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Associations between the Built Environment and Dietary Intake, Physical Activity, and Obesity: A Scoping Review of Reviews

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Abstract

There exists a large body of literature examining the association between built environment factors and dietary intake, physical activity, and weight status; however, synthesis of this literature has been limited. To address this gap, we conducted a scoping review of reviews and identified 74 reviews and meta-analyses that investigated the association between built environment factors and dietary intake, physical activity, and/or weight status. Results across reviews were mixed, with heterogeneous effects demonstrated in terms of strength and statistical significance; however, preliminary support was identified for several built environment factors. For example, quality of dietary intake appeared to be associated with the availability of grocery stores; higher levels of physical activity appeared to be most consistently associated with greater walkability, and lower weight status was associated with greater diversity in land-use mix. Overall, reviews reported substantial concern regarding methodological limitations and poor quality of existing studies. Future research should focus on improving study quality (e.g., using longitudinal methods, including natural experiments, and newer mobile sensing technologies) and consensus should be drawn regarding how to define and measure both built environment factors and weight-related outcomes.

Keywords

built environment; obesity; diet; physical activity; scoping review

Introduction

Obesity is a global public health problem.[1] While high-income countries were the first to be impacted by higher prevalence rates of obesity,[2] prevalence rates have been increasing across middle- and low-income countries.[3,4] Researchers have estimated that, if secular trends continue, 38% of the world's adult population will be overweight and 20% will be obese by 2030.[5] In terms of broader public health impact, this high global prevalence

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of obesity has increased rates of obesity-related chronic conditions such as heart disease, stroke, diabetes, certain cancers, and hypertension.[6]

The global health burden obesity and obesity-related chronic conditions among adults has highlighted the importance of identifying factors that may influence obesity. A large amount of research has focused on the contribution of individual behaviors (e.g., eating and activity habits) to weight gain[7–9]; however, the emergence of ecological approaches in public health has broadened this focus to include factors across multiple levels of influence.[10,11] Many researchers have argued that environmental factors may be particularly pertinent to consider, given that availability and access to resources may facilitate or hinder individual health behaviors and attempts at health behavior change.[12–14] Indeed, some have argued that obesity represents a normal response to life's "obesogenic" environments, wherein cheap, palatable, and energy-dense foods are commonplace, and daily need for energy expenditure is limited.[15] Given the population-wide scope of the obesity epidemic, researchers have theorized that interventions focused on environmental changes hold potential to provide more extensive and far-reaching impacts than interventions focused solely on the behavior change of individuals.[14]

Built environment factors, which describe the changeable, man-made aspects of the environment,[16] may be particularly important to consider. Built environment factors can include urban design (including availability of resources and aesthetics/appeal of public spaces), land use (density and location of commercial, industrial, residential, and office spaces), and transportation systems (including physical infrastructure of bike paths, bridges, railroad tracks, roads, and sidewalks).[17] Built environment factors have the potential to support or constrain eating and activity behaviors; for example the availability of food options such as grocery stores or farmers markets versus fast-food restaurants may potentially influence eating habits and the availability of parks and recreational facilities may influence whether individuals regularly engage in physical activity.[18–20]

There exists a large body of research evidence examining the association between built environment and both obesity and weight-related behaviors (e.g., dietary intake and physical activity of individuals). In 2012, Ding and Gebel[21] conducted a review of review studies investigating associations between the built environment, physical activity, and obesity, and in 2019 Travert and colleagues[22] conducted a review of review studies investigating associations between the built environment, dietary intake, and physical activity. To date, however, there has not been a comprehensive review of reviews examining how built environment features are associated with all of these outcomes (dietary intake, physical activity, and obesity) combined.

To address this gap, and to provide a comprehensive "state of the science" across these broad areas, we proposed to conduct a scoping review of reviews that would synthesize the vast amount of existing research related to the built environment, dietary intake, physical activity, and obesity. Unlike traditional systematic reviews, which attempt to answer a well-defined research question, scoping reviews seek to use systematic search methods to identify and map a wide range of literature broadly, identifying research gaps and opportunities to apply innovative approaches.[23] In the current scoping review, we aimed to synthesize the current research literature, evaluate the quality of reviews by examining key methodological issues, and establish an agenda for future research by identifying gaps/potential focus areas for intervention development.

Methods

The current review identified and summarized the characteristics, range of methodologies, and key findings of existing systematic reviews and meta-analyses discussing the association between built environment factors and physical activity, dietary behaviors, and obesity. Methodologically, the current review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)[24] model and the Arksey and O'Malley[23] 5-stage framework for conducting scoping studies. We conducted a search for reviews using five academic research databases: PubMed, Web of Science, EBSCOhost, ProQuest, and Google Scholar. A wide range and combination of search terms were used to identify relevant articles, including Medical Subject Headings (MeSH) terms "obesity," "exercise," "physical activity," "weight," "environment," "nutrition," "eating," "eating behaviors," "diet," and "food," and the following key words: "scoping review," "scoping study," "systematic review," "meta-analysis," "recreational facility," "rural," "urban," "built environment," "environmental correlates," "parks," "hiking trails," "walking trails," "bike path," "recreation," "activity center," "green space," "open space," "dietary behaviors," "food environment," "retail food environment," "obese," "physical environment," "weight status," "food environment," and "physical activity environment" (for full list of search term combinations, see Table S1 in the online supplemental information available on the journal website). No restrictions were made in searches related to article publication date. The initial literature search was conducted from April to May 2018, with a follow-up search conducted in September 2020 in response to peer-review.

Inclusion/Exclusion Criteria and Study Selection

To be included in the scoping review, articles had to be 1) either a systematic review, scoping review, or meta-analysis, 2) focused on examining the association of built environment factors on dietary intake, physical activity, and/or obesity, and 3) published in English in an academic, peer-reviewed journal. Articles were excluded if they 1) focused on health outcomes/chronic conditions that were not obesity, 2) did not include results related to built environment features, or 3) were reviews of other reviews. There were no restrictions on dates of relevant articles that could be included in the scoping review. BD and UU screened the titles and abstracts of reviews identified through the academic research database search. Reviews that appeared to meet eligibility criteria during this phase were selected for full-text review. Full-text review was conducted independently by BD, UU, and AB, with data extracted using a data charting form created by BD; each review was read by at least two authors, and disagreements between reviewers were resolved through consensus discussion and review by KMR. During the full-text review, reference lists were scanned in order to identify additional reviews not identified through the initial searches.

For each review, the following factors were extracted:

1. age of the priority population and other demographic characteristics (including the countries from which individual studies collected data),
2. total number of papers included,
3. whether study quality was assessed,
4. outcomes related to dietary intake, physical activity, or weight status.

This information was used to summarize trends in methods and focus of included reviews, and to summarize associations between built environment features and dietary intake, physical activity, and weight status. Finally, following the format of a previous review by Ding and Gebel,[21] we categorized the primary methodological issues highlighted in each review and further catalogued recommendations made by review authors.

Definition of Constructs

Throughout this review, we describe the "food environment" as built environment features that are related to dietary intake (e.g., access or availability of grocery stores and fast-food restaurants) and the "activity environment" as features that are related to physical activity (e.g., parks or recreational facilities). Moreover, results of reviews investigating "access to" and "availability of" (e.g., using proximity/distance to or density of) certain built environment features are combined; thus, these terms are used interchangeably and refer to overall presence of a built environment feature. The term "dietary intake" refers to multiple outcomes, including fruit and vegetable intake, macronutrient intake, and total caloric intake. Similarly, the term "physical activity" also refers to multiple outcomes, ranging from walking to active play or active commuting to structured moderate/vigorous physical activity. Finally, countries of origin for included studies were classified by income (low-income, lower-middle income, upper-middle income, or high-income) using 2020 World Bank income categories.[25]

Results/Major Findings

Summary of Included Studies

A total of 1,098 articles were identified through database searches (see Figure 1). After the removal of duplicates, 780 articles were screened (through review of study title and abstract) to determine eligibility and inclusion into the scoping review. A total of 99 articles were identified and selected for full-text review; 74 met all inclusion/exclusion criteria and were retained for the current scoping review. Of these, systematic reviews were the most common (n=64); remaining review types included meta-analyses (n=3), combined systematic reviews and meta-analyses (n=5), and systematic scoping reviews (n=2).

Over half of the included reviews (n=46, or 62.2%) included studies examining the association between the built environment and physical activity, whereas remaining reviews focused on the associations between the built environment and weight status (n=34, or 45.9%) and dietary intake (n=14, or 18.9%); some reviews included more than one outcome and thus were counted under multiple categories. Most reviews primarily included studies using cross-sectional study designs; however 7 reviews focused on natural experiments (i.e., examining the impact of changes in the built environment, such as the opening of a new grocery store or installation of a new walking trail, on weight or weight-related behaviors).[26–32]

Included reviews were published between 2002 and 2020. While most of the included reviews (n=61) were conducted after 2009, when PRISMA review guidelines were established,[33] 13 were conducted before this time. Of the 74 included reviews, 52 (70.3%) included only papers describing data collected in high-income countries, 12 (16.2%) included studies from a mix of high-income and upper-middle income countries, 3 (4.1%) included studies from only upper-middle income countries, 2 (2.7%) included studies from a mix of high- to lower-middle income countries, and one (1.4%) specifically focused on studies from low- and upper-middle income countries; the final 4 reviews (5.4%) did not describe country of origin of included studies. A summary of included reviews, including review type, number of studies included in the review, the countries where included studies were conducted, priority population of the review, purpose of the review, built environment factors targeted, key outcome measures, and the key findings are available in Table S2 (see online supporting information on the journal website).

Associations between the Built Environment and Dietary Intake, Physical Activity, and Weight Status

Built Environment and Dietary Intake.

Fourteen reviews[26,27,32,34–44] examined the association of the built environment (e.g., location/presence of food stores and fast-food restaurants) on dietary intake. Across reviews, outcomes focused primarily on fruit and vegetable intake and whether individuals met nutritional guidelines (e.g., recommendations for daily fruit and vegetable or fat consumption). A review of the qualitative literature noted that lack of accessibility to grocery stores and supermarkets (due to distance or transportation limitations) and limited availability of healthy food options in local stores were key built environment barriers to purchasing and consuming healthier foods[40]; however, results from quantitative reviews were mixed. Five reviews[27,34,36,37,43] reported support for associations between greater access to supermarkets and higher diet quality (e.g., higher intake of fruits and vegetables, lower intake of saturated fats, or higher overall diet quality index scores) while five others (including two reviews focused on natural experiments)[26,27,38,39,41] reported primarily null results. Three reviews[35,37,41] reported significant associations between access to fast food restaurants and lower diet quality, while five others[38,39,42–44] reported primarily null results. In a review of natural experiments, Woodruff and colleagues[32] reported that the opening of a new food retailer (e.g., a supermarket, farmers market, or produce stand) tended to produce some short-term increases in fruit and vegetable consumption in adults who choose to shop at these establishments; however, there was little evidence supporting the longer-term persistence of these effects or of broader community impacts on fruit and vegetable consumption.

Built Environment and Physical Activity.

Three meta-analyses,[45–47] 38 systematic reviews,[27–31,34,36,37,48–77] and five combined systematic reviews and meta-analyses[78–82] investigated associations between built environment factors and physical activity. Figure 2 summarizes the associations between built environment factors and physical activity across all included reviews (i.e., whether the studies included in reviews were primarily/leaning toward support of a significant association, truly mixed, or primarily/leaning null). Across all included reviews, the most consistent association observed (supported by 83.3% of reviews that included the construct) was a positive association between physical activity and the index score of "walkability," followed by positive associations with access to recreational facilities (supported by 69.6% of reviews), nearby shops and services (supported by 66.7% of reviews), and parks/trails (supported by 62.5% of reviews). The least consistent support across reviews was found for street connectivity (supported by only 31.6% of reviews), residential density (supported by 30% of reviews), and safety (supported by 26.3% of reviews; as a note, only results from reviews investigating safety in relation to built environment features were included in this figure; results from reviews assessing safety in relation to crime or other social environment features were excluded).

All eight of the studies including meta-analyses reported small-to-moderate but significant associations between built environment factors and physical activity.[45–47,78–82] Hajna and colleagues[78] reported that adults residing in highly walkable neighborhoods accumulated 766 more steps per day (equivalent to about a third of a mile walked) than those in less walkable neighborhoods. Similarly, Ewing and Cervero[46] reported that walking for transportation was most strongly associated with street density and distance to nearby shops and services. Duncan and colleagues[45] found that, after adjusting for common demographic covariates such as income and education, adults were more likely to be physically active if they reported presence of physical activity facilities, sidewalks, and shops/services within their neighborhood, or that heavy traffic was not a problem (odds ratios ranging from 1.20 to 1.30). Yang and colleagues[47] did not find consistent evidence that any built environment feature was associated with higher rates of recreational cycling, but found that a one percent increase in street connectivity or the availability of cycling facilities and paths were associated with 39% and 28% higher rates of cycling for commuting purposes, respectively.

McGrath, Hopkins, and Hinckson[79] conducted the only meta-analysis investigating the association between built environment and physical activity in youth. Results from this study demonstrated that associations between built environment features designed to promote walking and/or play and physical activity varied by age, such that there were only small and non-significant associations between built environment and physical activity for 9-year-olds, larger (but still non-significant) associations observed for 12-year-olds, and significant positive associations of moderate magnitude observed in 15-year-olds.

Three meta-analyses focused on associations between the built environment and physical activity in older adults.[80–82] All three demonstrated significant positive associations between total walking and walkability, availability of nearby shops and services, and access to nearby transit.[80–82] Mixed results were found for aesthetics and for availability of or access to parks and recreational facilities: one meta-analysis found no association between aesthetics and total walking,[81] another found an association between aesthetics and walking but not between aesthetics and leisure-time physical activity,[82] and the third found significant positive associations between aesthetics and both walking and total physical activity.[80] Two of the three meta-analyses[80,81] supported significant positive associations between parks and either walking or total physical activity, while the third found no significant association.[82] Finally, the two meta-analyses that specifically investigated access to recreational facilities found that access to these facilities was significantly positively associated with total physical activity but not walking.[80,82]

Built Environment and Weight Status.

A total of 34 reviews[16,26,27,34–39,42,44,51,54,65–68,83–99] focused on the association between the built environment and obesity or weight status. Thirteen of these reviews focused on the associations between food environment features (e.g., access to grocery stores and restaurants) and weight status,[26,35,38,39,42,44,88–92,98,99] ten focused on the association between activity environment features (e.g., access to recreational facilities and sidewalks) and weight status,[36,51,54,65–68,86,87,95] and eleven attempted to combine these literatures to investigate the combined influence of food and activity environment factors on weight status.[16,27,34,37,83–85,93,94,96,97]

Figure 3 summarizes the associations between built environment factors and weight status across all included reviews (i.e., whether the studies included in reviews were primarily/leaning toward support of a significant association, were truly mixed, or primarily/mostly null effects). Across all included reviews, the most consistent association observed was between greater diversity in land-use mix and lower weight status (supported by 80% of the reviews that included this feature). Over half of included reviews also found support for associations between lower weight status and more pleasant aesthetics (supported by 75% of reviews), greater healthfulness of the overall food environment (combining the impact of multiple food environment features, supported by 66.7% of reviews), and greater or access to parks and playgrounds (supported by 54.5% of reviews). In contrast, the least consistent support across reviews was found for access to supermarkets (supported by only 41.7% of reviews), population density (supported by 37.5% of reviews), and access to full-service restaurants (supported by 33.3% of reviews).

Methodological Challenges

Key methodological challenges observed across the 74 included reviews are summarized in Table 1. Across reviews, the most common limitation (present in 82.4% of included reviews) was that most or all studies included were cross-sectional in design. Moreover, a majority of reviews included few studies conducted outside of the U.S. (63.5% of included reviews), and most of the reviews that did include studies conducted outside of the U.S. did not include enough of these studies to allow for cross-country comparisons. One notable exception was a review by Chennakesavalu and Gangemi[88] that investigated variations in associations between fast food environment and obesity rates in studies conducted in the U.S. compared to studies conducted outside of the U.S. This review concluded that results across countries could be summarized as mixed at best; however, a greater proportion of studies conducted in the U.S. demonstrated significant associations in the expected direction between fast-food restaurants and weight status (59% of studies conducted in the U.S. versus 40% of those conducted in other countries). A review by Elshahat and colleagues[74] focused on associations between built environment features and physical activity in adults residing in low- and middle-income countries. The authors noted that the primary difference between their results and results from other reviews of studies conducted in high-income countries was the lack of a significant association between nearby transit options and physical activity (which, the authors noted, may be due to the wide availability of alternative transportation options such as private minibuses, taxis, and rickshaws in low- and middle-income countries). Finally, a review by Lee and colleagues[55] investigated associations between built environment features and physical activity in adolescents living in East Asian countries. The authors of this review reported similar patterns to results found in other U.S.-centric reviews; however, they noted that few studies conducted in East Asian countries assessed safety. In contrast, several other reviews included in the current study reported significant positive associations between safety and physical activity in children.[51,60,76]

Over half of included reviews (62.2%) did not include any quality assessment of included studies. Of the 28 reviews that included quality assessments, 20 (71.4%) used existing tools to assess the quality of studies while 8 reviews (28.6%) used tools developed or significantly modified by the authors of the review. Of the reviews conducting quality assessments, 10 (35.7%) rated all or most of the included studies as low quality (e.g., for use of study designs that could not support causal inference, such as cross-sectional designs, failure to use validated/reliable measures of built environment and/or outcome variables, inadequate control of confounding variables or clustering effects, and/or sampling procedures that led to high risk of selection bias). Of the 20 studies using an existing/validated quality assessment tool, 9 (45.0%) rated all or most studies as "low quality," while only one out of the 8 studies that reported use of an author-developed tool (12.5%) rated all or most studies as "low quality."

Other limitations identified within reviews included an inability to compare results across studies due to variability in the type of built environment measures used (44.6% of included reviews) or in the definitions of "place" and buffer sizes used (17.6% of included reviews), and inclusion of multiple studies using the same sample (9.5% of included reviews).

Recommendations for Future Reviews

Table 2 presents recommendations for future reviews. The top recommendation (described in 74.3% of included reviews) was that future studies should utilize stronger study designs (e.g., natural experiments and other longitudinal designs that improve causal inference over cross-sectional methods). Next, reviews suggested that future studies should use valid and reliable measures for assessing built environment and study outcomes (recommended by 37.8% of reviews), to examine mediators and moderators of associations between built environment and diet, physical activity, and weight status (recommended by 36.5% of reviews). Additional suggestions were that multilevel models should be used to adequately capture interactions between built environment factors (recommended by 23.0% of reviews), that more studies should be conducted outside of the United States (recommended by 18.9% of reviews), that both perceived and objective measures should be used when assessing built environment (recommended by 17.6% of reviews), and that "place" and "buffer size" (the spatial definition of a person's built environment) should be more clearly defined and standardized across the literature (recommended by 16.2% and 14.9% of reviews, respectively).

Discussion

The current scoping review of reviews synthesized key findings of 74 systematic reviews and meta-analyses examining the associations between the built environment and dietary intake, physical activity, and weight status. Most reviews focused on associations between the built environment and either physical activity or weight status; fewer focused on associations between the built environment and dietary intake. Within reviews focused on dietary intake, most studies focused primarily on whether individuals met dietary recommendations such as those for fruit and vegetable intake; few included broader measurements such as overall dietary quality or total caloric intake, a surprising gap given the key role that these constructs play in weight regulation.[100] Similarly, the majority of studies that investigated associations between built environment features and weight status focused on only environmental features related to either physical activity or dietary intake; few studies investigated combined associations between both food and activity environments on body weight.

Associations between the Built Environment and Dietary Intake, Physical Activity, and Weight Status

Taken together, a mixed pattern of results was demonstrated in reviews assessing the association between built environment features and dietary intake, physical activity, and weight status. Stronger support was identified for some built environment factors compared to others. Dietary intake appeared to be most consistently influenced by availability of grocery stores and supermarkets. Higher levels of physical activity appeared to be most consistently associated with greater overall walkability, with support additionally found for positive associations between physical activity and access to recreational facilities, availability of nearby shops and services (or other non-residential destinations), and access to parks and trails. Finally, lower weight status was most consistently associated with greater diversity in land-use mix (and less sprawl), with support also found for associations between lower weight status and more pleasant aesthetics, a higher-quality overall food environment, and greater availability of parks and playgrounds.

Despite the emergence of support for the association between several built environment features and either weight or weight-related behaviors, there was substantial heterogeneity of results across reviews (and, in many cases, in results across studies included within reviews). Indeed, many reviews noted substantial limitations in drawing conclusions due to the variability in measures used to assess built environment and weight-related outcomes across studies. Furthermore, methodological quality of studies included in reviews varied, with many studies conducting correlational analyses with cross-sectional data; few studies included longitudinal follow-up, and even fewer used quasi-experimental designs such as natural experiments. While these issues of study design were noted across a majority of reviews, only a third of reviews included quality assessments. These patterns suggest several important recommendations for future research.

Recommendations for Future Research

Recommendation 1: Prioritize study designs that support causal inference.

—Over 80% of reviews primarily included studies that used cross-sectional designs. A fundamental weakness of cross-sectional methods is that these data can only be used to establish correlations between constructs; data derived from these studies cannot support causal inference. Thus, evidence from these studies cannot establish whether built environmental factors drive behavior or, conversely, if behavior leads to individuals self-selecting into communities with certain sets of built environment features (often described as "self-selection" or "selective mobility" bias).[21,101,102]

While true experiments such as randomized clinical trials may often be infeasible, other options can help strengthen causal inference in this literature. First, longitudinal designs are necessary to establish temporal precedence between exposure to built environment factors and health behaviors. For these studies, the length of observational periods should be considered carefully, given that different built environment factors may have effects on behavior that occur at different durations or latency.[83] A subset of longitudinal designs that offer more strength in causal inference include quasi-experimental designs such as natural experiments. In these designs, researchers study changes in behavior before and after changes in built environment factors (e.g., changes in health behaviors due to transportation policy changes, opening of a new grocery store, creation of a bike lane, or the opening of a new park), ideally with the use of a matched control group. Five of the reviews included in the current scoping review focused on results of natural experiments[26–30]; however, substantial heterogeneity in methodological approaches (including wide variability in outcome measures used) prevented the authors of these reviews from drawing definitive conclusions.

Causal inference may also be limited by "selective *daily* mobility bias," or confounding of the association between built environment features and eating and activity habits by other, often unmeasured, variables.[103,104] As an example, a person with high self-efficacy for physical activity may both be more likely to visit a park and more likely to engage in physical activity; a study that does not measure self-efficacy may erroneously identify a larger association between park visitation and physical activity engagement than exists. A 2013 article by Chaix and colleagues[104] provides examples of how this bias can impact studies using Global Positioning System (GPS) methods to assess exposures to built environment features, and further provides methodological recommendations for mitigating this bias.

Recommendation 2: Develop and use valid and reliable measures for assessing built environment, dietary intake, physical activity, and weight status.

Measures of Built Environment.: Across reviews, built environment factors were assessed using both objective (e.g., geographic information systems [GIS] mapping, public records, and direct investigator measurement) and subjective (e.g., participant self-report on surveys) methods. When subjective measures were used, review authors noted that questionnaires were often created anew for each study, without assessment of questionnaire validity or reliability, with items ranging from open-ended questions that asked individuals about their neighborhood environment to checklists asking individuals to select features that did or did not exist in their neighborhood.

When possible, future studies should use existing, validated tools. In areas where no validated tools exist, research should focus on developing and evaluating these tools *prior* to their use in larger cross-sectional or longitudinal studies. To assist with standardization of measures, the Division of Nutrition, Physical Activity, and Obesity at the Centers for Disease Control released a Built Environment Assessment Tool,[105] the National Institutes of Health ADOPT Core Measures Working Group identified a list of core measures to assess built environment features related to weight and weight-related behaviors,[106] and the Active Living Research Group provides a list of tools that can be used to assess built environment features related to phyical activity.[107] Comparison of results across study samples can also be improved by using measures that have been implemented broadly, such as those used in the International Physical Activity and Environment Network (IPEN) study,[108] which was conducted in over 14,000 adults residing in 12 countries. Given that urban morphology can differ across countries (especially between high- and low-income countries), researchers should consider using measures adapted to local regions. Alternatively, the IPEN team has published a common GIS protocol, developed using a multi-stage process with input from international GIS teams, that has shown sensitivity to variability in environments within and between cities across the 12 included countries.[109]

Several reviews also stressed the importance of incorporating both objective and subjective measures of the built environment. Across studies and reviews, there were differences in results from studies using objective versus subjective measures of built environment features; however, this variation may not solely be due to differences in measurement error between methods. Rather, individuals experience their environment in different ways than it is objectively observed, and thus an individual's self-reported perceptions of their environment may not match objective measurement.[45] For example, eight grocery stores may be counted as accessible to an individual using GIS mapping techniques, but the same individual may only have knowledge of two of the stores, or may know of some of these stores but perceive them as inaccessible or inadequate for their needs. Thus, an individual's perception of their resources may be a larger driver of shopping behavior than the objective reality.[40] Conversely, self-report measures are limited by known recall biases,[110] which may be overcome through use of objective measures. Thus, the use of both objective and subjective measures within a single study can help researchers investigate these trends.

Measures of Dietary Intake, Physical Activity, and Weight Status.: Measures of physical activity, dietary intake, and weight status also varied widely across studies included in each review. Dietary assessment methods ranged from brief questionnaires asking about fruit and vegetable intake to more complex food diaries or 24-hour dietary recalls conducted by trained research staff. To date, the strongest evidence base exists for the use of detailed food diaries or 24-hour recall methods,[111,112] with recommendations for both including multiple measurements (e.g., assessing intake on at least 3 days during a week, representing two weekdays and one weekend day). When brief measures are needed, rather than developing study-specific measures, researchers should use existing, validated measures such as the Rapid Eating Assessment for Participants shortened version (REAPs).[113] As an example, this 16-item self-report measure can provide an estimate of total number of servings consumed for fruits, vegetables, dairy items, and meats, along with number of soft drinks consumed and total consumption of fat, fiber, cholesterol, and sugar.[113] This allows for investigation into specific eating behaviors, as appropriate (e.g., availability of fast food establishments may be differentially associated with consumption of fat versus fruit and vegetable intake). To account for regional differences in dietary patterns, Dao and colleagues[114] have compiled an overview of international Dietary Assessment Toolkits.

Of note, most reviews included studies focused on meeting specific intake recommendations (e.g., for fruits and vegetables or saturated fat); while a few also assessed overall dietary quality (e.g., using a dietary quality index such as the Healthy Eating Index[115]), there has been little focus on investigating associations between built environment features and overall caloric intake. Given the key role of energy intake in body weight regulation,[100] future studies should examine whether built environment features are associated with differences in total caloric intake.

Assessment of physical activity was conducted with either objective (e.g., accelerometry) or self-report measures (ranging from retrospective recall questionnaires to activity logs). Given that self-report measures tend to lead to overestimates of physical activity and underestimates of sedentary behavior,[116] accelerometry or other objective measures should be used when feasible.[117,118] Beyond this general recommendation, however, researchers should also carefully consider whether domain-specific (e.g., assessing leisure-time physical activity versus occupational activity) or behavior-specific (e.g., assessing walking versus biking) measures should be used. Importantly, some built environment features would be expected to be associated with some types of physical activity behaviors but not others, and thus using the wrong measure may obscure observation of an association. For example, the review by Saelens and Handy[58] noted strong support for a positive association between proximity to non-residential destinations and walking for transportation, but only limited support for associations between proximity to these destinations and walking for recreation. A study including a measure of overall walking or overall physical activity may miss these associations.

Finally, weight status was also assessed using either objective (using assessor-measured heights/weights) or self-report measures, both as a continuous variable (e.g., total body weight or body mass index) and as a categorical variable (overweight/obesity status, or body mass index [BMI] category). Given that individuals tend to under-report weight and over-estimate height,[119] studies should use objective versus self-report measures of body weight when possible.[120] Newer technological developments, such as “smart” scales which can be used remotely to send participant body weight directly to research servers, may be particularly helpful for studies attempting to obtain objective measures of body weight.[121] Emerging evidence suggests that these scales have reliable concordance with weights measured during in-person assessment visits.[122,123] Further, to enhance comparison of effects across studies, researchers should note differences in weight and BMI as continuous measurements rather than solely reporting weight status categories.

Emerging Approaches.: The widespread proliferation of smartphones has increasingly allowed for more detailed assessment of exposures to built environment features and health habits. For example, the commonality of smartphones allows researchers to objectively measure built environment exposures and track individuals' movements through real-time geospatial monitoring (via GPS), and further simplifies collection of self-report and objective health behavior data (e.g., through delivery of short surveys and/or collection of movement data using built-in accelerometers). This use of mobile sensing technology strengthens researchers' ability to assess temporal associations between exposure to built environment features and health behaviors, improving ability to assess temporal and context-dependent patterns in associations.[124] For example, a recent study by Cerin and colleagues[125] demonstrated that associations between physical activity and built environment exposures (e.g., land-use mix, access to parks, and access to public transportation) were stronger during certain times of day and days of the week.

Ecological momentary assessment (EMA) methods capitalize on the ease of collecting self-report and passively-monitored data via smartphones to collect real-time information related to an individual's behaviors, attitudes, perceptions, and emotions, in the context in which they occur.[126] For example, study participants could be asked to complete brief measures assessing environmental exposures, dietary intake or physical activity throughout the day (at random or at pre-specified times) or after specific events. EMA approaches can improve the quality of data collection (e.g., by limiting recall bias common in retrospective recall measures) and allow researchers to investigate exposures and outcomes that may vary over time and context.[127]

Most recently, geographically-explicit ecological momentary assessment (GEMA) methods combined traditional EMA methods with the continuous monitoring of geospatial data (namely, GPS and GIS data) available via mobile sensing technology.[128] As examples, the location of an individual when they complete EMA-style questionnaires can be saved and used to assess recent environmental exposures, or EMA-style brief questionnaires could be triggered in response to a specific environmental exposure identified via a smartphone GPS (e.g., a questionnaire about dietary habits or physical activity could be prompted when a participant walks near a fast food restaurant or public park). Future application of GEMA approaches will allow for investigation into how associations between built environment features and health behaviors may vary temporally across specific contexts and/or exposures.[102]

Recommendation 3: Develop and use standardized definitions of "place."— Another key challenge noted across reviews was the multitude of definitions that have been used when assessing built environment. Built environment was assessed using both administrative boundaries (e.g., identifying all built environment features within the city, county, census tract, or zip code in which an individual resides) and by use of spatial "buffers" (e.g., mapping all built environment features in a 1-mile radius around an individual's residence). The review by Leal & Chaix[93] investigated associations between environment features and cardiometabolic risk factors (including obesity) found that most included studies used administrative areas, while only 19.8% used spatial buffers. This reliance on administrative boundaries could introduce error (e.g., when an individual lives on the edge of one administrative area and spends most of their time in another area) and reduce the ability of researchers to detect important effects.[129,130]

When buffers are used, the nature (radial vs. lines following streets) and size of the buffer is also important to consider given that this choice can impact study results.[129] Research has demonstrated that appropriate buffer sizes may vary by type of feature or behavioral domain.[129,131] For example, one study found that physical activity was most associated with the number of recreational facilities when a 3km buffer was used but was most associated with intersection density when 1km buffers were used.[131] Thus, future research should focus on developing domain-, behavior-, and population-specific buffer guidelines. For example, mixed-methods designs (combining qualitative feedback from potential participants with global positioning systems [GPS] data) could be used to ascertain what size buffer would contain recreational facilities that a participant would attend, eliminating facilities that are not within a “reasonable” driving distance.

Beyond considerations of buffer size, much of the literature examining associations between built environment features and dietary intake and physical activity habits has been limited by the definition of place solely in relation to residential address (the review by Leal and Chaix found that 90% of studies exclusively investigated exposures in the residential environment).[93] Outside of select populations (e.g., young children, older adults, or persons with limited mobility), however, most individuals are exposed to a variety of environments and built environment features outside of their immediate residential area as they move about throughout their day to complete tasks and engage in activities, thus leading to calls for researchers to identify alternative definitions of place (e.g., areas surrounding workplaces or schools) that may be relevant for behaviors such as physical activity.[21]

Unfortunately, it remains unknown which spatial locations (and, relatedly, under which contexts and times) exert the largest impact on individuals’ dietary intake and physical activity behaviors, a methodological challenge described as the “uncertain geographic context problem.”[132,133] It also may be that combined exposure to built environment features across several spatial definitions of place (e.g., areas surrounding an individual’s residential address, work, travel paths, and other frequently-visited places) are important for influencing eating and activity behaviors.[89] Furthermore, there may be variability across priority populations or even between individuals in associations between specific spatial contexts and eating/activity behaviors.[132] This methodological problem has potential to introduce some of the challenges to causal inference discussed earlier (e.g., selective daily mobility bias). Commentaries by Jankowska and colleagues[134] and Kwan[102,132] offer suggestions for addressing the uncertain geographical context problem, including the use of sensitivity analyses and the use of mobile sensing technologies to develop individual activity spaces representing all of the areas that an individual visits during their daily activities/ travel. Additional recommendations for using newer technologies to develop individualized models of environmental exposures and health behaviors have been developed by James and colleagues,[135] Kerr and colleagues,[136] and Matthews and Yang.[137]

Recommendation 4: Researchers should develop clear conceptual models that examine key mediators and moderators.—A little over one-third of the included reviews noted the importance of investigating key mediators and moderators of the associations between built environment and dietary intake, physical activity, and weight status. There are known associations between built environment factors and certain confounders, such as socioeconomic factors.[34,138–141] Other important interactions may also confound results.[89] Studies should clearly map out what additional variables may confound or interact with selected built environment features, measure these variables, and employ appropriate statistical modeling techniques. These conceptual and statistical models should also account for potential threshold effects and other non-linear associations between variables. These steps should be conducted prospectively and, ideally, be preregistered (e.g., through posting study protocol in a public repository; the Center for Open Science[142] provides templates and guidance for completing this process). Pre-registration can reduce the likelihood of the "file-drawer problem," wherein null results are not published. It can also reduce the likelihood of spurious results entering the literature through post-hoc inclusion of potential moderators/confounders, data-mining, and p-hacking (e.g., when models are modified until statistically-significant results are found).[143] Finally, including a figure representing the underlying conceptual model in published manuscripts, with notations indicating what variables were measured and statistically adjusted for, can help clarify strengths and weaknesses of a given approach and guide systematic accumulation of evidence.

Related, almost a third of reviews recognized the usefulness of multi-level models (e.g., using an ecological framework)[12] when conceptualizing the associations between built environment and dietary intake, physical activity, and weight status. These models can capture the complex constellation of factors that interact to influence an individuals' health behaviors. Even just on the built environment level, an individual is often exposed to a multitude of different built environment features. The combined impact of several environmental factors may thus be a larger driver of behavior than any one built environment feature or category of built environment features in isolation. Indeed, across reviews, the use of index scores (e.g., scores for "healthful" food environments or overall "walkability") led to stronger and more consistent effects on weight and weight-related behaviors compared to those found when studies investigated the association of individual built environment factors.[41,75,89] Conversely, different built environment features may interact in ways that obscure observation of associations. For example, neighborhoods with higher walkability (associated with lower weight status)[97] may also have greater access to convenience stores (which are associated with higher overweight/obesity).[99] As a result of these complex interactions, United States Department of Health and Human Services' Community Preventive Services Task Force recommended in their 2016 Community Guide[144] that built environment interventions aimed at increasing physical activity should use combinations of multiple approaches (e.g., combining transportation improvements with changes in land use or environmental design) rather than use any one approach alone.

Recommendation 5: Team-science approaches should guide the development of fewer, but more rigorous studies.—Some of the variation in measurement methods used across reviews may be a result of pragmatic limitations such as funding. While reviews noted the importance of using both objective and subjective measures of built environment, and more valid/reliable methods of assessing dietary intake, physical activity, and weight status, these methods can be costly (requiring technology or assessor training far beyond standard self-report measurements) compared to simpler measurement protocols. Moreover, small sample sizes or conduct of studies in specialized populations can limit the generalizability of results. Thus, we recommend that fewer small, cross-sectional studies should be conducted in favor of larger-scale, team-science based science approaches using the best available methods. For example, the IPEN project mentioned earlier created international linkages between researchers to assess associations between built environment exposures and physical activity across 12 countries on 5 continents,[108] providing a strength of evidence unmatched by any single-population study. Increased sharing and linking of data across research teams may also provide important insights. As an example, the Patient-Centered Outcomes Research Institute has led the development of a nationwide network to link electronic health record information longitudinally across major U.S. healthcare systems[145]; linking datasets such as these with other public health data sources could provide a powerful method to evaluate the impact of changing built environments.[146]

Recommendation 6: Additional work should be conducted in more geographically-diverse samples.—Almost three quarters of included reviews included only studies conducted in high-income countries. Moreover, almost two-thirds primarily included studies conducted in the United States, and reviews that included studies conducted outside of the United States mostly included studies from other Western, Educated, Industrialized, Rich, and Democratic (WEIRD)[147] countries. Few cross-country comparisons were made within reviews, although Elshahat and colleagues[74] noted that transportation options in low- and middle-income countries may lead to differences from high-income countries in associations between public transit access and physical activity in older adults, and Lee and colleagues[55] noted that studies investigating the associations between built environment features and physical activity in East Asian countries were less likely than studies in the U.S. to assess safety as a built environment feature that may influence activity. More research is needed to determine whether results are generalizable only to individuals residing in the U.S., to individuals residing in WEIRD countries, or more broadly.

Strengths and Limitations of the Current Review

There are several strengths of the current review. By employing scoping review methods, we were able to synthesize results across a wide body of literature. Previous attempts to review associations between built environment and weight or weight-related behaviors in this literature largely focused on select populations or on the influence of built environment on one factor (i.e., physical activity, dietary intake, or weight status separately); combining the literature across these areas allows us to present a broader look of how the built environment may be associated with weight and weight-related behaviors. This broad look highlighted important gaps in this literature, such as the relative dearth of literature available on built environment factors and dietary intake/weight status compared to the large amount of literature investigating associations between built environment factors and physical activity.

We were also able to catalogue methodological weaknesses prevalent across reviews and summarize and extend the recommendations that reviews presented for future research.

Limitations to the current review were largely related to broader weaknesses of scoping reviews compared to more traditional systematic reviews and meta-analyses. While scoping reviews have the benefit of providing a wide-range, "snapshot in time" view of a body of literature, they may lack the depth of traditional systematic reviews and meta-analyses. The field may benefit from the use of meta-analytic techniques to combine results across the studies included in the identified reviews; however, given the substantial challenge of heterogeneity in study methodology and selection of outcome measures, the combination of these study results using these methods may not be useful for drawing broader conclusions. Another key limitation was that the current review included only scoping reviews, systematic reviews, and meta-analyses; thus, important results may have been missed in our search, and newer results (published since the most recent reviews) may not have been captured. Finally, the current review only included studies focused on two weight-related behaviors (dietary intake and physical activity); to comprehensively understand the wide range of potential associations between built environment and weight status, future reviews should also include other weight-related behaviors (e.g., sedentary behavior[148] or sleep habits[149]).

Conclusion

This scoping review of reviews synthesized the literature on the associations between built environment and dietary intake, physical activity, and obesity. While we were able to identify a small subset of built environment factors that demonstrated consistent associations with weight and weight-related behaviors than others, results largely demonstrated heterogeneous effects in terms of strength and statistical significance. Across all the reviews included, there existed substantial concern regarding methodological limitations of existing studies. To improve the quality of evidence across the literature, future studies should 1) use stronger study designs, such as longitudinal designs and natural experiments; 2) develop and implement valid and reliable measures for assessing built environment, dietary intake, physical activity, and weight status; 3) develop and use standardized definitions of "place"; 4) build clear conceptual models that investigate key mediators and moderators; 5) use team-science approaches to produce fewer, but higher-quality studies; and 6) replicate results in samples outside of the United States. By establishing whether and describing how built environment factors can influence weight and weight-related behaviors, this literature will provide a foundation for the development of future built environment and multi-level health promotion interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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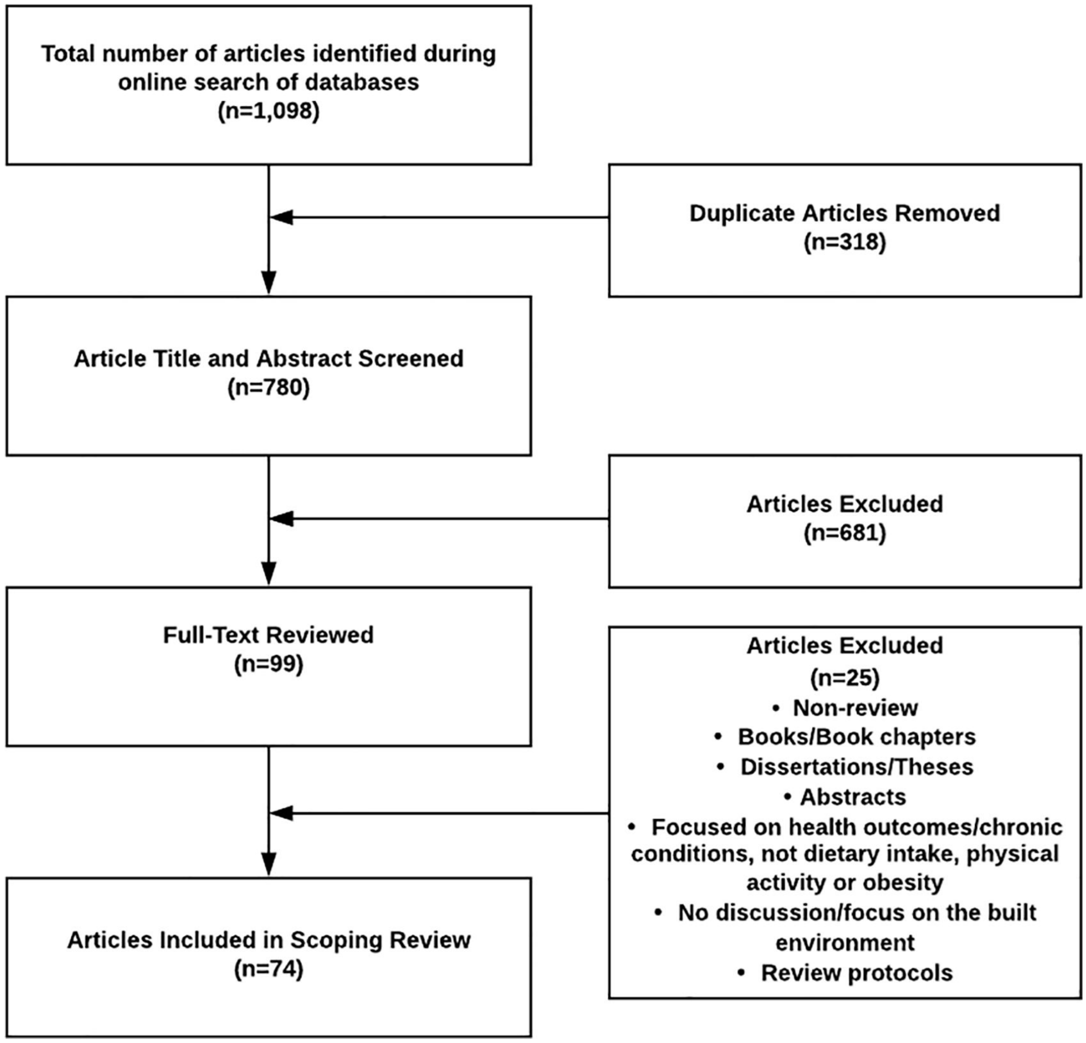

Figure 1.
Flow diagram for study inclusion.

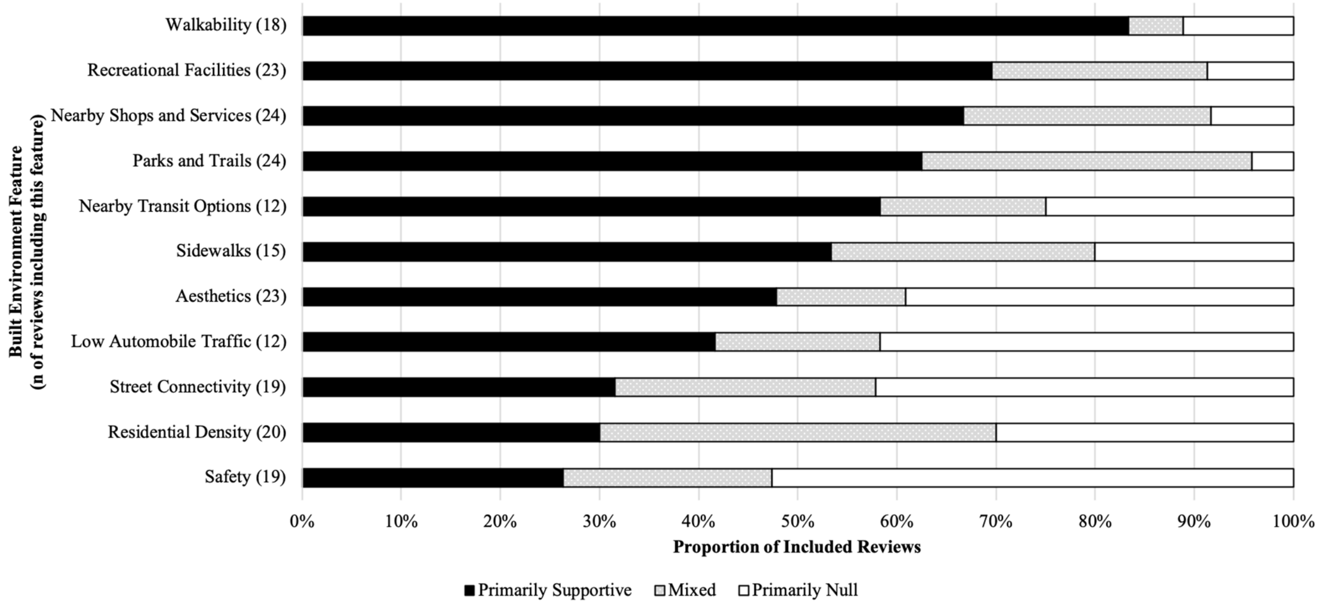

Figure 2.

Results of included reviews investigating the association of built environment factors on physical activity.

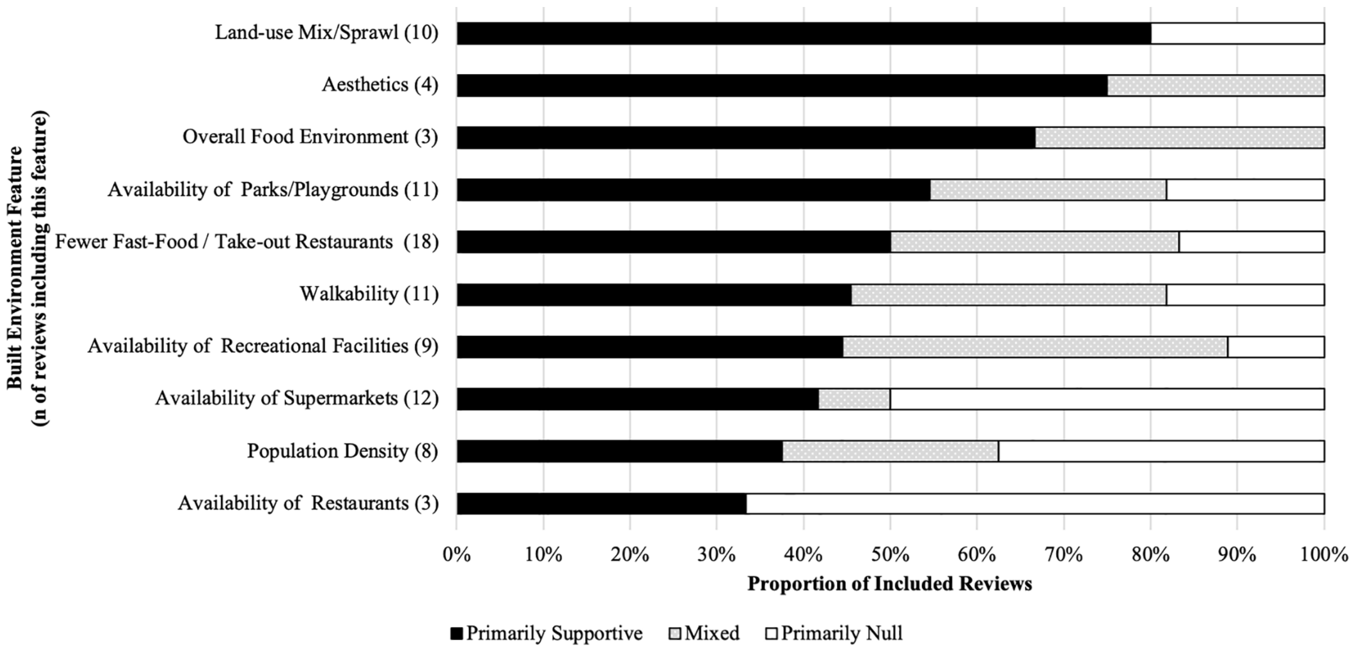

Figure 3.

Results of included reviews investigating the association of built environment factors on weight status.

Table 1.

Methodological Issues	No. of reviews	References
Included studies primarily used cross-sectional designs	61	16, 26, 28, 30, 35–36, 38–39, 41–45, 47–58, 61–69, 71–88, 90–94, 96–99
Included studies primarily conducted in the United States	47	16, 26–28, 30, 32, 34, 36, 38–43, 45–52, 54, 56, 58–61, 64–66, 69, 71, 73, 76–77, 83, 85–91, 93–94, 99
No quality assessment was conducted on included studies	46	16, 31–32, 34–39, 41, 43–49, 51–53, 56–59, 61–67, 69–71, 73, 75, 78, 83–86, 88, 90–92, 97
Included studies lacked valid/reliable measures of the built environment	33	16, 28, 29, 34, 36, 38–39, 41–45, 48–50, 52–54, 56, 58, 60, 64, 73, 83, 85–89, 92, 94, 98–99
Variations in definitions of "place" and buffer sizes that precluded comparison of results across studies	13	41–44, 48–49, 59, 83, 86, 96–99
Inclusion of multiple studies using the same sample	7	38, 52, 62, 76, 81, 87, 95

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Table 2.

Recommendations	No. of reviews	References
Stronger study designs (including natural experiments and other longitudinal designs)	55	26, 28–30, 35–36, 38–39, 41–42, 44–45, 47–49, 51–53, 55–58, 60–72,74–75, 77, 80, 82–84, 86, 88–99
Include valid and reliable measures	28	16, 26–27, 30, 32, 35–36, 39, 41–44, 48, 50, 54, 57, 62, 64, 72, 75, 78, 80, 83, 87–89, 91, 98
Examine key mediators and moderators of associations between built environment and dietary intake, physical activity, and weight status	27	16, 28–29, 31, 35–37, 40, 43, 48, 52, 58–60, 62, 69, 73, 76, 79–83, 86, 92–93, 98
Use of multi-level models/interventions	17	16, 26, 37–39, 40, 45, 49, 53, 58, 61, 76–77, 83, 85, 92–93
Both objective and perceived measures of built environment features should be used	13	32, 35, 42, 43, 45, 52, 55, 63, 66, 72, 77, 82, 86
More studies should be conducted outside of the United States	14	16, 42–43, 47, 62, 64, 69, 72, 74–75, 79, 81, 87, 97
Clearer definitions of "place" should be developed/ standardized	12	32, 35, 41, 43, 49, 52, 59, 69, 82, 83, 98–99
Buffer size should be clearly defined/standardized	11	32, 42–43, 48–49, 69, 73, 86, 90–91, 98