, 2017 [55]	United States	Women	BMI	Census limits	2	1	Both	Yes	Expected	Deprivation 1/1
Stafford, 2010 [56]	United Kingdom	Profession	BMI	Census limits	1	3	Stratified	No	Null	Composite index socioeconomic ¼
Stoddard, 2013 [57]	United States	Patients with diabetes	BMI	Census limits	1	2	Both	No	Expected	Composite index socioeconomic 3/3
Sugiyama, 2016 [58]	Australia	Adults	Waist circumference	Network buffer	1	2	Stayers	No	Expected	Distance to landmark 2/2 Walkability 0/1
Sund, 2010 [59]	Norway	Adults	BMI	Census limits	1	2	Stayers	No	Null	Deprivation 0/1

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Result (summary)	Statistically significant associations by indicator type
Wasfi, 2016 [60]	Canada	Adults	BMI	Administrative limits	7	7	Both	No	Expected	Walkability 1/1
Xiao, 2017 [61]	United States	Older adults	BMI	Census limits	1	2	Both	No	Expected	Composite index socioeconomic 4/4
Xu, 2013 [62]	China	Adults	BMI and waist ratio	Administrative limits	4	4	Both	Yes	Null	Food environment 13/48
Zenk, 2017 [63]	United States	Adults	BMI	Euclidean Buffer	2	2	Stayers	Yes	Null	Food environment 1/6
Zenk, 2017 [64]	United States	Veterans	BMI	Euclidean Buffer	6	6	Stratified	Yes	Null	Food environment 17/48
Zhang, 2016 [65]	United States	Diabetes	BMI	Network buffer	1	2	Stayers	Yes	Null	Food environment 0/1
Zhao, 2014 [66]	United States	African-American and Hispanic women	BMI	Census limits	2	1	Both	No	Null	Food environment 0/20 Racial composition 0/2 Deprivation 4/8 Security 0/4 Density 0/2

## REFERENCES

1. Albrecht, S.S., et al., *Change in waist circumference with longer time in the United States among Hispanic and Chinese immigrants: the modifying role of the neighborhood built environment*. *Ann Epidemiol*, 2015. **25**(10): p. 767-72.e2.
2. Arcaya, M., et al., *Effects of proximate foreclosed properties on individuals' weight gain in Massachusetts, 1987-2008*. *American journal of public health*, 2013. **103**(9): p. e50-56.
3. Auchincloss, A.H., et al., *Neighborhood Health-Promoting Resources and Obesity Risk (the Multi-Ethnic Study of Atherosclerosis)*. *Obesity*, 2012.
4. Auerbach, B.J., et al., *Factors associated with maintenance of body mass index in the Jackson Heart Study: A prospective cohort study secondary analysis*. *Preventive Medicine*, 2017. **100**: p. 95-100.
5. Barrientos-Gutierrez, T., et al., *Neighborhood Physical Environment and Changes in Body Mass Index: Results From the Multi-Ethnic Study of Atherosclerosis*. *Am J Epidemiol*, 2017. **186**(11): p. 1237-1245.
6. Berry, T.R., et al., *A longitudinal and cross-sectional examination of the relationship between reasons for choosing a neighbourhood, physical activity and body mass index*. *International Journal of Behavioral Nutrition and Physical Activity*, 2010. **7**.
7. Berry, T.R., et al., *Changes in BMI over 6 years: the role of demographic and neighborhood characteristics*. *International Journal of Obesity*, 2010. **34**(8): p. 1275-1283.
8. Block, J.P., et al., *Proximity to food establishments and body mass index in the Framingham Heart Study offspring cohort over 30 years*. *Am J Epidemiol*, 2011. **174**(10): p. 1108-14.
9. Blok, D.J., et al., *Changes in smoking, sports participation and overweight: Does neighborhood prevalence matter?* *Health & Place*, 2013. **23**: p. 33-38.
10. Boone-Heinonen, J., et al., *The Neighborhood Energy Balance Equation: Does Neighborhood Food Retail Environment plus Physical Activity Environment = Obesity? The CARDIA Study*. *Plos One*, 2013. **8**(12).
11. Braun, L.M., et al., *Walkability and cardiometabolic risk factors: Cross-sectional and longitudinal associations from the Multi-Ethnic Study of Atherosclerosis*. *Health & Place*, 2016. **39**: p. 9-17.
12. Braun, L.M., et al., *Changes in walking, body mass index, and cardiometabolic risk factors following residential relocation: Longitudinal results from the CARDIA study*. *J Transp Health*, 2016. **3**(4): p. 426-439.
13. Brown, B.B., et al., *Transit Use, Physical Activity, and Body Mass Index Changes: Objective Measures Associated With Complete Street Light-Rail Construction*. *American Journal of Public Health*, 2015. **105**(7): p. 1468-1474.
14. Burdette, A.M. and B.L. Needham, *Neighborhood environment and body mass index trajectories from adolescence to adulthood*. *J Adolesc Health*, 2012. **50**(1): p. 30-7.
15. Christine, P.J., et al., *Exposure to Neighborhood Foreclosures and Changes in Cardiometabolic Health: Results From MESA*. *American Journal of Epidemiology*, 2017. **185**(2): p. 106-114.
16. Colchero, M.A. and D. Bishai, *Effect of neighborhood exposures on changes in weight among women in Cebu, Philippines (1983-2002)*. *American Journal of Epidemiology*, 2008. **167**(5): p. 615-623.
17. Coogan, P.F., et al., *Neighborhood Socioeconomic Status in Relation to 10-Year Weight Gain in the Black Women's Health Study*. *Obesity*, 2010. **18**(10): p. 2064-2065.
18. Coogan, P.F., et al., *Longitudinal assessment of urban form and weight gain in African-American women*. *Am J Prev Med*, 2011. **40**(4): p. 411-8.
19. Cummins, S., E. Flint, and S.A. Matthews, *New Neighborhood Grocery Store Increased Awareness Of Food Access But Did Not Alter Dietary Habits Or Obesity*. *Health Affairs*, 2014. **33**(2): p. 283-291.
20. Do, D.P. and C. Zheng, *A marginal structural modeling strategy investigating short and long-term exposure to neighborhood poverty on BMI among US black and white adults*. *Health & Place*, 2017. **46**: p. 201-209.
21. Eid, J., et al., *Fat city: Questioning the relationship between urban sprawl and obesity*. *Journal of Urban Economics*, 2008. **63**(2): p. 385-404.
22. Feng, X.Q. and A. Wilson, *Getting Bigger, Quicker? Gendered Socioeconomic Trajectories in Body Mass Index across the Adult Lifecourse: A Longitudinal Study of 21,403 Australians*. *Plos One*, 2015. **10**(10).
23. Gebel, K., et al., *Mismatch between perceived and objectively assessed neighborhood walkability attributes: Prospective relationships with walking and weight gain*. *Health & Place*, 2011. **17**(2): p. 519-524.
24. Gibson, D.M., *The neighborhood food environment and adult weight status: estimates from longitudinal data*. *Am J Public Health*, 2011. **101**(1): p. 71-8.

25. Halonen, J.I., et al., *Green and Blue Areas as Predictors of Overweight and Obesity in an 8-Year Follow-Up Study*. *Obesity*, 2014. **22**(8): p. 1910-1917.
26. Hirsch, J.A., et al., *Built environment change and change in BMI and waist circumference: Multi-ethnic Study of Atherosclerosis*. *Obesity (Silver Spring)*, 2014. **22**(11): p. 2450-7.
27. Jones, M. and J. Huh, *Toward a multidimensional understanding of residential neighborhood: a latent profile analysis of Los Angeles neighborhoods and longitudinal adult excess weight*. *Health Place*, 2014. **27**: p. 134-41.
28. Joost, S., et al., *Persistent spatial clusters of high body mass index in a Swiss urban population as revealed by the 5-year GeoCoLaus longitudinal study*. *BMJ Open*, 2016. **6**(1): p. e010145.
29. Kapinos, K.A., O. Yakusheva, and D. Eisenberg, *Obesogenic environmental influences on young adults: Evidence from college dormitory assignments*. *Economics & Human Biology*, 2014. **12**: p. 98-109.
30. Kimbro, R.T., G. Sharp, and J.T. Denney, *Home and away: Area socioeconomic disadvantage and obesity risk*. *Health Place*, 2017. **44**: p. 94-102.
31. Kwarteng, J.L., et al., *Independent Effects of Neighborhood Poverty and Psychosocial Stress on Obesity Over Time*. *Journal of Urban Health*, 2017. **94**(6): p. 791-802.
32. Kwarteng, J.L., et al., *NEIGHBOURHOOD POVERTY, PERCEIVED DISCRIMINATION AND CENTRAL ADIPOSITY IN THE USA: INDEPENDENT ASSOCIATIONS IN A REPEATED MEASURES ANALYSIS*. *J Biosoc Sci*, 2016. **48**(6): p. 709-22.
33. Lamb, K.E., et al., *Associations between major chain fast-food outlet availability and change in body mass index: a longitudinal observational study of women from Victoria, Australia*. *Bmj Open*, 2017. **7**(10).
34. Laraia, B.A., et al., *Food Environment and Weight Change: Does Residential Mobility Matter?: The Diabetes Study of Northern California (DISTANCE)*. *Am J Epidemiol*, 2017. **185**(9): p. 743-750.
35. Lee, J.J., et al., *Association of built environment characteristics with adiposity and glycaemic measures*. *Obesity Science & Practice*, 2017. **3**(3): p. 333-341.
36. Leonard, T., et al., *Do neighborhoods matter differently for movers and non-movers? Analysis of weight gain in the longitudinal dallas heart study*. *Health & Place*, 2017. **44**: p. 52-60.
37. Li, F., et al., *Built Environment and 1-Year Change in Weight and Waist Circumference in Middle-Aged and Older Adults*. *American Journal of Epidemiology*, 2009. **169**(4): p. 401-408.
38. Lippert, A.M., et al., *Associations of Continuity and Change in Early Neighborhood Poverty With Adult Cardiometabolic Biomarkers in the United States: Results From the National Longitudinal Study of Adolescent to Adult Health, 1995-2008*. *Am J Epidemiol*, 2017: p. 1-12.
39. Ludwig, J., et al., *Neighborhoods, obesity, and diabetes--a randomized social experiment*. *N Engl J Med*, 2011. **365**(16): p. 1509-19.
40. Mendez, D.D., et al., *Neighborhood factors and six-month weight change among overweight individuals in a weight loss intervention*. *Prev Med Rep*, 2016. **4**: p. 569-573.
41. Meyer, K.A., et al., *Combined measure of neighborhood food and physical activity environments and weight-related outcomes: The CARDIA study*. *Health & Place*, 2015. **33**: p. 9-18.
42. Mujahid, M.S., et al., *Cross-sectional and longitudinal associations of BMI with socioeconomic characteristics*. *Obesity Research*, 2005. **13**(8): p. 1412-1421.
43. Murray, E.T., et al., *Trajectories of neighborhood poverty and associations with subclinical atherosclerosis and associated risk factors: the multi-ethnic study of atherosclerosis*. *American journal of epidemiology*, 2010. **171**(10): p. 1099-1108.
44. Picavet, H.S., et al., *Greener living environment healthier people?: Exploring green space, physical activity and health in the Doetinchem Cohort Study*. *Prev Med*, 2016. **89**: p. 7-14.
45. Pitts, S.B.J., et al., *Examining the Association between Intervention-Related Changes in Diet, Physical Activity, and Weight as Moderated by the Food and Physical Activity Environments among Rural, Southern Adults*. *Journal of the Academy of Nutrition and Dietetics*, 2017. **117**(10): p. 1618-1627.
46. Powell-Wiley, T.M., et al., *Neighborhood-level socioeconomic deprivation predicts weight gain in a multi-ethnic population: longitudinal data from the Dallas Heart Study*. *Prev Med*, 2014. **66**: p. 22-7.
47. Powell-Wiley, T.M., et al., *Change in Neighborhood Socioeconomic Status and Weight Gain Dallas Heart Study*. *American Journal of Preventive Medicine*, 2015. **49**(1): p. 72-79.
48. Powell-Wiley, T.M., et al., *Associations of Neighborhood Crime and Safety and With Changes in Body Mass Index and Waist Circumference The Multi-Ethnic Study of Atherosclerosis*. *American Journal of Epidemiology*, 2017. **186**(3): p. 280-288.

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49. Rachele, J.N., et al., *Neighborhood socioeconomic disadvantage and body mass index among residentially stable mid-older aged adults: Findings from the HABITAT multilevel longitudinal study*. *Prev Med*, 2017. **105**: p. 271-274.
50. Richardson, A.S., et al., *Multiple pathways from the neighborhood food environment to increased body mass index through dietary behaviors: A structural equation-based analysis in the CARDIA study*. *Health & Place*, 2015. **36**: p. 74-87.
51. Richardson, A.S., et al., *Pathways through which higher neighborhood crime is longitudinally associated with greater body mass index*. *International Journal of Behavioral Nutrition and Physical Activity*, 2017. **14**.
52. Ruel, E., et al., *Neighborhood effects on BMI trends: examining BMI trajectories for Black and White women*. *Health Place*, 2010. **16**(2): p. 191-8.
53. Rummo, P.E., et al., *Does unmeasured confounding influence associations between the retail food environment and body mass index over time? The Coronary Artery Risk Development in Young Adults (CARDIA) study*. *International Journal of Epidemiology*, 2017. **46**(5): p. 1456-1464.
54. Sarkar, C., J. Gallacher, and C. Webster, *Built environment configuration and change in body mass index: the Caerphilly Prospective Study (CaPS)*. *Health Place*, 2013. **19**: p. 33-44.
55. Sheehan, C.M., et al., *Long-term neighborhood poverty trajectories and obesity in a sample of california mothers*. *Health Place*, 2017. **46**: p. 49-57.
56. Stafford, M., et al., *Deprivation and the Development of Obesity A Multilevel, Longitudinal Study in England*. *American Journal of Preventive Medicine*, 2010. **39**(2): p. 130-139.
57. Stoddard, P.J., et al., *Neighborhood Deprivation and Change in BMI Among Adults With Type 2 Diabetes*. *Diabetes Care*, 2013. **36**(5): p. 1200-1208.
58. Sugiyama, T., et al., *Residential proximity to urban centres, local-area walkability and change in waist circumference among Australian adults*. *Prev Med*, 2016. **93**: p. 39-45.
59. Sund, E.R., A. Jones, and K. Midthjell, *Individual, family, and area predictors of BMI and BMI change in an adult Norwegian population: Findings from the HUNT study*. *Social Science and Medicine*, 2010. **70**(8): p. 1194-1202.
60. Wasfi, R.A., et al., *Neighborhood Walkability and Body Mass Index Trajectories: Longitudinal Study of Canadians*. *Am J Public Health*, 2016. **106**(5): p. 934-40.
61. Xiao, Q., et al., *Neighborhood Socioeconomic Deprivation and Weight Change in a Large US Cohort*. *American Journal of Preventive Medicine*, 2017. **52**(6): p. E173-E181.
62. Xu, H., S.E. Short, and T. Liu, *Dynamic relations between fast-food restaurant and body weight status: a longitudinal and multilevel analysis of Chinese adults*. *J Epidemiol Community Health*, 2013. **67**(3): p. 271-9.
63. Zenk, S.N., et al., *Longitudinal Associations Between Observed and Perceived Neighborhood Food Availability and Body Mass Index in a Multiethnic Urban Sample*. *Health Educ Behav*, 2017. **44**(1): p. 41-51.
64. Zenk, S.N., et al., *Geographic Accessibility Of Food Outlets Not Associated With Body Mass Index Change Among Veterans, 2009-14*. *Health Affairs*, 2017. **36**(8): p. 1433-1442.
65. Zhang, Y.T., et al., *Is a reduction in distance to nearest supermarket associated with BMI change among type 2 diabetes patients?* *Health & Place*, 2016. **40**: p. 15-20.
66. Zhao, Z.X., R. Kaestner, and X. Xu, *Spatial mobility and environmental effects on obesity*. *Economics & Human Biology*, 2014. **14**: p. 128-140.

## Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
<b>TITLE</b>			
Title	1	Identify the report as a scoping review.	Page 1
<b>ABSTRACT</b>			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Page 2
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Pages 4-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 5
<b>METHODS</b>			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Page 6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 7
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Supplementary file 1
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Page 7
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 7-8
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 7
Critical appraisal of individual	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe	Page 20





SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
sources of evidence§		the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 7
<b>RESULTS</b>			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 8
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Supplementary file 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Not done
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Supplementary file 2
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Pages 9-16
<b>DISCUSSION</b>			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Pages 16-19
Limitations	20	Discuss the limitations of the scoping review process.	Page 19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 21
<b>FUNDING</b>			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 22

JB1 = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

\* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

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# BMJ Open

## Neighborhood effects on obesity: a scoping review of time-varying outcomes and exposures in longitudinal designs

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<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Research methods
Keywords:	PUBLIC HEALTH, EPIDEMIOLOGY, STATISTICS & RESEARCH METHODS

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3 1 **NEIGHBORHOOD EFFECTS ON OBESITY: A SCOPING REVIEW OF**  
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5 2 **TIME-VARYING OUTCOMES AND EXPOSURES IN LONGITUDINAL**  
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7 3 **DESIGNS**  
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4 27 **KEYWORDS**

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6 28 Obesity, neighborhood effect, longitudinal design, scoping review  
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11 30 **ABSTRACT**

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14 31 Context and objectives

15 32 Neighborhood effect research on obesity took off in the early 2000s, and was composed of mostly  
16 33 cross-sectional observational studies interested in various characteristics of the built environment and  
17 34 the socioeconomic environment. To limit biases related to self-selection and life course exposures,  
18 35 many researchers apply longitudinal designs in their studies. Until now, no review has specifically  
19 36 and exclusively examined longitudinal studies and the specific designs of these studies. In this review,  
20 37 we intend to answer the following research question: How are the temporal measurements of  
21 38 contextual exposure and obesity outcomes integrated into longitudinal studies that explore how  
22 39 neighborhood-level built and socioeconomic environments impact adult obesity?  
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29 40 Design

30 41 A systematic search strategy was designed to address the research question. The search was  
31 42 performed in *Embase*, *Web of Science* and *PubMed* targeting scientific papers published before  
32 43 01/01/2018. The eligible studies reported results on adults, included exposure that was limited to  
33 44 neighborhood characteristics at the sub-municipal level, included an outcome limited to obesity  
34 45 proxies (OP), and reported a design with at least two exposure measurements or two outcome  
35 46 measurements.  
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42 48 Results

43 49 This scoping review identified 66 studies that fit the eligibility criteria. A wide variety of  
44 50 neighborhood characteristics were also measured, making it difficult to draw general conclusions  
45 51 about associations between neighborhood exposure and obesity. We applied a typology that classified  
46 52 studies by whether exposure and outcome were measured as varying or fixed. Using this typology,  
47 53 we found that 32 studies reported both neighborhood exposure and obesity outcomes that were  
48 54 varying in time, 28 reported varying outcomes but fixed exposures, and six had fixed outcomes and  
49 55 varying exposures.  
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55 56 Conclusions  
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3 57 Our typology illustrates the variety of longitudinal designs that were used in the selected studies. In  
4 58 the light of our results, we make recommendations on how to better report longitudinal designs and  
5 59 facilitate comparisons between studies.  
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9 **60 ARTICLE SUMMARY**

11 61 Strengths and limitations of this study:

- 13  
14 62 • To our knowledge, this is the first scoping review focussing on the designs of  
15 63 longitudinal studies of neighborhood effect on obesity.  
16  
17 64 • This study proposes a typology to that classifies longitudinal studies by their  
18 65 design.  
19  
20 66 • The descriptive nature of a scoping review excludes quantitative analyses of the  
21 67 results.  
22  
23 68 • This scoping review excludes studies on children, which limits its scope but  
24 69 increases the homogeneity of the results.  
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## 1. BACKGROUND

Before the emergence of ecological models for weight change [1-3], obesity was mostly considered an individual responsibility. Efforts to combat the obesity epidemic were therefore focused on trying to influence the behaviors of individuals to either reduce their caloric intake or increase their caloric expenditure, or both. But such public health interventions did not have the expected results [4]. Worldwide, adult populations have shown increasing rates of obesity prevalence, although a slower rate has been observed in high-income countries [5, 6]. In children, trends in obesity prevalence have plateaued in high-income countries but are steadily increasing in East and South Asia [7].

Due to the mitigated success from the interventions that focused on individuals, some researchers expanded their focus by including the contextual factors in the causal web that may lead to obesity. Among the many levels of contextual factors, those related to neighborhoods quickly became aspects of interest for reasons both theoretical and practical. The observational theory that being overweight is heterogeneously geographically distributed on the neighborhood scale is a strong incentive for researchers to focus on the contextual influences that occur close to one's residence [8]. Also, the increase in obesity prevalence correlates over time with strong global contextual changes. A number of these changes include trade liberalization, economic growth and rapid urbanization, which impact the shape and dynamics of neighborhoods [9]. Among the more practical reasons for focusing on the neighborhood level is the hypothesis that the home environment is relatively easier to influence compared to the global food market or industrialization. Moreover, in some countries, local and national governments have the legislative and regulatory powers to plan neighborhoods. They are also responsible for health policies and services, which act as incentives for the government to lower health care costs and increase well-being by using contextual interventions.

Neighborhood effect research on obesity grew in popularity in the early 2000's [10], consisting of mostly cross-sectional observational studies. These studies were focused on various characteristics of the built environment (e.g. dwelling density, street connectivity, land use mix, food availability) and the socioeconomic environment (e.g. deprivation, safety, social cohesion) and their effect on different obesity proxies (OP) (e.g. BMI (Body Mass Index), weight, waist circumference). The last two decades saw the publication of a substantial number of such studies [10-19]. As of today, recent literature reviews specifically interested in the neighborhood level have identified urban sprawl (positively) and land use mix (negatively) to be associated with weight, only in North America [10] [14]. A very recent literature review of longitudinal studies on built environment and cardio-metabolic health also found strong evidence for the impact of walkability on obesity [20]. But authors have also reported methodological challenges, such as self-selection bias and the lack of life course

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3 105 exposure, and have suggested improving neighborhood effect studies by using longitudinal designs  
4 106 (i.e. using repeated measures of outcome and/or exposure) in order to move towards causality models  
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6 107 [10, 14, 21].  
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9 108 Self-selection is a bias that can be introduced when individual residential localization choices are  
10 109 related to individual obesity outcomes [22, 23]. For instance, people who enjoy physical activity  
11 110 might prefer residential neighborhoods where many opportunities for such activities exist. People  
12 111 who enjoy traveling by car might prefer car-friendly neighborhoods compared to those who prefer  
13 112 walking [24]. These preferences and behaviors are often associated with obesity outcomes, but the  
14 113 time sequence between residential choice and weight gain cannot be disentangled in cross-sectional  
15 114 studies. In addition to the temporal sequence problem, cross-sectional studies have a limited capacity  
16 115 to examine the cumulative effect of neighborhood exposure on an individual [22, 25, 26]. An  
17 116 unhealthy obesity status can be the result of a very gradual weight gain. This potentially long latency  
18 117 combined with the effect of frequent residential moving is not captured by the current studies on  
19 118 neighborhood exposure [25, 27].  
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26 119 The ability of longitudinal studies to control for self-selection bias and life course exposure depends  
27 120 in part on their design; i.e. how outcome and exposure measurements are considered in time.  
28 121 Additionally, although some reviews of neighborhood effects on obesity are interested in longitudinal  
29 122 studies, no review was specifically devoted to the specific designs that were used.  
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## 33 123 **2. RESEARCH QUESTION AND OBJECTIVES**

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36 124 This scoping review was specifically designed to answer the following research question: How are  
37 125 the temporal measurements of contextual exposure and obesity outcomes integrated into longitudinal  
38 126 studies that explore how neighborhood-level built and socioeconomic environments impact adult  
39 127 obesity?  
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43 128 To address this research question, the specific objectives of this review were to:

- 44  
45 129 1. detail the number of studies investigating longitudinal neighborhood effects on obesity status  
46 130 and to describe their general characteristics;  
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48 131 2. describe and classify the study designs used to investigate longitudinal neighborhood effects  
49 132 on obesity status;  
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51 133 3. carry out a qualitative overview of the associations between neighborhood exposure and  
52 134 obesity status among studies that apply a longitudinal design.  
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### 135 3. MATERIALS AND METHODS

136 We decided to use a scoping review approach because the large number of study designs that were  
 137 used in the literature makes it difficult and irrelevant to sum and compare results quantitatively [28].  
 138 Methods for this review are described in greater detail in the protocol [29]. A concise description of  
 139 the methods is provided in the following sections.

#### 140 3.1 Systematic search strategy

141 A systematic search strategy was designed to reflect the research question as closely as possible and  
 142 to collect all possible studies relevant to this field of research while screening for the eligibility criteria  
 143 described in Table 1.

Table 1 Eligibility criteria for selection of publications. Modified from the PICO (Population, Intervention, Comparison, Outcome) framework [27].

<b>Criteria</b>	<b>Description</b>
<b>Population</b>	Eligible study populations were composed of adults between 18 and 65 years of age. At least two OPs (obesity proxies) and/or neighborhood characteristics must have been measured during adulthood (18 to 65 years old); other measurements may be collected in childhood, youth or older age.
<b>Exposure</b>	Exposure was measured by any indicator of neighborhood socioeconomic and/or built environment, where neighborhood is defined as an administratively delimited geographic area enclosing the participant's residence, a buffer-delimited area around the participant's residence, or a perceived area delimited by the participant. The geographic area must have been defined at the neighborhood level, which is smaller than a municipal area.
<b>Outcome</b>	The term "obesity" is generally used to refer to the accumulation of body fat and can be measured in numerous ways. Eligible studies were those reporting measured or self-reported OP such as total body weight, BMI, waist circumference, waist/hip ratio and/or skin fold thickness (with no specific thresholds). In this review, any study considering obesity status as an outcome was included.
<b>Study Design</b>	The studies must have included a longitudinal perspective in the measurement of the exposure and/or outcome. For example, studies applying the following designs were considered longitudinal: case-control studies and cohort studies, where exposure is measured at different points in time or classified as a pattern over time; or experimental or quasi-experimental schemes, where participants are exposed to different living environments over time. Cross-sectional and ecological studies were systematically excluded. Study designs that focused only on life course changes in obesity status without measuring contextual exposure were not included in this review.

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3 147 A search strategy was drafted by an experienced librarian (Frédéric Bergeron) and completed by the  
4 148 research team. The final search strategy involved identifying five keywords specifically related to the  
5 149 research question and articulated using Boolean operators:

8 150 Outcome terms AND longitudinal design terms AND (geographic context terms AND (social  
9 151 environment exposure terms OR physical environment exposure terms)).

12 152 This research strategy was modified to fit the search terms specific to three scientific citation index  
13 153 databases: *Embase*, *Web of Science* and *PubMed*. The full search strategy for PubMed is presented as  
14 154 an example in Supplementary file 1. Only peer-reviewed literature that was published in referenced  
15 155 journals in English were considered. The search was performed in February 2018 for scientific papers  
16 156 published before 01/01/2018.

### 21 157 **3.2 Screening and Eligibility**

23 158 The selection process was performed independently by two investigators (LL and SP). Kappa  
24 159 correlation was calculated to assess the inter-investigator agreement for selecting articles according  
25 160 to the title and abstract. Disagreements were resolved by attempting to reach a consensus between the  
26 161 two investigators. When a consensus could not be reached, a third observer (AL) was consulted to  
27 162 make a final decision. Most of the articles excluded at this point were ecological studies, studies with  
28 163 exposures measured at a scale other than the neighborhood, and studies with outcomes that were not  
29 164 obesity status. Pertinent articles from the reference list of included papers were also added to the  
30 165 screened records.

### 36 166 **3.3 Charting**

38 167 The charting process was conducted according to the steps described in the previously published  
39 168 protocol [29]. The construction of the chart also includes an iterative procedure of improvement, in  
40 169 order to consider other types of longitudinal designs that were not expected prior to the charting.

44 170 In its final form, the charting table contained the following information, extracted by one investigator  
45 171 (LL):

- 48 172 • Basic characteristics (year published, country of data collection, target population, type of  
49 173 outcome measure, exposure measure [type and neighborhood unit])
- 51 174 • Longitudinal characteristics (number of outcome measures, number of exposure measures,  
52 175 residential mobility of the population, change in neighborhood characteristics, typology of  
53 176 study designs, statistical analysis)
- 56 177 • Direction and statistical significance of reported associations

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3 178 Results were synthesized by grouping studies according to their basic and longitudinal characteristics  
4 179 and then summarizing their overall findings by analysing the reported associations.

### 6 7 180 **3.4 Patient and Public Involvement**

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9 181 This research was done without patient involvement. Patients were not invited to comment on the  
10 182 study design and were not consulted to develop patient relevant outcomes or interpret the results.  
11 183 Patients were not invited to contribute to the writing or editing of this document for readability or  
12 184 accuracy

## 15 16 185 **4. RESULTS**

### 17 18 186 **4.1 Publication selection**

19  
20 187 Citations collected from the database searches were managed using Endnote X7.5. Duplicates were  
21 188 deleted. A flowchart of the selection process is presented in Figure 1. From the 12,757 identified  
22 189 studies, after screening for relevant titles, abstracts and full manuscripts, 66 articles that fitted the  
23 190 eligibility criteria were selected [30-95]. Summary characteristics are shown in Table 2 and complete  
24 191 characteristics of the studies are shown in Supplementary file 2.

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29 192 [Figure 1]

### 30 31 193 **4.2 Basic characteristics**

#### 32 33 194 4.2.1 Year published

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36 195 [Figure 2]

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38 196 The selected studies were published over a relatively short time span, with the earliest publication in  
39 197 2005 (Figure 2). A general increasing pattern was observed, with a greater number of studies  
40 198 published each year. A particularly notable increase was observed for the last year of the review  
41 199 period (20 papers in 2017).

#### 42 43 200 4.2.2 Countries of Origin

44  
45 201 Among the selected articles, the studied populations were not particularly diverse. The majority of  
46 202 studies were from North America (79%, n= 52), and more specifically from the United States (74%,  
47 203 n=37). Of the non-American study populations, seven (11%) were European, two (3%) were from  
48 204 Asia and five (8%) were Australian.

### 205 4.2.3 Target Population

206 We focused on adult populations, who have more stable weight status patterns than children. Thus,  
 207 the selection criteria were set to include only studies in which two measurements were collected for  
 208 OPs and/or neighborhood exposure during adulthood (18-65 years old). The majority of studies  
 209 (n=33) examined non-specific adult populations. Six studies examined young adults (generally  
 210 younger than 35 years old), while seven other studies were focused on older adults (generally older  
 211 than 45 years old). Fourteen studies also chose specific subgroups of the adult population that are  
 212 susceptible to a differentiated neighborhood effect compared to the general adult population (women,  
 213 African-American women, people with diabetes and migrants). Fourteen studies stratified their results  
 214 for gender, four for race, and two for urban/rural places of residence.

### 215 4.2.4 Outcome Measurements

216 The studies presented in this review were selected for outcomes associated with obesity. BMI was  
 217 used as an outcome by 76% (n=50) of the studies, while waist circumference (or a ratio associated to  
 218 waist and hip circumference) was used by 8% (n=5) of the studies (Table 2). 11% (n=7) used both  
 219 BMI and waist circumference. One study included measurements of subcutaneous adipose tissue  
 220 (SAT) and visceral adipose tissue (VAT) [64].

221 *Table 2 Distribution of the included studies, their overall findings and design characteristics*

Characteristics	Included studies		Overall study findings				
	n	%	Null n	Mixed n	Expected n	Inverse n	% studies with expected findings
<b>All</b>	<b>66</b>	<b>100%</b>	28	15	22	1	33%
<b>Outcome</b>							
BMI	50	76%	18	13	18	1	36%
BMI and waist circumference	7	11%	6	1	.	.	.
Waist circumference	5	8%	2	.	3	.	60%
Weight	3	5%	2	1	.	.	.
Adipose tissue volume	1	2%	.	.	1	.	100%
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Type of attribute</b>							
Built environment	32	49%	15	10	6	1	19%
Socioeconomic	30	46%	11	4	15	.	50%
Both	4	6%	2	1	1	.	25%
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Geographic unit</b>							
Census limits	25	38%	9	5	11	.	44%
Euclidean Buffer	13	20%	6	2	4	1	31%
Other	10	15%	6	3	1	.	10%
Administrative limits	9	14%	4	1	4	.	44%
Network buffer	7	11%	3	2	2	.	29%
Self-reported	2	3%	.	2	.	.	.
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Residential mobility</b>							

Characteristics	Included studies		Overall study findings				
	n	%	Null n	Mixed n	Expected n	Inverse n	% studies with expected findings
Stayers and movers	46	70%	19	10	16	1	35%
Stayers	12	18%	6	2	4	.	33%
Stratified	6	9%	1	3	2	.	33%
Movers	2	3%	2	.	.	.	.
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Change in neighborhood characteristics</b>							
No	38	58%	13	9	16	.	42%
Yes	28	42%	15	6	6	1	21%
<b>All</b>	<b>66</b>	<b>100%</b>					
<b>Typology</b>							
Varying Outcome-Varying Exposure	32	49%	16	7	8	1	25%
Varying Outcome-Fixed Exposure	28	42%	10	8	10	.	36%
Fixed Outcome-Varying Exposure	6	9%	2	.	4	.	67%
<b>All</b>	<b>66</b>	<b>100%</b>					

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#### 223 4.2.5 Exposure Measurements

224 Each of the selected studies was classified according to the primary exposure that was examined.

225 About half the studies fell into the built environment category (49%, n=32) and slightly fewer fell

226 into the socioeconomic indicators category (46%, n=30). A small proportion of studies included both

227 types (6%, n=4). Table 3 shows all associations measured in all included studies (n=483) and groups

228 them into indicator categories. Food environment indicators appeared most often (46%, n=223),

229 followed by area deprivation (14%, n=66), green spaces (8%, n=40), socioeconomic composite index

230 (7%, n=34), and perceived environment indicators (5%, n=25). The indicators used were widely

231 varied in all the categories. For example, some food environment indicators focused on assessing

232 healthy food environments, such as grocery store and supermarket densities [30, 63], and others

233 focused on fast-food restaurant and convenience store densities [66, 91]. For composite indexes,

234 authors applied an array of indexing methods, from pre-existing indexes [51, 78, 85], to summing

235 different indicators [43, 71, 81] or using principal component analyses [46, 55, 75, 76, 90, 96].

236 *Table 3 Number of associations measured in selected studies and percent of statistically significant associations by indicator*  
 237 *type*

Indicator type	Associations N (% of all associations in study)	Statistically significant associations N (% by indicator type)
<b>Food environment</b>	223 (46.4%)	54 (24.2%)
<b>Deprivation</b>	66 (13.7%)	18 (27.3%)
<b>Green space</b>	40 (8.3%)	8 (20.0%)

<b>Composite index socioeconomic</b>	34 (7.0%)	21 (61.8%)
<b>Security</b>	25 (5.2%)	2 (8.0%)
<b>Perceived environment</b>	23 (4.8%)	4 (17.4%)
<b>Physical activity establishment</b>	15 (3.1%)	4 (26.7%)
<b>Walkability</b>	12 (2.5%)	1 (8.3%)
<b>Composite index built environment</b>	10 (2.1%)	5 (50.0%)
<b>Land use</b>	9 (1.9%)	2 (22.2%)
<b>Transportation infrastructure</b>	6 (1.3%)	4 (66.7%)
<b>Density</b>	5 (1.0%)	2 (40.0%)
<b>Racial composition</b>	4 (0.8%)	2 (50.0%)
<b>Distance to landmark</b>	2 (0.4%)	2 (100.0%)
<b>Other</b>	2 (0.4%)	2 (100.0%)
<b>Foreclosure</b>	2 (0.4%)	1 (50.0%)
<b>Sprawl</b>	2 (0.4%)	0 (0.0%)
<b>Prevalence of health behavior</b>	1 (0.2%)	1 (100.0%)
<b>All</b>	<b>481</b>	<b>133</b>

238

239 There was also a large amount of variability in the choice of neighborhood units that were used to  
 240 calculate exposure. The neighborhood areas most often used were those defined by census limits  
 241 (n=25, 38%), but quite a few studies relied on measurements such as Euclidean distance (n=13, 20%)  
 242 or network distance (n=7, 11%), with a radius ranging from 100 m to 5 km around the individual's  
 243 residence. Only two studies (2%) asked participants for a self-reported neighborhood area, and one  
 244 study defined a neighborhood as a participant's activity space, including non-residential  
 245 neighborhood exposure.

### 246 4.3 Longitudinal Characteristics

247 The included studies applied longitudinal designs, meaning that more than one measurement of  
 248 neighborhood exposure or outcome in time was applied. Although all of the studies fit under the  
 249 general definition of a longitudinal design, a few characteristics related to repeated measures and time  
 250 allowed them to be categorized into subgroups.

#### 251 4.3.1 Number of Outcome Measurements

252 There was wide variation in the number of outcomes measured among the selected studies. Six studies  
 253 included only one outcome measurement, of which most were interventions or community trials.  
 254 Thirty studies included two outcome measurements and 30 others included three or more different  
 255 measurements. Among those, Laraia [63], who studied the impact of food environment on weight  
 256 change in a population of patients who were clinically followed for diabetes, reported a median of 17  
 257 BMI measurements for the patients enrolled, with these measurements ranging from 10 to 27. This  
 258 study reported the highest number of outcome measurements of all the studies selected for this review.

#### 259 4.3.2 Number of Exposure Measurements

260 Neighborhood exposure measurements are more difficult to set in time than outcome measurements  
261 because they involve both the geographic location of the participants (generally in the form of an  
262 address, postal code or census area) and the contextual characteristics of their neighborhood (e.g.  
263 walkability, safety, greenness). Researchers can collect both pieces of information simultaneously or  
264 at different times. For example, Richardson [80] collected crime data from the city of Pittsburgh up  
265 to two years before the baseline year and also at the time of address collection from the participants  
266 in order to assess long term neighborhood exposure and its effect on BMI. Other studies did not  
267 simultaneously collect participant addresses and examine neighborhood characteristics simply  
268 because no neighborhood data were available at the baseline year. For example, Wasfi [89] linked the  
269 2012 Walkscore® data to address records from 1994-1995 since historical Walkscore® data were  
270 available for that same period.

271 Studies including only one neighborhood exposure measurement were the most common (n=29),  
272 followed by studies including two measurements (n=17). The highest number of exposure  
273 assessments was reported by Murray and co-authors [72], who used a 20-year residential history  
274 questionnaire to assess the influence of poverty on BMI. They interpolated census-tract poverty for  
275 every month between three US censuses for every participant.

#### 276 4.3.3 Residential Mobility

277 The residential mobility of participants is another characteristic related to time, as changes in  
278 residential location can contribute to changes in exposure to contexts. The vast majority (n=52, 79%)  
279 of the studies included both participants who still remained at the same residence at the time of the  
280 follow-up (stayers) and participants who had changed residences (movers). Six studies (9%) that  
281 included both stayers and movers in their sample presented a stratified analysis for residential  
282 mobility status. A few studies (n=12, 18%) included samples composed of participants who stayed in  
283 the same neighborhood for the entire duration of the follow-up period. Only two studies (3%) had  
284 samples composed of only people who moved during the follow-up period (movers).

#### 285 4.3.4 Change in Neighborhood Characteristics

286 Another important characteristic linked to the longitudinal designs we examined is whether or not  
287 neighborhood context was considered a time-varying quantity. That is, regardless of whether or not  
288 participants changed their residential location, did the studies examine how the characteristics of the  
289 neighborhood changed over time? Less than half of the studies (n=28) considered the temporal  
290 changes in neighborhood context. There were several reasons that were provided for not measuring

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3 291 changes in neighborhood characteristics when two residential location measurements were collected.  
4 292 These reasons included the absence of historical data, such as the Walkscore® [40, 89], or the  
5 293 availability of data at only one time during the follow-up period, such as through a census or land  
6 294 survey [46, 57, 75, 76].  
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#### 10 295 4.3.5 Statistical analysis

11  
12 296 Among the included publications, three main types of statistical analysis were applied to take into  
13 297 consideration the longitudinal structure of repeated measures. The most prevalent type of statistical  
14 298 analysis was multilevel model (n=28), which use a nested structure to allow within-individual random  
15 299 variation [97]. Multilevel models in included publications were composed of a combination of two to  
16 300 four levels, out of five possible levels (waves of the survey, individuals, family, neighborhoods, larger  
17 301 geographic area). The second most common statistical analysis type was the use of linear, logistic, or  
18 302 ordinal regression (n=13) to perform an analysis of change in a continuous, dichotomic, or ordinal  
19 303 OP. The third most frequent type of statistical analysis was fixed effect model(n=8), which use each  
20 304 individual as is own control to account for unmeasured time invariant characteristics. Two studies  
21 305 also used first-difference models similar to fixed effects models. The remaining studies used less  
22 306 common statistical strategies such as structural equations and spatial analysis or a combination of two  
23 307 types.  
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#### 31 308 4.3.6 Typology of Study Designs

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33 309 After examining the selected studies, we identified a three-category typology based on how outcomes  
34 310 and exposures were considered, related to time: time-varying outcome and fixed exposure studies  
35 311 (VO-FE), fixed outcome and time-varying exposure studies (FO-VE), and time-varying outcome and  
36 312 time-varying exposure studies (VO-VE).  
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41 313 In reality, both obesity and neighborhood exposures are time-varying. However, while planning a  
42 314 longitudinal study, the researchers considered their research questions and the data that were available  
43 315 in order to decide whether their statistical model should be based on fixed or time-varying outcomes  
44 316 and exposures. If only one measurement was collected for outcome or exposure then this part of the  
45 317 design was considered as fixed. The outcome was considered time-varying when repeated  
46 318 measurements of OP were reported. The context was considered time-varying when either or both the  
47 319 geographical localization of participants and the neighborhood characteristics were repeatedly  
48 320 measured over time. The fixed outcome and fixed exposure design (FO-FE) was implicitly excluded  
49 321 from this review, since according to the eligibility criteria, no longitudinal studies applied this type  
50 322 of design.  
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3 323 Of the 28 studies using a VO-FE design (time-varying outcomes and fixed exposure), 18 only  
4 324 collected two measurements for the outcome using a typical baseline and follow-up design. Other  
5 325 studies used up to seven outcome measurements [45]. In general, the sole contextual measurement  
6 326 from these studies was synchronized with baseline outcome measurements, but Auchincloss [31]  
7 327 synchronized a contextual measurement with the third of four clinical assessments of BMI in order  
8 328 to measure the impact of perceived walkability and food environment [32].

9 329 The most prevalent type of design was the VO-VE type with time-varying outcomes and time-varying  
10 330 exposures, which included 32 studies. Of those, 27 had the same number of outcome and exposure  
11 331 measurements (either geographical localization or context characteristics). Hisrch [55], for example,  
12 332 used a US sample to measure BMI, waist circumference, geographical location and contextual  
13 333 characteristics at five points in time to examine the association between built environment and  
14 334 obesity. Twenty-four studies measured the characteristics of context and their changes over time  
15 335 while the others examined participant residential mobility to yield changes in exposure.

16 336 The FO-VE (fixed outcome and time-varying exposure) design was the least prevalent type of study.  
17 337 Six authors used this type of design, two of them in randomized social experiments from the Moving  
18 338 to Opportunity (MTO) study [42, 43] and two others were focused on neighborhood poverty  
19 339 trajectories [44, 45].

#### 20 340 **4.4 Qualitative Synthesis of Results**

21 341 Although the objective of this review was mainly to examine longitudinal designs, a qualitative  
22 342 synthesis of the associations is presented to summarize the results obtained from the selected studies.

23 343 For each study, all associations were qualified based on statistical significance (at a level of 5%) and  
24 344 expected direction (as defined by the author). For studies using multiple models, results from the final  
25 345 and fully adjusted models were used. For articles measuring more than one association (n=46), an  
26 346 aggregated indicator was created to qualify the overall study findings, based on the criteria from two  
27 347 previous reviews [98, 99], and is presented in Table 4.

28 348 *Table 4 Criteria used to define overall study findings based on the associations measured*

Overall study findings	Statistical significance reported	Direction reported
<b>Null</b>	0 %-33% statistically significant associations	Inverse or expected
<b>Mixed</b>	34%-59% statistically significant associations	Inverse or expected
<b>Expected</b>	More than 60% statistically significant associations	Expected
<b>Inverse</b>	More than 60% statistically significant associations	Inverse

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3 350 Table 2 summarizes the overall findings of the reviewed studies according to their different  
4 351 characteristics. Of all the papers included in the review (n=66), 42% (n=28) reported a majority of  
5 352 non-significant associations and 33% (n=24) reported a majority of significant associations in the  
6 353 expected or inverse direction. The results were mixed for 23% of the papers, as they did not indicate  
7 354 a majority of significant, non-significant associations or inverse of the expected result.

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11 355 When considering basic characteristics, studies that used waist circumference as an outcome measure,  
12 356 studies that measured socioeconomic neighborhood exposure and studies with fixed outcomes and  
13 357 varying exposure resulted in more than 60% of aggregated associations that were statistically  
14 358 significant in the expected direction. Categories with fewer than five studies were not considered for  
15 359 this analysis, as presented in Table 2.

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20 360 Table 3 shows the results of the 481 disaggregated associations grouped by indicator type. Overall  
21 361 composite indexes of the socioeconomic environment and indicators of transportation infrastructure  
22 362 revealed more than 60% of the statistically significant associations, all in the expected direction.  
23 363 Groups of indicators with fewer than five associations were not considered for this analysis.  
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## 28 29 365 **5. DISCUSSION**

### 30 31 366 **5.1 Main findings**

#### 32 33 367 5.1.1 Basic Characteristics

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36 368 We conducted a systematic search of the scientific literature that examined associations between  
37 369 neighborhood characteristics and obesity outcomes and found 66 papers. These papers included some  
38 370 form of longitudinal design with repeated measures of outcome and/or repeated measures of  
39 371 exposure. Most of the papers that were selected for our review were published very recently. This  
40 372 rapid increase in the number of papers published in this area of research reflects a more general trend  
41 373 in studies about neighborhood effect on health as observed by Oakes [100], who in 2005, also revealed  
42 374 a substantial increase in such publications. However, this trend may also be due to the overall  
43 375 accelerated pace of publications that has been observed across most scientific domains [101].

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49 376 There have been many calls to improve the research on neighborhood effect on health over the last  
50 377 20 years [10, 17, 21, 23, 100, 102]. In addition to the longitudinal designs, which were the main focus  
51 378 of this review, we found that the more common suggestions for design improvement (conducting  
52 379 more studies on population subgroups, using adequate OPs, better identifying and defining  
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3 380 neighborhoods) were taken into account in at least a few of the studies among the 66 that were  
4 381 selected.

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7 382 Ding and Gebel [21] suggested that conducting more studies focused on populations outside the  
8 383 United States and on population groups such as women and ethnic minorities is a potential way to  
9 384 improve overall neighborhood effect research. Although most studies used samples from WEIRD  
10 385 populations (Western, Educated, Industrialized, Rich and Democratic [103]), a few of them focused  
11 386 on specific groups defined by gender, race, age or immigration status.

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15 387 We also found that most of the studies selected BMI as an OP. Some authors have suggested that  
16 388 BMI does not accurately reflect the distribution of fat mass throughout the body, a factor that is  
17 389 hypothesized to have a substantial impact on the risk of cardiovascular disease and insulin resistance  
18 390 [104]. The use of waist circumference measurements is recommended at the individual level [105,  
19 391 106], but this information is rarely available at the population level.

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24 392 The studies in this review used diverse indicators to describe contextual exposure. The large variety  
25 393 of indicators in these studies makes it difficult to compare studies and draw conclusions for each type  
26 394 of indicator. Mackenbach [10], in a review of studies examining the association between the built  
27 395 environment and weight, made a similar observation for both cross-sectional and longitudinal studies.  
28 396 However, in our review, we observed that this was not the case for food environment and  
29 397 socioeconomic indexes. These two categories combined amounted to nearly half of the associations  
30 398 measured in the selected studies. The popularity of food environment indicators suggests that research  
31 399 on diet-related behaviors attracts more interest among the scientific community than physical activity  
32 400 and its determinants [107]. This may be because food availability data can be more easily collected  
33 401 than data on opportunities to participate in physical activity. Or perhaps because researchers observe  
34 402 the synchronicity between the changes in global food systems and the onset of the obesity epidemic  
35 403 to be an indication that the food environment could be the main influence for global weight gain  
36 404 [108]. The long history of literature linking socioeconomic status and cardiovascular risk factors [100,  
37 405 109, 110] and the availability of historical socioeconomic data in national censuses may have also  
38 406 motivated numerous researchers to examine socioeconomic indexes. When we looked specifically at  
39 407 the indicators examined in these two prevailing categories (food environment and socioeconomic  
40 408 indexes), there was a wide diversity of indicators within the categories that made it difficult to  
41 409 compare studies.  
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### 5.1.2 Longitudinal Characteristics

As the main focus of this review, we first summarized how exposures and outcomes were set in time by applying a typology comprising three categories according to the longitudinal nature of the exposures and the outcomes. Using this typology allowed us to identify two key points: what the studies measured and what biases they attempted to address.

Studies with varying outcomes and fixed exposure (VO-FE) are generally designed to control for selection bias. Recording participant OP at an initial baseline exam, follow-up, and sometimes in between, limits the possibility that OP differences between individuals were only due to their OP prior to starting the study. This is an important improvement from cross-sectional studies. Some studies in this review reported contrasting results between cross-sectional and longitudinal data. Albrecht et al. [30] observed associations between the baseline waist circumferences and neighborhood food resources. However, they found no associations when using the changes in waistline circumference. Lee et al. [64] observed inconsistent results for the cross-sectional and longitudinal associations between intersection density, food store density and green space and visceral adipose tissue. Most studies with a VO-FE design used multilevel models to account for intra-individual variability.

Fixed outcome and varying exposure (FO-VE) studies are designed to examine life course changes in neighborhood exposure or changes in neighborhood characteristics. As early as 2001, Diez Roux [23] recognized the importance of examining “the cumulative or interacting effects of neighborhood environments measured at different times over the life course, the effects of duration of exposure to certain neighborhood conditions, the effects of changes over time in neighborhood characteristics, and the impact of moving from one neighborhood to another.” Our review found that every aspect of the longitudinal neighborhood effect that was suggested by Diez Roux has been the focus of at least one of the selected studies. Most of the studies in this group used linear or logistic regression to estimate the effect of a change in the exposure or an exposure trajectory on an OP.

The VO-VE design, which was applied in the largest number of studies in this review, controls both for selection bias and life course exposure. For example, Burdette et al. [43] examined both temporal sequencing and life course and showed using a growth curve model that in a population of adolescents from the United States, those who lived in more disadvantaged neighborhoods at baseline gained weight at a faster rate than those from a less disadvantaged neighborhood. Leonard et al. [65] demonstrated that the conditions of neighborhood change was related to changes in weight only among those who did not move from their neighborhood, thus controlling for self-selection bias and life course changes in neighborhood exposure. As fixed effects models control for time invariant

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3 443 factors and require a change in exposure, all the studies using fixed effects models were found in this  
4 444 type of longitudinal designs. Multilevel models were also used to analyse VO-VE designs and a few  
5 445 studies [41, 44, 77, 89] presented results for both fixed effects and multilevel models. Some authors  
6 446 [31, 37, 59] also took advantage of multiple exposure measurements to build a cross-classified  
7 447 multilevel model where individuals were not nested in one neighborhood, but moved in time and were  
8 448 cross-classified into many neighborhoods.

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13 449 The “fixed-varying” typology highlights the numerous research questions in the selected studies.  
14 450 Some studies posed research questions with particularities beyond the scope of this review, such as  
15 451 mediating behaviors or individual characteristics. But we could list at least six research questions  
16 452 directly related to neighborhood effect on obesity with some degree of longitudinal variation:

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- 21 454 • What is the effect of neighborhood characteristics on OP change?
  - 22 455 • What is the effect of neighborhood characteristics on OP trajectory?
  - 23 456 • What is the effect of neighborhood characteristics change on OP change?
  - 24 457 • What is the effect of moving to another neighborhood on OP?
  - 25 458 • What is the effect of neighborhood trajectory on OP?
  - 26 459 • What is the effect of a neighborhood intervention on obesity?
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31 459 Each one of these questions is relevant and illustrates one particular aspect of obesity and  
32 460 neighborhood evolution. However, the longitudinal characteristics added even more variety to the  
33 461 diverse neighborhood indicators, neighborhood definitions and OPs previously described, which  
34 462 makes it more difficult to draw meaningful conclusions that may be helpful for intervention design.

### 35 463 5.1.3 Qualitative Synthesis of Results

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38 464 Although this was not the main focus of our review, we found no strong evidence on neighborhood  
39 465 effects on obesity in the longitudinal studies. Only 25 studies (38%) yielded statistically significant  
40 466 results in the expected direction. However, this does not necessarily indicate that neighborhood  
41 467 context has no effect, but that the specific characteristics of the neighborhood and how they are  
42 468 measured is important.

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45 469 In terms of contextual measurements, we found that studies reporting socioeconomic indicators of  
46 470 context yielded the majority of significant associations whereas studies on the built environment  
47 471 yielded the majority of non-significant association (Table 2). This may be because contextual  
48 472 socioeconomic indicators do in fact have a stronger effect on obesity or that associations with  
49 473 socioeconomic indicators are biased by more closely correlated individual socioeconomic indicators

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3 474 that are difficult to control for. This adds to the general findings from literature reviews that these  
4 475 results are generally equivocal. Black and Macinko [17] observed that economic resources and  
5 476 physical activity features of the neighborhood are significantly associated with obesity, while the  
6 477 associations between income inequality and racial composition were mixed, and food availability  
7 478 associations were inconsistent. Leal and Chaix [111] reported associations that were remarkably to  
8 479 reasonably consistent in all four categories (sociodemographic environment, physical environment,  
9 480 services and social interaction). Mackenbach [10] reported mixed results for the physical  
10 481 environment.  
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16 482 When considering the obesity outcome measurement, our review shows that studies using waist  
17 483 circumference, although few in number, yielded more statistically significant associations than  
18 484 studies using only BMI. This could be explained by the fact that the distribution of fat may be  
19 485 differentially influenced by lifestyle choices induced by neighborhood characteristics (i.e. increase in  
20 486 muscular mass or decrease in visceral fat versus subcutaneous fat) [104, 112-114] or that the studies  
21 487 using waistline measurements could have characteristics (number of participants, follow-up length,  
22 488 measurement quality,...) which could be associated with more statistical associations in the expected  
23 489 direction.  
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30 490 Finally, the type of design, whether using fixed or varying outcomes and exposures, did not seem to  
31 491 influence the significance or the direction of the association between the neighborhood exposure and  
32 492 the obesity outcome. Studies with fixed outcomes and varying exposure (FO-VE) did yield more  
33 493 statistically significant results than other types of longitudinal designs, but no definitive conclusions  
34 494 can be drawn due to the small number of studies. More studies of this type could contribute to better  
35 495 knowledge about neighborhood effects on obesity, but authors of such studies should be aware that  
36 496 there is less control over self-selection bias when the follow-up period is short or the exposure is not  
37 497 randomized.  
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## 43 498 **5.2 Strengths and Weaknesses**

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45 499 We reviewed studies that were selected through a comprehensive research strategy. We also included  
46 500 a few papers that were cited in relevant publications. The selection criteria were designed to focus on  
47 501 observational studies. In strictly following the search strategy, we included some experimental and  
48 502 trial studies that appeared in our search results [42, 48, 58, 68, 95]. However, these results could not  
49 503 be considered as a comprehensive appreciation of experimental schemes, and could, therefore, be the  
50 504 topic of a review paper of their own [115].  
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3 505 A person's weight status can vary greatly over their life course, with some periods and determinants  
4 506 playing more critical roles in the potential development of obesity [26, 116]. Therefore, although  
5 507 some authors have suggested that neighborhood effects are stronger when considering trajectories  
6 508 that include childhood, we have decided to limit this scoping review to measuring obesity in adults  
7 509 [117], for uniformity. This restriction likely limited the number of eligible publications and reduced  
8 510 the number of longitudinal designs to examine, but it also reduced the heterogeneity among the  
9 511 selected studies and likely facilitated greater comparability among them, considering that OP cut-off  
10 512 values are different for adults and children. [118] .  
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16 513 We also chose to limit our review to studies that focused on residential neighborhoods, despite  
17 514 research showing that they are not the only source of contextual exposure in a population [102].  
18 515 Accessibility to GPS technologies have allowed a number of studies to examine activity-space and  
19 516 better account for the environmental exposure of individuals. This environmental exposure includes  
20 517 the daily mobility of participants who are exposed to neighborhoods around their home, around their  
21 518 workplace, or other destinations related to their activities. One study [59] in our review found that  
22 519 accounting for activity-space and the time spent in different neighborhoods does influence the impact  
23 520 on obesity risk. Extending neighborhood effect research beyond residential environments could help  
24 521 draw a more complete picture of how neighborhoods and obesity status interact in time and space.  
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### 31 522 **5.3 Unanswered Questions**

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33 523 Better understanding longitudinal designs used in studies on neighborhood effect on obesity prompts  
34 524 questions that cannot be answered in this review. The most obvious one would be whether quantitative  
35 525 analysis of the results of longitudinal studies can be applied. Restricting the reviews to a specific  
36 526 category of indicators, such as the food environment or socioeconomic index or a specific type of  
37 527 design, could possibly provide enough homogeneity to perform such analyses. This would facilitate  
38 528 a quality analysis among studies, which was not possible in this review. Appraising statistical models,  
39 529 the length of follow-up periods, the number of measurements and population size would be helpful  
40 530 for not only selecting studies for a systematic review, but also for suggesting quality standards for  
41 531 future longitudinal studies.  
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### 48 532 **5.4 Implications for Future Research**

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50 533 One of the biggest challenges in conducting this review was the general difficulty in identifying the  
51 534 longitudinal characteristics in the selected studies. This reflects the challenging task of identifying  
52 535 and reporting every aspect of a study that can be influenced by time, and the difficulty in connecting  
53 536 these longitudinal characteristics with a specific research question. One of the most obvious examples  
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3 537 is the residential mobility status of a population. In some articles, a group's choice to move or to stay  
4 538 in the same location was made clear, and was sometimes even stated in the publication's title [63, 65,  
5 539 95] or research question [76]. But other authors neglected to mention the mobility status of their  
6 540 population or gave very little information about this factor, making it difficult to interpret the study's  
7 541 results and their significance. Similarly, some publications provided very few details about changes  
8 542 in neighborhood characteristics or the time that neighborhood characteristic measurements were  
9 543 collected. Therefore, we suggest that future studies on longitudinal characteristics of neighborhood  
10 544 effects should report the following items whenever possible:

- 16 545 • **Mobility status:** specify whether participants moved residential locations during the follow-  
17 546 up period, stayed in the same residential location or whether the sample contains both types  
18 547 of mobility statuses.
- 21 548 • **Time of residential location measurement:** Report time (date or wave) at which the  
22 549 residential neighborhood of participants was localized;
- 24 550 • **Time of neighborhood characteristics measurements:** Report time at which the data  
25 551 describing neighborhood characteristics were collected. Specify if neighborhood  
26 552 characteristics vary in time (multiple neighborhood characteristic measurements).

30 553 The availability of data describing exposures or outcomes is an important obstacle when conducting  
31 554 quality longitudinal studies. Acquiring access to repeated measures of BMI or waist circumference  
32 555 that are linked to high-quality retrospective neighborhood measurements is highly challenging outside  
33 556 large-scale initiatives and especially outside WEIRD populations. Even with access to this  
34 557 information, capturing measurements that are more representative of neighborhoods, such as the  
35 558 perceived neighborhood or activity space, is a challenging task. It is worth considering the use of new  
36 559 technologies such as GPS data from mobile phones, geo-located data from social media, satellite  
37 560 imaging [73] and administrative open data as they become more available to researchers [119, 120].

## 43 561 **6. CONCLUSION**

46 562 Our scoping review, aimed at characterizing the designs of longitudinal studies examining  
47 563 neighborhood effects on obesity, identified 66 studies that fit our eligibility criteria. Overall, these  
48 564 longitudinal study designs were mostly intended to control for self-selection bias, although a fair  
49 565 number of studies also took life course exposure into consideration. The studies were very diverse in  
50 566 terms of the questions asked, indicators used and designs proposed, which limited the potential for  
51 567 conducting quantitative reviews of the results. On the other hand, the populations that were studied  
52 568 lacked diversity, suggesting that future studies should expand their interest to those outside WEIRD



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3 569 (Western, Educated, Industrialized, Rich and Democratic) populations. Additionally, we have  
4 570 proposed improvements for reporting longitudinal characteristics that could help authors design  
5 571 future longitudinal studies.

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8 572 The diversified longitudinal study designs examined in this review reveal the intricate pathways in  
9 573 which the neighborhood and obesity may interact with time. Identifying these pathways is  
10 574 indispensable in the discussion about causality. However, at this time, they also compound the  
11 575 overwhelming diversity of neighborhood effect designs, which is an issue that has been identified as  
12 576 potentially hindering researchers from uncovering information that may prove useful for clinical or  
13 577 urban practices.

## 18 578 **7. DATA AVAILABILITY**

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21 579 All data relevant to the study are included in the article or uploaded as supplementary information.

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23  
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## 37 588 **10. AUTHOR CONTRIBUTIONS**

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41 589 Laurence Letarte designed this study, acquired, analyzed and interpreted the data and wrote the  
42 590 article. Sonia Pomerleau participated in data acquisition and contributed important intellectual  
43 591 content to the article. André Tchernof and Laurent Biertho revised the article and contributed  
44 592 important intellectual content. Alexandre Lebel participated in the study design, data interpretation,  
45 593 and revised the article and contributed important intellectual content. Owen Waygood participated in  
46 594 the study design, revised the article and contributed important intellectual content.

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## 600 12. REFERENCES

- 601 1. Glass, T.A. and M.J. McAtee, *Behavioral science at the crossroads in public health: extending horizons, envisioning the future*. Soc Sci Med, 2006. **62**(7): p. 1650-71.
- 602 2. Kumanyika, S.K., L. Parker, and L.J. Sim, *Bridging the evidence gap in obesity prevention: a framework to inform decision making*. 2010: National Academies Press.
- 603 3. Swinburn, B., G. Egger, and F. Raza, *Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity*. Preventive medicine, 1999. **29**(6): p. 563-570.
- 604 4. Gotay, C.C., et al., *Updating the Canadian obesity maps: an epidemic in progress*. Can J Public Health, 2013. **104**(1): p. e64-e68.
- 605 5. Collaboration, N.R.F., *Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19· 2 million participants*. The Lancet, 2016. **387**(10026): p. 1377-1396.
- 606 6. Ng, M., et al., *Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013*. Lancet, 2014. **384**(9945): p. 766-81.
- 607 7. Abarca-Gómez, L., et al., *Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128· 9 million children, adolescents, and adults*. The Lancet, 2017. **390**(10113): p. 2627-2642.
- 608 8. Lebel, A., et al., *The Geography of Overweight in Quebec: A Multilevel Perspective*. Can J Public Health, 2009. **100**(1): p. 18-23.
- 609 9. Malik, V.S., W.C. Willett, and F.B. Hu, *Global obesity: trends, risk factors and policy implications*. Nature Reviews Endocrinology, 2013. **9**(1): p. 13-27.
- 610 10. Mackenbach, J.D., et al., *Obesogenic environments: a systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project*. BMC Public Health, 2014. **14**.
- 611 11. Papas, M.A., et al., *The built environment and obesity*. Epidemiologic Reviews, 2007. **29**: p. 129-143.
- 612 12. Booth, K.M., M.M. Pinkston, and W.S.C. Poston, *Obesity and the built environment*. Journal of the American Dietetic Association, 2005. **105**(5): p. S110-S117.
- 613 13. Feng, J., et al., *The built environment and obesity: A systematic review of the epidemiologic evidence*. Health & Place, 2010. **16**(2): p. 175-190.
- 614 14. Garfinkel-Castro, A., et al., *The Built Environment and Obesity*, in *Metabolic Syndrome: A Comprehensive Textbook*, R.S. Ahima, Editor. 2016. p. 275-286.
- 615 15. Durand, C.P., et al., *A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning*. Obesity Reviews, 2011. **12**(501): p. e173-e182.
- 616 16. Casagrande, S.S., et al., *Built Environment and Health Behaviors Among African Americans A Systematic Review*. American Journal of Preventive Medicine, 2009. **36**(2): p. 174-181.
- 617 17. Black, J.L. and J. Macinko, *Neighborhoods and obesity*. Nutrition Reviews, 2008. **66**(1): p. 2-20.
- 618 18. Lachowycz, K. and A.P. Jones, *Greenspace and obesity: a systematic review of the evidence*. Obesity Reviews, 2011. **12**(501): p. e183-e189.
- 619 19. Lovasi, G.S., et al., *Built Environments and Obesity in Disadvantaged Populations*. Epidemiologic Reviews, 2009. **31**(1): p. 7-20.

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3 646 20. Chandrabose, M., et al., *Built environment and cardio-metabolic health: systematic review*  
4 647 *and meta-analysis of longitudinal studies*. Obesity Reviews, 2019. **20**(1): p. 41-54.  
5 648 21. Ding, D. and K. Gebel, *Built environment, physical activity, and obesity: What have we*  
6 649 *learned from reviewing the literature?* Health & Place, 2012. **18**(1): p. 100-105.  
7 650 22. Merlo, J., *Contextual influences on the individual life course: Building a research framework*  
8 651 *for social epidemiology*. Psychosocial Intervention, 2011. **20**(1): p. 109-118.  
9 652 23. Diez Roux, A.V., *Investigating neighborhood and area effects on health*. American journal  
10 653 of public health, 2001. **91**(11): p. 1783-1789.  
11 654 24. Kitamura, R., P.L. Mokhtarian, and L. Laidet, *A micro-analysis of land use and travel in five*  
12 655 *neighborhoods in the San Francisco Bay Area*. Transportation, 1997. **24**(2): p. 125-158.  
13 656 25. Wheeler, D.C. and C.A. Calder, *Sociospatial Epidemiology: Residential History Analysis*, in  
14 657 *Handbook of Spatial Epidemiology*, A.B. Lawson, et al., Editors. 2016, CRC Press.  
15 658 26. Ben-Shlomo, Y. and D. Kuh, *A life course approach to chronic disease epidemiology:*  
16 659 *conceptual models, empirical challenges and interdisciplinary perspectives*. Int J Epidemiol,  
17 660 2002. **31**(2): p. 285-93.  
18 661 27. Boscoe, F.P., *The use of residential history in environmental health studies*, in *Geospatial*  
19 662 *Analysis of Environmental Health*. 2011, Springer. p. 93-110.  
20 663 28. Arksey, H. and L. O'Malley, *Scoping studies: towards a methodological framework*.  
21 664 International journal of social research methodology, 2005. **8**(1): p. 19-32.  
22 665 29. Letarte, L., et al., *Longitudinal designs to study neighbourhood effects on the development of*  
23 666 *obesity: a scoping review protocol*. BMJ open, 2018. **8**(1): p. e017704.  
24 667 30. Albrecht, S.S., et al., *Change in waist circumference with longer time in the United States*  
25 668 *among Hispanic and Chinese immigrants: the modifying role of the neighborhood built*  
26 669 *environment*. Ann Epidemiol, 2015. **25**(10): p. 767-72.e2.  
27 670 31. Arcaya, M., et al., *Effects of proximate foreclosed properties on individuals' weight gain in*  
28 671 *Massachusetts, 1987-2008*. American journal of public health, 2013. **103**(9): p. e50-56.  
29 672 32. Auchincloss, A.H., et al., *Neighborhood Health-Promoting Resources and Obesity Risk (the*  
30 673 *Multi-Ethnic Study of Atherosclerosis)*. Obesity, 2012.  
31 674 33. Auerbach, B.J., et al., *Factors associated with maintenance of body mass index in the Jackson*  
32 675 *Heart Study: A prospective cohort study secondary analysis*. Preventive Medicine, 2017. **100**:  
33 676 p. 95-100.  
34 677 34. Barrientos-Gutierrez, T., et al., *Neighborhood Physical Environment and Changes in Body*  
35 678 *Mass Index: Results From the Multi-Ethnic Study of Atherosclerosis*. Am J Epidemiol, 2017.  
36 679 **186**(11): p. 1237-1245.  
37 680 35. Berry, T.R., et al., *Changes in BMI over 6 years: the role of demographic and neighborhood*  
38 681 *characteristics*. International Journal of Obesity, 2010. **34**(8): p. 1275-1283.  
39 682 36. Berry, T.R., et al., *A longitudinal and cross-sectional examination of the relationship between*  
40 683 *reasons for choosing a neighbourhood, physical activity and body mass index*. International  
41 684 Journal of Behavioral Nutrition and Physical Activity, 2010. **7**.  
42 685 37. Block, J.P., et al., *Proximity to food establishments and body mass index in the Framingham*  
43 686 *Heart Study offspring cohort over 30 years*. Am J Epidemiol, 2011. **174**(10): p. 1108-14.  
44 687 38. Blok, D.J., et al., *Changes in smoking, sports participation and overweight: Does*  
45 688 *neighborhood prevalence matter?* Health & Place, 2013. **23**: p. 33-38.  
46 689 39. Boone-Heinonen, J., et al., *The Neighborhood Energy Balance Equation: Does*  
47 690 *Neighborhood Food Retail Environment plus Physical Activity Environment = Obesity? The*  
48 691 *CARDIA Study*. Plos One, 2013. **8**(12).  
49 692 40. Braun, L.M., et al., *Walkability and cardiometabolic risk factors: Cross-sectional and*  
50 693 *longitudinal associations from the Multi-Ethnic Study of Atherosclerosis*. Health & Place,  
51 694 2016. **39**: p. 9-17.  
52  
53  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3 695 41. Braun, L.M., et al., *Changes in walking, body mass index, and cardiometabolic risk factors*  
4 696 following residential relocation: Longitudinal results from the CARDIA study. *J Transp*  
5 697 Health, 2016. **3**(4): p. 426-439.
- 6 698 42. Brown, B.B., et al., *Transit Use, Physical Activity, and Body Mass Index Changes: Objective*  
7 699 *Measures Associated With Complete Street Light-Rail Construction*. *American Journal of*  
8 700 *Public Health*, 2015. **105**(7): p. 1468-1474.
- 9 701 43. Burdette, A.M. and B.L. Needham, *Neighborhood environment and body mass index*  
10 702 *trajectories from adolescence to adulthood*. *J Adolesc Health*, 2012. **50**(1): p. 30-7.
- 11 703 44. Christine, P.J., et al., *Exposure to Neighborhood Foreclosures and Changes in*  
12 704 *Cardiometabolic Health: Results From MESA*. *American Journal of Epidemiology*, 2017.  
13 705 **185**(2): p. 106-114.
- 14 706 45. Colchero, M.A. and D. Bishai, *Effect of neighborhood exposures on changes in weight among*  
15 707 *women in Cebu, Philippines (1983-2002)*. *American Journal of Epidemiology*, 2008. **167**(5):  
16 708 p. 615-623.
- 17 709 46. Coogan, P.F., et al., *Neighborhood Socioeconomic Status in Relation to 10-Year Weight Gain*  
18 710 *in the Black Women's Health Study*. *Obesity*, 2010. **18**(10): p. 2064-2065.
- 19 711 47. Coogan, P.F., et al., *Longitudinal assessment of urban form and weight gain in African-*  
20 712 *American women*. *Am J Prev Med*, 2011. **40**(4): p. 411-8.
- 21 713 48. Cummins, S., E. Flint, and S.A. Matthews, *New Neighborhood Grocery Store Increased*  
22 714 *Awareness Of Food Access But Did Not Alter Dietary Habits Or Obesity*. *Health Affairs*,  
23 715 2014. **33**(2): p. 283-291.
- 24 716 49. Do, D.P. and C. Zheng, *A marginal structural modeling strategy investigating short and long-*  
25 717 *term exposure to neighborhood poverty on BMI among US black and white adults*. *Health &*  
26 718 *Place*, 2017. **46**: p. 201-209.
- 27 719 50. Eid, J., et al., *Fat city: Questioning the relationship between urban sprawl and obesity*.  
28 720 *Journal of Urban Economics*, 2008. **63**(2): p. 385-404.
- 29 721 51. Feng, X.Q. and A. Wilson, *Getting Bigger, Quicker? Gendered Socioeconomic Trajectories*  
30 722 *in Body Mass Index across the Adult Lifecourse: A Longitudinal Study of 21,403 Australians*.  
31 723 *Plos One*, 2015. **10**(10).
- 32 724 52. Gebel, K., et al., *Mismatch between perceived and objectively assessed neighborhood*  
33 725 *walkability attributes: Prospective relationships with walking and weight gain*. *Health &*  
34 726 *Place*, 2011. **17**(2): p. 519-524.
- 35 727 53. Gibson, D.M., *The neighborhood food environment and adult weight status: estimates from*  
36 728 *longitudinal data*. *Am J Public Health*, 2011. **101**(1): p. 71-8.
- 37 729 54. Halonen, J.I., et al., *Green and Blue Areas as Predictors of Overweight and Obesity in an 8-*  
38 730 *Year Follow-Up Study*. *Obesity*, 2014. **22**(8): p. 1910-1917.
- 39 731 55. Hirsch, J.A., et al., *Built environment change and change in BMI and waist circumference:*  
40 732 *Multi-ethnic Study of Atherosclerosis*. *Obesity (Silver Spring)*, 2014. **22**(11): p. 2450-7.
- 41 733 56. Jones, M. and J. Huh, *Toward a multidimensional understanding of residential*  
42 734 *neighborhood: a latent profile analysis of Los Angeles neighborhoods and longitudinal adult*  
43 735 *excess weight*. *Health Place*, 2014. **27**: p. 134-41.
- 44 736 57. Joost, S., et al., *Persistent spatial clusters of high body mass index in a Swiss urban*  
45 737 *population as revealed by the 5-year GeoCoLaus longitudinal study*. *BMJ Open*, 2016. **6**(1):  
46 738 p. e010145.
- 47 739 58. Kapinos, K.A., O. Yakusheva, and D. Eisenberg, *Obesogenic environmental influences on*  
48 740 *young adults: Evidence from college dormitory assignments*. *Economics & Human Biology*,  
49 741 2014. **12**: p. 98-109.
- 50 742 59. Kimbro, R.T., G. Sharp, and J.T. Denney, *Home and away: Area socioeconomic*  
51 743 *disadvantage and obesity risk*. *Health Place*, 2017. **44**: p. 94-102.
- 52 744 60. Kwarteng, J.L., et al., *Independent Effects of Neighborhood Poverty and Psychosocial Stress*  
53 745 *on Obesity Over Time*. *Journal of Urban Health*, 2017. **94**(6): p. 791-802.

- 1  
2  
3 746 61. Kwarteng, J.L., et al., *NEIGHBOURHOOD POVERTY, PERCEIVED DISCRIMINATION*  
4 747 *AND CENTRAL ADIPOSITY IN THE USA: INDEPENDENT ASSOCIATIONS IN A*  
5 748 *REPEATED MEASURES ANALYSIS*. *J Biosoc Sci*, 2016. **48**(6): p. 709-22.
- 6 749 62. Lamb, K.E., et al., *Associations between major chain fast-food outlet availability and change*  
7 750 *in body mass index: a longitudinal observational study of women from Victoria, Australia*.  
8 751 *Bmj Open*, 2017. **7**(10).
- 9 752 63. Laraia, B.A., et al., *Food Environment and Weight Change: Does Residential Mobility*  
10 753 *Matter?: The Diabetes Study of Northern California (DISTANCE)*. *Am J Epidemiol*, 2017.  
11 754 **185**(9): p. 743-750.
- 12 755 64. Lee, J.J., et al., *Association of built environment characteristics with adiposity and glycaemic*  
13 756 *measures*. *Obesity Science & Practice*, 2017. **3**(3): p. 333-341.
- 14 757 65. Leonard, T., et al., *Do neighborhoods matter differently for movers and non-movers?*  
15 758 *Analysis of weight gain in the longitudinal dallas heart study*. *Health & Place*, 2017. **44**: p.  
16 759 52-60.
- 17 760 66. Li, F., et al., *Built Environment and 1-Year Change in Weight and Waist Circumference in*  
18 761 *Middle-Aged and Older Adults*. *American Journal of Epidemiology*, 2009. **169**(4): p. 401-  
19 762 408.
- 20 763 67. Lippert, A.M., et al., *Associations of Continuity and Change in Early Neighborhood Poverty*  
21 764 *With Adult Cardiometabolic Biomarkers in the United States: Results From the National*  
22 765 *Longitudinal Study of Adolescent to Adult Health, 1995-2008*. *Am J Epidemiol*, 2017: p. 1-  
23 766 12.
- 24 767 68. Ludwig, J., et al., *Neighborhoods, obesity, and diabetes--a randomized social experiment*. *N*  
25 768 *Engl J Med*, 2011. **365**(16): p. 1509-19.
- 26 769 69. Mendez, D.D., et al., *Neighborhood factors and six-month weight change among overweight*  
27 770 *individuals in a weight loss intervention*. *Prev Med Rep*, 2016. **4**: p. 569-573.
- 28 771 70. Meyer, K.A., et al., *Combined measure of neighborhood food and physical activity*  
29 772 *environments and weight-related outcomes: The CARDIA study*. *Health & Place*, 2015. **33**:  
30 773 p. 9-18.
- 31 774 71. Mujahid, M.S., et al., *Cross-sectional and longitudinal associations of BMI with*  
32 775 *socioeconomic characteristics*. *Obesity Research*, 2005. **13**(8): p. 1412-1421.
- 33 776 72. Murray, E.T., et al., *Trajectories of neighborhood poverty and associations with subclinical*  
34 777 *atherosclerosis and associated risk factors: the multi-ethnic study of atherosclerosis*.  
35 778 *American journal of epidemiology*, 2010. **171**(10): p. 1099-1108.
- 36 779 73. Picavet, H.S., et al., *Greener living environment healthier people?: Exploring green space,*  
37 780 *physical activity and health in the Doetinchem Cohort Study*. *Prev Med*, 2016. **89**: p. 7-14.
- 38 781 74. Pitts, S.B.J., et al., *Examining the Association between Intervention-Related Changes in Diet,*  
39 782 *Physical Activity, and Weight as Moderated by the Food and Physical Activity Environments*  
40 783 *among Rural, Southern Adults*. *Journal of the Academy of Nutrition and Dietetics*, 2017.  
41 784 **117**(10): p. 1618-1627.
- 42 785 75. Powell-Wiley, T.M., et al., *Neighborhood-level socioeconomic deprivation predicts weight*  
43 786 *gain in a multi-ethnic population: longitudinal data from the Dallas Heart Study*. *Prev Med*,  
44 787 2014. **66**: p. 22-7.
- 45 788 76. Powell-Wiley, T.M., et al., *Change in Neighborhood Socioeconomic Status and Weight Gain*  
46 789 *Dallas Heart Study*. *American Journal of Preventive Medicine*, 2015. **49**(1): p. 72-79.
- 47 790 77. Powell-Wiley, T.M., et al., *Associations of Neighborhood Crime and Safety and With*  
48 791 *Changes in Body Mass Index and Waist Circumference The Multi-Ethnic Study of*  
49 792 *Atherosclerosis*. *American Journal of Epidemiology*, 2017. **186**(3): p. 280-288.
- 50 793 78. Rachele, J.N., et al., *Neighborhood socioeconomic disadvantage and body mass index among*  
51 794 *residentially stable mid-older aged adults: Findings from the HABITAT multilevel*  
52 795 *longitudinal study*. *Prev Med*, 2017. **105**: p. 271-274.
- 53  
54  
55  
56  
57  
58  
59  
60

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2  
3 796 79. Richardson, A.S., et al., *Multiple pathways from the neighborhood food environment to*  
4 797 *increased body mass index through dietary behaviors: A structural equation-based analysis*  
5 798 *in the CARDIA study.* Health & Place, 2015. **36**: p. 74-87.
- 6 799 80. Richardson, A.S., et al., *Pathways through which higher neighborhood crime is*  
7 800 *longitudinally associated with greater body mass index.* International Journal of Behavioral  
8 801 Nutrition and Physical Activity, 2017. **14**.
- 9 802 81. Ruel, E., et al., *Neighborhood effects on BMI trends: examining BMI trajectories for Black*  
10 803 *and White women.* Health Place, 2010. **16**(2): p. 191-8.
- 11 804 82. Rummo, P.E., et al., *Does unmeasured confounding influence associations between the retail*  
12 805 *food environment and body mass index over time? The Coronary Artery Risk Development*  
13 806 *in Young Adults (CARDIA) study.* International Journal of Epidemiology, 2017. **46**(5): p.  
14 807 1456-1464.
- 15 808 83. Sarkar, C., J. Gallacher, and C. Webster, *Built environment configuration and change in body*  
16 809 *mass index: the Caerphilly Prospective Study (CaPS).* Health Place, 2013. **19**: p. 33-44.
- 17 810 84. Sheehan, C.M., et al., *Long-term neighborhood poverty trajectories and obesity in a sample*  
18 811 *of california mothers.* Health Place, 2017. **46**: p. 49-57.
- 19 812 85. Stafford, M., et al., *Deprivation and the Development of Obesity A Multilevel, Longitudinal*  
20 813 *Study in England.* American Journal of Preventive Medicine, 2010. **39**(2): p. 130-139.
- 21 814 86. Stoddard, P.J., et al., *Neighborhood Deprivation and Change in BMI Among Adults With*  
22 815 *Type 2 Diabetes.* Diabetes Care, 2013. **36**(5): p. 1200-1208.
- 23 816 87. Sugiyama, T., et al., *Residential proximity to urban centres, local-area walkability and*  
24 817 *change in waist circumference among Australian adults.* Prev Med, 2016. **93**: p. 39-45.
- 25 818 88. Sund, E.R., A. Jones, and K. Midthjell, *Individual, family, and area predictors of BMI and*  
26 819 *BMI change in an adult Norwegian population: Findings from the HUNT study.* Social  
27 820 Science and Medicine, 2010. **70**(8): p. 1194-1202.
- 28 821 89. Wasfi, R.A., et al., *Neighborhood Walkability and Body Mass Index Trajectories:*  
29 822 *Longitudinal Study of Canadians.* Am J Public Health, 2016. **106**(5): p. 934-40.
- 30 823 90. Xiao, Q., et al., *Neighborhood Socioeconomic Deprivation and Weight Change in a Large*  
31 824 *US Cohort.* American Journal of Preventive Medicine, 2017. **52**(6): p. E173-E181.
- 32 825 91. Xu, H., S.E. Short, and T. Liu, *Dynamic relations between fast-food restaurant and body*  
33 826 *weight status: a longitudinal and multilevel analysis of Chinese adults.* J Epidemiol  
34 827 Community Health, 2013. **67**(3): p. 271-9.
- 35 828 92. Zenk, S.N., et al., *Longitudinal Associations Between Observed and Perceived Neighborhood*  
36 829 *Food Availability and Body Mass Index in a Multiethnic Urban Sample.* Health Educ Behav,  
37 830 2017. **44**(1): p. 41-51.
- 38 831 93. Zenk, S.N., et al., *Geographic Accessibility Of Food Outlets Not Associated With Body Mass*  
39 832 *Index Change Among Veterans, 2009-14.* Health Affairs, 2017. **36**(8): p. 1433-1442.
- 40 833 94. Zhang, Y.T., et al., *Is a reduction in distance to nearest supermarket associated with BMI*  
41 834 *change among type 2 diabetes patients?* Health & Place, 2016. **40**: p. 15-20.
- 42 835 95. Zhao, Z.X., R. Kaestner, and X. Xu, *Spatial mobility and environmental effects on obesity.*  
43 836 Economics & Human Biology, 2014. **14**: p. 128-140.
- 44 837 96. Rummo, P.E., et al., *Fast food price, diet behavior, and cardiometabolic health: Differential*  
45 838 *associations by neighborhood SES and neighborhood fast food restaurant availability in the*  
46 839 *CARDIA study.* Health Place, 2015. **35**: p. 128-35.
- 47 840 97. Twisk, J.W., *Applied longitudinal data analysis for epidemiology: a practical guide.* 2013:  
48 841 Cambridge University Press.
- 49 842 98. Ding, D., et al., *Neighborhood environment and physical activity among youth a review.* Am  
50 843 J Prev Med, 2011. **41**(4): p. 442-55.
- 51 844 99. Brown, V., M. Moodie, and R. Carter, *Evidence for associations between traffic calming and*  
52 845 *safety and active transport or obesity: A scoping review.* Journal of Transport & Health, 2017.  
53 846 **7**: p. 23-37.

- 1  
2  
3 847 100. Oakes, J.M., et al., *Twenty Years of Neighborhood Effect Research: An Assessment*. Curr  
4 848 Epidemiol Rep, 2015. **2**(1): p. 80-87.
- 5 849 101. Unesco and F. Schlegel, *UNESCO science report: towards 2030*. 2015: UNESCO Publ.
- 6 850 102. Perchoux, C., et al., *Residential buffer, perceived neighborhood, and individual activity*  
7 851 *space: New refinements in the definition of exposure areas - The RECORD Cohort Study*.  
8 852 Health Place, 2016. **40**: p. 116-22.
- 9 853 103. Henrich, J., S.J. Heine, and A. Norenzayan, *The weirdest people in the world?* Behavioral  
10 854 and Brain Sciences, 2010. **33**(2-3): p. 61-+.
- 11 855 104. Tchernof, A. and J.P. Despres, *PATHOPHYSIOLOGY OF HUMAN VISCERAL OBESITY:*  
12 856 *AN UPDATE*. Physiological Reviews, 2013. **93**(1): p. 359-404.
- 13 857 105. World Health Organization, *Obesity: preventing and managing the global epidemic*. 2000.
- 14 858 106. Despres, J.-P., et al., *Regional distribution of body fat, plasma lipoproteins, and*  
15 859 *cardiovascular disease*. Arteriosclerosis, Thrombosis, and Vascular Biology, 1990. **10**(4): p.  
16 860 497-511.
- 17 861 107. Rodgers, A., et al., *Prevalence trends tell us what did not precipitate the US obesity epidemic*.  
18 862 Lancet Public Health, 2018. **3**(4): p. e162-e163.
- 19 863 108. Swinburn, B.A., et al., *The global obesity pandemic: shaped by global drivers and local*  
20 864 *environments*. The Lancet, 2011. **378**(9793): p. 804-814.
- 21 865 109. Kaplan, G.A. and J.E. Keil, *Socioeconomic factors and cardiovascular disease: a review of*  
22 866 *the literature*. Circulation, 1993. **88**(4): p. 1973-1998.
- 23 867 110. Suglia, S.F., et al., *Why the Neighborhood Social Environment Is Critical in Obesity*  
24 868 *Prevention*. Journal of Urban Health-Bulletin of the New York Academy of Medicine, 2016.  
25 869 **93**(1): p. 206-212.
- 26 870 111. Leal, C.C., B., *The influence of geographic life environments on cardiometabolic risk factors:*  
27 871 *a systematic review, a methodological assessment and a research agenda*. Obes Rev, 2011.  
28 872 **12**(3): p. 217-30.
- 29 873 112. Arsenault, B.J., et al., *Visceral adipose tissue accumulation, cardiorespiratory fitness, and*  
30 874 *features of the metabolic syndrome*. Archives of internal medicine, 2007. **167**(14): p. 1518-  
31 875 1525.
- 32 876 113. Despres, J.P., *Obesity and Cardiovascular Disease: Weight Loss Is Not the Only Target*.  
33 877 Canadian Journal of Cardiology, 2015. **31**(2).
- 34 878 114. Vissers, D., et al., *The effect of exercise on visceral adipose tissue in overweight adults: a*  
35 879 *systematic review and meta-analysis*. PloS one, 2013. **8**(2): p. e56415.
- 36 880 115. Mayne, S.L., A.H. Auchincloss, and Y.L. Michael, *Impact of policy and built environment*  
37 881 *changes on obesity-related outcomes: a systematic review of naturally occurring*  
38 882 *experiments*. Obesity reviews : an official journal of the International Association for the  
39 883 Study of Obesity, 2015. **16**(5): p. 362-375.
- 40 884 116. Ziyab, A.H., et al., *Developmental trajectories of Body Mass Index from infancy to 18 years*  
41 885 *of age: prenatal determinants and health consequences*. Journal of Epidemiology and  
42 886 Community Health, 2014. **68**(10): p. 934-941.
- 43 887 117. Glass, T.A. and U. Bilal, *Are neighborhoods causal? Complications arising from the*  
44 888 *'stickiness' of ZNA*. Social Science & Medicine, 2016.
- 45 889 118. Ogden, C.L. and K.M. Flegal, *Changes in terminology for childhood overweight and obesity*.  
46 890 Age, 2010. **12**(12).
- 47 891 119. Kwan, M.-P., *The Limits of the Neighborhood Effect: Contextual Uncertainties in*  
48 892 *Geographic, Environmental Health, and Social Science Research*. Annals of the American  
49 893 Association of Geographers, 2018: p. 1-9.
- 50 894 120. Ohmer, M.L., et al., *Measures for Community and Neighborhood Research*. 2018: SAGE  
51 895 Publications.

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5 897 Figure 1 Flowchart of the article selection process  
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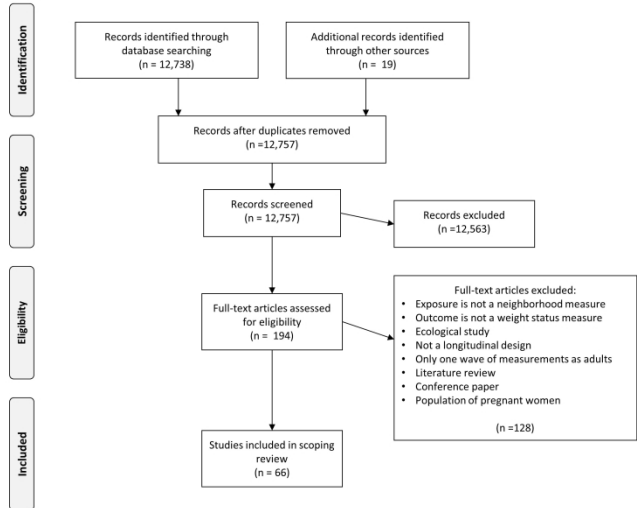
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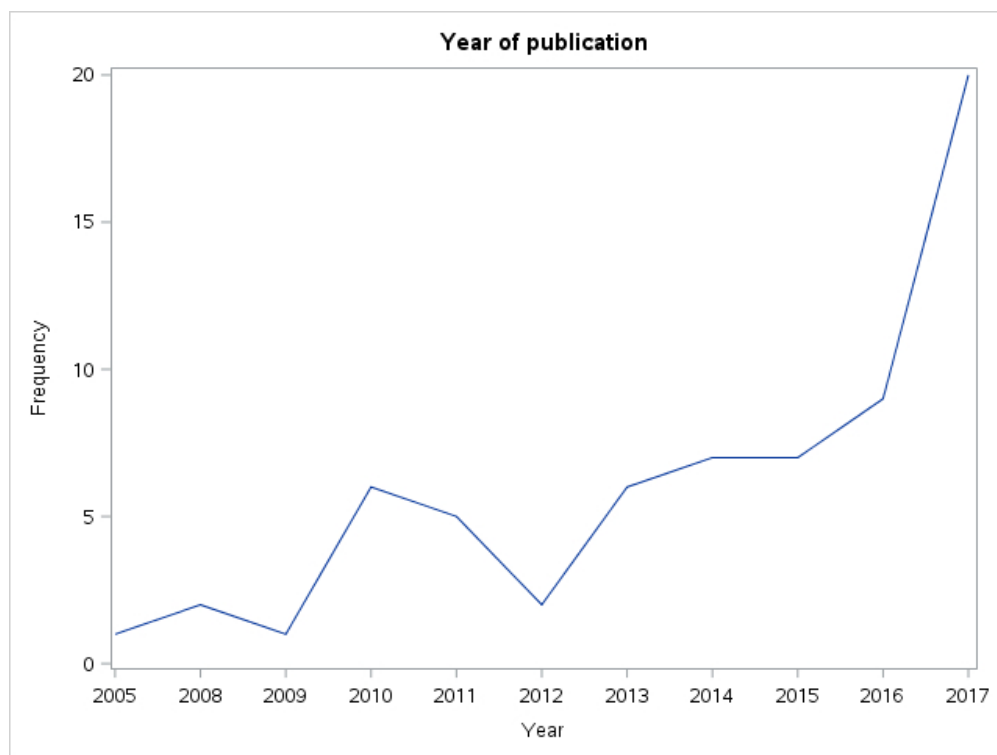


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Flowchart of the article selection process

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## SUPPLEMENTARY FILE 1 : SAMPLE SEARCH STRATEGY

Outcome terms AND longitudinal design terms AND (geographic context terms AND (social environment exposure terms OR physical environment exposure terms) )

<b>Terms</b>	<b>Type*</b>
<b>Outcome</b>	
1 Obesity	MeSH:noexp, TIAB
2 Obesity, Morbid	MeSH
3 Body Mass Index	MeSH, TIAB
4 BMI	TIAB
5 Overweight	MeSH:noexp, TIAB
6 Weight	TIAB
7 Adiposity	TIAB
<b>Longitudinal design</b>	
8 Cohort studies	MeSH
9 Prospective studies	MeSH
10 Cohort*	TIAB
11 Follow up	TIAB
12 Longitudinal	TIAB
13 Retrospective	TIAB
14 Life course	TIAB
15 Randomized	TIAB
16 Change	TIAB
17 Experimental	TIAB
18 History	TIAB
<b>Geographic context</b>	
19 Environment	MeSH:noexp
20 Residence characteristics	MeSH:noexp
21 Neighborhood*	TIAB
22 Neighbourhood*	TIAB
23 Catchment Area (Health)	MeSH
24 Residential	TIAB
25 Residence	TIAB
26 Context	TIAB
27 Composition	TIAB
28 Urban	TIAB
<b>Social environment exposure</b>	
29 Sociological Factors	MeSH:noexp, TIAB
30 Socioeconomic Factors	MeSH
31 Low-income	TIAB
32 Education	TIAB
33 Poverty	TIAB
34 Socioeconomic	TIAB
35 Income	TIAB
36 Social conditions	TIAB
<b>Physical environment exposure</b>	

37	Environment Design	MeSH
38	City Planning	MeSH, TIAB
39	Food service	MeSH
40	Urban planning	TIAB
41	Built Environment	TIAB
42	Physical environment	TIAB
43	Urban form	TIAB
44	Obesogenic environment	TIAB

\*“Type” refers to the tags complementing search terms in queries. “MeSH” (Medical Subject Heading) terms will be searched in the controlled vocabulary assigned by U.S National Library of medicine to index scientific articles in its database. “MeSH:noexp” terms have the same function as MeSH, except that the search will be limited to the exact term not including subordinate terms generally linked to MeSH terms. “TIAB” terms will be searched in the title and abstract of the citations.

## SUPPLEMENTARY FILE 2 : CHARACTERISTICS OF SELECTED STUDIES

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Statistical analysis	Result (summary)	Statistically significant associations by indicator type
Albrecht, 2015 [1]	United States	Migrants	Waist circumference	Euclidean Buffer	1	5	Both	No	Multilevel model	Null	Food environment 0/4 Walkability 0/2 Physical activity establishment 0/2
Arcaya, 2013 [2]	United States	Adults	BMI	Euclidean Buffer	3.8	3.8	Both	Yes	Multilevel model	Expected	Foreclosure 1/1
Auchincloss, 2012 [3]	United States	Older adults	BMI	Self-reported	1	4	Both	No	Proportional hazards regression	Expected	Food environment 1/1 Walkability 0/1
Auerbach, 2017 [4]	United States	African American women	BMI	Self-reported	1	2	Both	No	Poisson regression analysis	Expected	Physical activity establishment 1/1 Food environment 0/1 Security 1/1
Barrientos-Gutierrez, 2017 [5]	United States	Older adults	BMI	Euclidean Buffer	4	5	Both	Yes	Fixed effects model	Null	Food environment 0/2 Physical activity establishment 0/1 Walkability 0/1
Berry, 2010 [6]	Canada	Adults	BMI	Census limits	1	2	Both	No	Linear regression	Mixed	Composite index socioeconomic 1/1 Walkability 0/1
Berry, 2010 [7]	Canada	Adults	BMI	Administrative limits	1	2	Stayers	No	Ordinal regression	Null	Composite index socioeconomic 0/1 Walkability 0/1
Block, 2011 [8]	United States	Adults	BMI	Other	7	7	Both	Yes	Multilevel model	Null	Food environment 5/36
Blok, 2013 [9]	Netherlands	Adults	BMI	Administrative limits	1	2	Both	No	Multilevel model	Expected	Prevalence of health behavior 1/1
Boone-Heinonen, 2013 [10]	United States	Young adults	BMI	Euclidean Buffer	4	4	Both	Yes	Fixed effects model	Null	Food environment 1/3 Density 0/1 Deprivation 1/1 Physical activity establishment 0/2

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Statistical analysis	Result (summary)	Statistically significant associations by indicator type
Braun, 2016 [11]	United States	Older adults	Waist circumference	Other	2	2	Movers	No	Fixed effects model	Null	Walkability 0/1
Braun, 2016 [12]	United States	Young adults	BMI and waist ratio	Other	2	2	Movers	Yes	Multiple	Null	Walkability 0/1
Brown, 2015 [13]	United States	Adults	BMI	Euclidean Buffer	2	2	Stayers	Yes	Linear regression	Expected	Transportation infrastructure 1/1
Burdette, 2012 [14]	United States	Young adults	BMI	Other	1	3	Both	No	Structural equations	Null	Composite index socioeconomic 1/1 Perceived environment 0/2
Christine, 2017 [15]	United States	Adults	BMI	Euclidean Buffer	2	2	Both	Yes	Multiple	Null	Foreclosure 0/1
Colchero, 2008 [16]	Philippines	Women	BMI	Administrative limits	1	7	Both	No	Multilevel model	Expected	Other 1/1 Density 1/1
Coogan, 2010 [17]	United States	African american women	BMI	Administrative limits	6	6	Both	No	Multilevel model	Expected	Composite socioeconomic index 2/2
Coogan, 2011 [18]	United States	African american women	BMI	Network buffer	3	4	Both	No	Multilevel model	Expected	Composite index built environment 2/2
Cummins, 2014 [19]	United States	Adults	BMI	Administrative limits	2	2	Stayers	Yes	Difference in difference	Null	Food environment 0/1
Do, 2017 [20]	United States	Adults	BMI	Administrative limits	6	6	Both	Yes	Multiple	Null	Deprivation 4/32
Eid, 2008 [21]	United States	Young adults	BMI	Euclidean Buffer	4.1	4.1	Both	No	First difference	Null	Sprawl 0/2 Land use 0/2
Feng, 2015 [22]	Australia	Adults	BMI	Census limits	1	2.9	Stayers	No	Multilevel model	Expected	Composite index socioeconomic 1/1
Gebel, 2011 [23]	Australia	Adults	BMI	Other	1	2	Stayers	No	Linear regression	Expected	Perceived environment 1/1
Gibson, 2011 [24]	United States	Adults	BMI	Administrative limits	3.3	3.3	Both	Yes	Fixed effects model	Mixed	Food environment 4/10

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Statistical analysis	Result (summary)	Statistically significant associations by indicator type
Halonen, 2014 [25]	Finland	Profession	BMI	Other	2	2	Stratified	No	Multilevel model	Mixed	Blue and green area 3/8
Hirsch, 2014 [26]	United States	Older adults	BMI and waist ratio	Euclidean Buffer	5	5	Both	Yes	Fixed effects model	Null	Composite built environment 2/6
Jones, 2014 [27]	United States	Adults	BMI and waist ratio	Census limits	1	2	Both	No	Multilevel model	Mixed	Composite index socioeconomic 1/2
Joost, 2016 [28]	Switzerland	Adults	BMI	Census limits	2	2	Both	No	Spatial analysis	Expected	Deprivation 1/1
Kapinos, 2014 [29]	United States	Students	BMI	Other	1	2	Both	No	Linear regression	Mixed	Food environment ¼ Physical activity establishment 2/2
Kimbrow, 2017 [30]	United States	Adults	BMI	Census limits	2	2	Both	Yes	Multilevel model	Null	Deprivation 0/2 Food environment 0/6
Kwarteng, 2017 [31]	United States	Adults	Waist circumference	Census limits	1	2	Both	No	Multilevel model	Expected	Deprivation 1/1
Kwarteng, 2016 [32]	United States	Adults	Waist circumference	Census limits	1	2	Both	No	Multilevel model	Expected	Deprivation 1/1
Lamb, 2017 [33]	Australia	Women	BMI	Network buffer	2	3	Stayers	Yes	Multilevel model	Null	Food environment 0/1
Laraia, 2017[34]	United States	Diabetes	BMI	Census limits	5	17	Stratified	Yes	Fixed effects model	Mixed	Food environment 2/4
Lee, 2017 [35]	United States	Adults	Other	Census limits	1	2	Both	No	Linear and logistic regression	Expected	Transportation 1/1 Greenspace 1/1 Inverse Land use 0/1 Food environment 5/5
Leonard, 2017 [36]	United States	Adults	BMI	Euclidean Buffer	2	2	Stratified	Yes	Multilevel model	Expected	Composite index socioeconomic 3/3
Li, 2009 [37]	United States	Older adults	BMI and waist ratio	Census limits	1	2	Both	No	Multilevel model	Null	Food environment 0/1 Walkability 0/1
Lippert, 2017 [38]	United States	Young adults	BMI and waist ratio	Census limits	2	1	Both	Yes	Logistic regression	Null	Deprivation 3/12



Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Statistical analysis	Result (summary)	Statistically significant associations by indicator type
Ludwig, 2011 [39]	United States	Women	BMI	Census limits	2	1	Both	No	Logistic regression	Expected	Deprivation 1/1
Mendez, 2016 [40]	United States	Participants in weightloss program	Weight	Census limits	1	2	Both	No	Fixed effects model	Null	Food environment 0/2 Racial composition 1/1 Deprivation 0/4
Meyer, 2015 [41]	United States	Adults	BMI	Network buffer	4	4	Both	Yes	Multilevel model	Mixed	Composite index built environment 1/2
Mujahid, 2005 [42]	United States	Older adults	BMI	Census limits	1	4	Both	No	Multilevel model	Null	Composite index socioeconomic 0/4
Murray, 2010 [43]	United States	Older adults	BMI	Census limits	20	1	Both	Yes	Linear regression	Expected	Deprivation 1/1
Picavet, 2016 [44]	Netherlands	Adults	BMI	Euclidean Buffer	4	4	Both	Yes	Multiple	Inverse	Green space 4/30
Pitts, 2017 [45]	United States	Rural adults	Weight	Other	1	2	Both	No	Linear regression	Null	Food environment 1/10 Physical activity establishment 0/6 Walkability 0/1 Security 0/1 Perceived 0/1
Powell-Wiley, 2014 [46]	United States	Adults	Weight	Census limits	2	2	Stayers	No	Multilevel model	Mixed	Composite index socioeconomic 1/2
Powell-Wiley, 2015 [47]	United States	Adults	BMI	Census limits	2	2	Stratified	No	Multilevel model	Expected	Composite index socioeconomic 3/3
Powell-Wiley, 2017 [48]	United States	Older adults	BMI and waist ratio	Other	5	5	Both	Yes	Multiple	Null	Perceived environment 2/18 Security 0/18
Rachele, 2017 [49]	Australia	Older adults	BMI	Census limits	1	4	Stayers	No	Multilevel model	Null	Composite index socioeconomic 0/2
Richardson, 2015 [50]	United States	Adults	BMI	Other	3	3	Both	Yes	Structural equation	Mixed	Food environment 1/2
Richardson, 2017 [51]	United States	African american	BMI	Euclidean Buffer	1	1	Both	Yes	Structural equation	Expected	Perceived environment 1/1 Security 1/1
Ruel, 2010 [52]	United States	Women	BMI	Census limits	1	4	Both	No	Multilevel model	Mixed	Composite index socioeconomic 0/1 Racial composition 1/1 Inverse

Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Statistical analysis	Result (summary)	Statistically significant associations by indicator type
Rummo, 2017 [53]	United States	Adults	BMI	Network buffer	6	6	Both	Yes	Multiple	Null	Food environment 2/7
Sarkar, 2013 [54]	United Kingdom	Older adults	BMI	Network buffer	1	3	Both	No	Multilevel model	Mixed	Land use 2/6 Green space 0/1 Physical activity establishment 1/1 Transportation infrastructure 2/4 Other 1/1 Density 1/1
Sheehan, 2017 [55]	United States	Women	BMI	Census limits	2	1	Both	Yes	Logistic regression	Expected	Deprivation 1/1
Stafford, 2010 [56]	United Kingdom	Profession	BMI	Census limits	1	3	Stratified	No	Multilevel model	Null	Composite index socioeconomic 1/4
Stoddard, 2013 [57]	United States	Patients with diabetes	BMI	Census limits	1	2	Both	No	Linear and logistic regression	Expected	Composite index socioeconomic 3/3
Sugiyama, 2016 [58]	Australia	Adults	Waist circumference	Network buffer	1	2	Stayers	No	Multilevel model	Expected	Distance to landmark 2/2 Walkability 0/1
Sund, 2010 [59]	Norway	Adults	BMI	Census limits	1	2	Stayers	No	Multilevel model	Null	Deprivation 0/1
Wasfi, 2016 [60]	Canada	Adults	BMI	Administrative limits	7	7	Both	No	Multiple	Expected	Walkability 1/1
Xiao, 2017 [61]	United States	Older adults	BMI	Census limits	1	2	Both	No	Logistic regression	Expected	Composite index socioeconomic 4/4
Xu, 2013 [62]	China	Adults	BMI and waist ratio	Administrative limits	4	4	Both	Yes	Multilevel model	Null	Food environment 13/48
Zenk, 2017 [63]	United States	Adults	BMI	Euclidean Buffer	2	2	Stayers	Yes	Multilevel model	Null	Food environment 1/6
Zenk, 2017 [64]	United States	Veterans	BMI	Euclidean Buffer	6	6	Stratified	Yes	Fixed effects model	Mixed	Food environment 17/48

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Author, year of publication	Country	Target group	Outcome	Geographic unit	Number of contextual measures	Number of outcome measures	Residential mobility	Change in neighborhood characteristics	Statistical analysis	Result (summary)	Statistically significant associations by indicator type
Zhang, 2016 [65]	United States	Diabetes	BMI	Network buffer	1	2	Stayers	Yes	First difference	Null	Food environment 0/1
Zhao, 2014 [66]	United States	African-American and Hispanic women	BMI	Census limits	2	1	Both	No	Linear regression	Null	Food environment 0/20 Racial composition 0/2 Deprivation 4/8 Security 0/4 Density 0/2

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## REFERENCES

1. Albrecht, S.S., et al., *Change in waist circumference with longer time in the United States among Hispanic and Chinese immigrants: the modifying role of the neighborhood built environment*. *Ann Epidemiol*, 2015. **25**(10): p. 767-72.e2.
2. Arcaya, M., et al., *Effects of proximate foreclosed properties on individuals' weight gain in Massachusetts, 1987-2008*. *American journal of public health*, 2013. **103**(9): p. e50-56.
3. Auchincloss, A.H., et al., *Neighborhood Health-Promoting Resources and Obesity Risk (the Multi-Ethnic Study of Atherosclerosis)*. *Obesity*, 2012.
4. Auerbach, B.J., et al., *Factors associated with maintenance of body mass index in the Jackson Heart Study: A prospective cohort study secondary analysis*. *Preventive Medicine*, 2017. **100**: p. 95-100.
5. Barrientos-Gutierrez, T., et al., *Neighborhood Physical Environment and Changes in Body Mass Index: Results From the Multi-Ethnic Study of Atherosclerosis*. *Am J Epidemiol*, 2017. **186**(11): p. 1237-1245.
6. Berry, T.R., et al., *A longitudinal and cross-sectional examination of the relationship between reasons for choosing a neighbourhood, physical activity and body mass index*. *International Journal of Behavioral Nutrition and Physical Activity*, 2010. **7**.
7. Berry, T.R., et al., *Changes in BMI over 6 years: the role of demographic and neighborhood characteristics*. *International Journal of Obesity*, 2010. **34**(8): p. 1275-1283.
8. Block, J.P., et al., *Proximity to food establishments and body mass index in the Framingham Heart Study offspring cohort over 30 years*. *Am J Epidemiol*, 2011. **174**(10): p. 1108-14.
9. Blok, D.J., et al., *Changes in smoking, sports participation and overweight: Does neighborhood prevalence matter?* *Health & Place*, 2013. **23**: p. 33-38.
10. Boone-Heinonen, J., et al., *The Neighborhood Energy Balance Equation: Does Neighborhood Food Retail Environment plus Physical Activity Environment = Obesity? The CARDIA Study*. *Plos One*, 2013. **8**(12).
11. Braun, L.M., et al., *Walkability and cardiometabolic risk factors: Cross-sectional and longitudinal associations from the Multi-Ethnic Study of Atherosclerosis*. *Health & Place*, 2016. **39**: p. 9-17.
12. Braun, L.M., et al., *Changes in walking, body mass index, and cardiometabolic risk factors following residential relocation: Longitudinal results from the CARDIA study*. *J Transp Health*, 2016. **3**(4): p. 426-439.
13. Brown, B.B., et al., *Transit Use, Physical Activity, and Body Mass Index Changes: Objective Measures Associated With Complete Street Light-Rail Construction*. *American Journal of Public Health*, 2015. **105**(7): p. 1468-1474.
14. Burdette, A.M. and B.L. Needham, *Neighborhood environment and body mass index trajectories from adolescence to adulthood*. *J Adolesc Health*, 2012. **50**(1): p. 30-7.
15. Christine, P.J., et al., *Exposure to Neighborhood Foreclosures and Changes in Cardiometabolic Health: Results From MESA*. *American Journal of Epidemiology*, 2017. **185**(2): p. 106-114.
16. Colchero, M.A. and D. Bishai, *Effect of neighborhood exposures on changes in weight among women in Cebu, Philippines (1983-2002)*. *American Journal of Epidemiology*, 2008. **167**(5): p. 615-623.
17. Coogan, P.F., et al., *Neighborhood Socioeconomic Status in Relation to 10-Year Weight Gain in the Black Women's Health Study*. *Obesity*, 2010. **18**(10): p. 2064-2065.
18. Coogan, P.F., et al., *Longitudinal assessment of urban form and weight gain in African-American women*. *Am J Prev Med*, 2011. **40**(4): p. 411-8.
19. Cummins, S., E. Flint, and S.A. Matthews, *New Neighborhood Grocery Store Increased Awareness Of Food Access But Did Not Alter Dietary Habits Or Obesity*. *Health Affairs*, 2014. **33**(2): p. 283-291.
20. Do, D.P. and C. Zheng, *A marginal structural modeling strategy investigating short and long-term exposure to neighborhood poverty on BMI among US black and white adults*. *Health & Place*, 2017. **46**: p. 201-209.
21. Eid, J., et al., *Fat city: Questioning the relationship between urban sprawl and obesity*. *Journal of Urban Economics*, 2008. **63**(2): p. 385-404.
22. Feng, X.Q. and A. Wilson, *Getting Bigger, Quicker? Gendered Socioeconomic Trajectories in Body Mass Index across the Adult Lifecourse: A Longitudinal Study of 21,403 Australians*. *Plos One*, 2015. **10**(10).
23. Gebel, K., et al., *Mismatch between perceived and objectively assessed neighborhood walkability attributes: Prospective relationships with walking and weight gain*. *Health & Place*, 2011. **17**(2): p. 519-524.
24. Gibson, D.M., *The neighborhood food environment and adult weight status: estimates from longitudinal data*. *Am J Public Health*, 2011. **101**(1): p. 71-8.

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25. Halonen, J.I., et al., *Green and Blue Areas as Predictors of Overweight and Obesity in an 8-Year Follow-Up Study*. *Obesity*, 2014. **22**(8): p. 1910-1917.
  26. Hirsch, J.A., et al., *Built environment change and change in BMI and waist circumference: Multi-ethnic Study of Atherosclerosis*. *Obesity (Silver Spring)*, 2014. **22**(11): p. 2450-7.
  27. Jones, M. and J. Huh, *Toward a multidimensional understanding of residential neighborhood: a latent profile analysis of Los Angeles neighborhoods and longitudinal adult excess weight*. *Health Place*, 2014. **27**: p. 134-41.
  28. Joost, S., et al., *Persistent spatial clusters of high body mass index in a Swiss urban population as revealed by the 5-year GeoCoLaus longitudinal study*. *BMJ Open*, 2016. **6**(1): p. e010145.
  29. Kapinos, K.A., O. Yakusheva, and D. Eisenberg, *Obesogenic environmental influences on young adults: Evidence from college dormitory assignments*. *Economics & Human Biology*, 2014. **12**: p. 98-109.
  30. Kimbro, R.T., G. Sharp, and J.T. Denney, *Home and away: Area socioeconomic disadvantage and obesity risk*. *Health Place*, 2017. **44**: p. 94-102.
  31. Kwarteng, J.L., et al., *Independent Effects of Neighborhood Poverty and Psychosocial Stress on Obesity Over Time*. *Journal of Urban Health*, 2017. **94**(6): p. 791-802.
  32. Kwarteng, J.L., et al., *NEIGHBOURHOOD POVERTY, PERCEIVED DISCRIMINATION AND CENTRAL ADIPOSITY IN THE USA: INDEPENDENT ASSOCIATIONS IN A REPEATED MEASURES ANALYSIS*. *J Biosoc Sci*, 2016. **48**(6): p. 709-22.
  33. Lamb, K.E., et al., *Associations between major chain fast-food outlet availability and change in body mass index: a longitudinal observational study of women from Victoria, Australia*. *Bmj Open*, 2017. **7**(10).
  34. Laraia, B.A., et al., *Food Environment and Weight Change: Does Residential Mobility Matter?: The Diabetes Study of Northern California (DISTANCE)*. *Am J Epidemiol*, 2017. **185**(9): p. 743-750.
  35. Lee, J.J., et al., *Association of built environment characteristics with adiposity and glycaemic measures*. *Obesity Science & Practice*, 2017. **3**(3): p. 333-341.
  36. Leonard, T., et al., *Do neighborhoods matter differently for movers and non-movers? Analysis of weight gain in the longitudinal dallas heart study*. *Health & Place*, 2017. **44**: p. 52-60.
  37. Li, F., et al., *Built Environment and 1-Year Change in Weight and Waist Circumference in Middle-Aged and Older Adults*. *American Journal of Epidemiology*, 2009. **169**(4): p. 401-408.
  38. Lippert, A.M., et al., *Associations of Continuity and Change in Early Neighborhood Poverty With Adult Cardiometabolic Biomarkers in the United States: Results From the National Longitudinal Study of Adolescent to Adult Health, 1995-2008*. *Am J Epidemiol*, 2017: p. 1-12.
  39. Ludwig, J., et al., *Neighborhoods, obesity, and diabetes--a randomized social experiment*. *N Engl J Med*, 2011. **365**(16): p. 1509-19.
  40. Mendez, D.D., et al., *Neighborhood factors and six-month weight change among overweight individuals in a weight loss intervention*. *Prev Med Rep*, 2016. **4**: p. 569-573.
  41. Meyer, K.A., et al., *Combined measure of neighborhood food and physical activity environments and weight-related outcomes: The CARDIA study*. *Health & Place*, 2015. **33**: p. 9-18.
  42. Mujahid, M.S., et al., *Cross-sectional and longitudinal associations of BMI with socioeconomic characteristics*. *Obesity Research*, 2005. **13**(8): p. 1412-1421.
  43. Murray, E.T., et al., *Trajectories of neighborhood poverty and associations with subclinical atherosclerosis and associated risk factors: the multi-ethnic study of atherosclerosis*. *American journal of epidemiology*, 2010. **171**(10): p. 1099-1108.
  44. Picavet, H.S., et al., *Greener living environment healthier people?: Exploring green space, physical activity and health in the Doetinchem Cohort Study*. *Prev Med*, 2016. **89**: p. 7-14.
  45. Pitts, S.B.J., et al., *Examining the Association between Intervention-Related Changes in Diet, Physical Activity, and Weight as Moderated by the Food and Physical Activity Environments among Rural, Southern Adults*. *Journal of the Academy of Nutrition and Dietetics*, 2017. **117**(10): p. 1618-1627.
  46. Powell-Wiley, T.M., et al., *Neighborhood-level socioeconomic deprivation predicts weight gain in a multi-ethnic population: longitudinal data from the Dallas Heart Study*. *Prev Med*, 2014. **66**: p. 22-7.
  47. Powell-Wiley, T.M., et al., *Change in Neighborhood Socioeconomic Status and Weight Gain Dallas Heart Study*. *American Journal of Preventive Medicine*, 2015. **49**(1): p. 72-79.
  48. Powell-Wiley, T.M., et al., *Associations of Neighborhood Crime and Safety and With Changes in Body Mass Index and Waist Circumference The Multi-Ethnic Study of Atherosclerosis*. *American Journal of Epidemiology*, 2017. **186**(3): p. 280-288.

- 1  
2  
3 49. Rachele, J.N., et al., *Neighborhood socioeconomic disadvantage and body mass index among residentially stable mid-older aged adults: Findings from the HABITAT multilevel longitudinal study*. *Prev Med*, 2017. **105**: p. 271-274.
- 6 50. Richardson, A.S., et al., *Multiple pathways from the neighborhood food environment to increased body mass index through dietary behaviors: A structural equation-based analysis in the CARDIA study*. *Health & Place*, 2015. **36**: p. 74-87.
- 9 51. Richardson, A.S., et al., *Pathways through which higher neighborhood crime is longitudinally associated with greater body mass index*. *International Journal of Behavioral Nutrition and Physical Activity*, 2017. **14**.
- 12 52. Ruel, E., et al., *Neighborhood effects on BMI trends: examining BMI trajectories for Black and White women*. *Health Place*, 2010. **16**(2): p. 191-8.
- 15 53. Rummo, P.E., et al., *Does unmeasured confounding influence associations between the retail food environment and body mass index over time? The Coronary Artery Risk Development in Young Adults (CARDIA) study*. *International Journal of Epidemiology*, 2017. **46**(5): p. 1456-1464.
- 18 54. Sarkar, C., J. Gallacher, and C. Webster, *Built environment configuration and change in body mass index: the Caerphilly Prospective Study (CaPS)*. *Health Place*, 2013. **19**: p. 33-44.
- 21 55. Sheehan, C.M., et al., *Long-term neighborhood poverty trajectories and obesity in a sample of california mothers*. *Health Place*, 2017. **46**: p. 49-57.
- 24 56. Stafford, M., et al., *Deprivation and the Development of Obesity A Multilevel, Longitudinal Study in England*. *American Journal of Preventive Medicine*, 2010. **39**(2): p. 130-139.
- 27 57. Stoddard, P.J., et al., *Neighborhood Deprivation and Change in BMI Among Adults With Type 2 Diabetes*. *Diabetes Care*, 2013. **36**(5): p. 1200-1208.
- 30 58. Sugiyama, T., et al., *Residential proximity to urban centres, local-area walkability and change in waist circumference among Australian adults*. *Prev Med*, 2016. **93**: p. 39-45.
- 33 59. Sund, E.R., A. Jones, and K. Midthjell, *Individual, family, and area predictors of BMI and BMI change in an adult Norwegian population: Findings from the HUNT study*. *Social Science and Medicine*, 2010. **70**(8): p. 1194-1202.
- 36 60. Wasfi, R.A., et al., *Neighborhood Walkability and Body Mass Index Trajectories: Longitudinal Study of Canadians*. *Am J Public Health*, 2016. **106**(5): p. 934-40.
- 39 61. Xiao, Q., et al., *Neighborhood Socioeconomic Deprivation and Weight Change in a Large US Cohort*. *American Journal of Preventive Medicine*, 2017. **52**(6): p. E173-E181.
- 42 62. Xu, H., S.E. Short, and T. Liu, *Dynamic relations between fast-food restaurant and body weight status: a longitudinal and multilevel analysis of Chinese adults*. *J Epidemiol Community Health*, 2013. **67**(3): p. 271-9.
- 45 63. Zenk, S.N., et al., *Longitudinal Associations Between Observed and Perceived Neighborhood Food Availability and Body Mass Index in a Multiethnic Urban Sample*. *Health Educ Behav*, 2017. **44**(1): p. 41-51.
- 48 64. Zenk, S.N., et al., *Geographic Accessibility Of Food Outlets Not Associated With Body Mass Index Change Among Veterans, 2009-14*. *Health Affairs*, 2017. **36**(8): p. 1433-1442.
- 51 65. Zhang, Y.T., et al., *Is a reduction in distance to nearest supermarket associated with BMI change among type 2 diabetes patients?* *Health & Place*, 2016. **40**: p. 15-20.
- 54 66. Zhao, Z.X., R. Kaestner, and X. Xu, *Spatial mobility and environmental effects on obesity*. *Economics & Human Biology*, 2014. **14**: p. 128-140.
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## Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
<b>TITLE</b>			
Title	1	Identify the report as a scoping review.	Page 1
<b>ABSTRACT</b>			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Page 2
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Pages 4-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 5
<b>METHODS</b>			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Page 6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 7
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Supplementary file 1
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Page 7
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 7-8
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 7
Critical appraisal of individual	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe	Page 20



SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
sources of evidence§		the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 7
<b>RESULTS</b>			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 8
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Supplementary file 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Not done
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Supplementary file 2
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Pages 9-16
<b>DISCUSSION</b>			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Pages 16-19
Limitations	20	Discuss the limitations of the scoping review process.	Page 19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 21
<b>FUNDING</b>			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 22

JB1 = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

\* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* ;169:467–473. doi: 10.7326/M18-0850



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