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Influence of Neighborhood Safety on Childhood Obesity: A Systematic Review and Meta-analysis of Longitudinal Studies

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Abstract

Unsafe residential neighborhoods are thought to be a risk factor for childhood obesity by discouraging physical activity while encouraging sedentary behaviors, but findings from cross-sectional studies are susceptible to selection bias (e.g., children who are obese disproportionately reside in unsafe neighborhoods). A literature search was conducted in the Cochrane Library, PubMed, Web of Science, and Google Scholar for articles published until January 2017 that used baseline neighborhood safety levels to predict future weight-related behaviors and body weight status among children aged 17 years and younger. Twenty-two prospective cohort studies conducted in seven countries were identified. The median sample size was 1,104, and the median follow-up was 3.5 years. Sixteen studies used parent- and/or child-reported neighborhood safety measures, and six adopted some objective measures (e.g., county crime rate, interviewers' block observations). The meta-analysis found that living in unsafe neighborhoods was associated with a reduction in children's physical activity by 0.13 hours/week. Living in unsafe neighborhoods predicted a trivial (but statistically significant) gain in BMI but no change in childhood overweight/obesity risk. Current research indicates a limited influence of neighborhood safety on childhood obesity; this finding could be partially due to measurement problems. Future longitudinal studies should adopt validated neighborhood safety measures.

Keywords

Neighborhood; Safety; Childhood obesity; Longitudinal study

Introduction

Obesity is a leading cause of morbidity and premature mortality in the U.S. and worldwide (1–4). Childhood obesity is linked to various immediate and long-term adverse health

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outcomes such as sleep apnea, hypertension, heart disease, stroke, type 2 diabetes, osteoarthritis, and certain types of cancer, and it leads to social and psychological problems such as stigmatization and poor self-esteem (5, 6). From 1976–1980 to 2013–2014, the prevalence of childhood obesity more than tripled (from 5.5% to 17.2%) among children aged 2–19 years (7). In 2010, 43 million children total (35 million in developing countries) were estimated to be overweight or obese (8). The prevalence of childhood overweight/obesity is projected to reach 9% or 60 million children in 2020 (9).

On a global scale, population growth and industrialization impact land use and urbanization, motorized transportation, and agricultural productivity, and consequently influence the obesity epidemic through nutrition transition and physical inactivity (10, 11). Industrial and urban development contribute to the formation of an obesogenic environment (12, 13)—“an environment that promotes gaining weight and one that is not conducive to weight loss” (14). One characteristic or type of obesogenic environment pertains to neighborhood safety (15, 16). There is some inconclusive evidence that unsafe residential neighborhoods tend to elevate the risk of childhood obesity by discouraging physical activity (e.g., outdoor activities in playgrounds and parks, sports and/or exercise at nearby recreational facilities) while encouraging sedentary behaviors (e.g., computer games, television watching) (17–20). Despite the large volume of studies on neighborhood safety and childhood obesity, the majority adopt a cross-sectional study design, which makes study findings particularly vulnerable to confounding (18, 21–25). For example, children with a higher risk of overweight/obesity could be more likely to live in unsafe neighborhoods, resulting in self-selection bias. In addition, childhood obesity is a complex outcome affected by multiple layers of factors in the socioecological framework—individual characteristics, parents, friends, schools, local communities, government agencies, the built environment, and the socioeconomic environment. Neighborhood safety could influence childhood obesity through various channels by interacting with these factors. Longitudinal studies that carefully take into consideration the time order of adiposity development and change in neighborhood safety and adjust for the confounding effects of other socioecological factors are required to rigorously assess the predictability of baseline residential neighborhood safety levels on children’s future trajectory of weight gains.

Several previous review articles were particularly relevant to this review. Carver et al. (2008) reviewed “stranger danger” and road safety in relation to physical activity among youth (18). Dunton et al. (2009), Carter and Dubois (2010), and Galvez et al. (2010) reviewed physical and social environmental features of neighborhoods in relation to child adiposity (21–23). Ding et al. (2011) reviewed the associations between neighborhood environment and physical activity among youth (24). Yu and Lippert (2016) reviewed neighborhood crime rate in relation to weight-related behaviors and obesity (25). None of these reviews exclusively focused on longitudinal studies, and none except Yu and Lippert (2016) centered on residential neighborhood safety (25).

This review contributes to the literature in the following aspects. First, to address self-selection and confounding bias, we exclusively reviewed longitudinal studies (i.e., prospective and retrospective cohort studies) on the influence of residential neighborhood safety. Second, we expanded the concept of neighborhood safety from crime rate to various

self-perceived or objectively measured neighborhood characteristics such as traffic flow, night lighting, and neighborhood decay. Third, we examined both body weight status as well as weight-related behaviors (e.g., diet, physical activity, and sedentary behavior). We tested our hypothesis that poor neighborhood safety at baseline would predict lower levels of physical activity but high levels of sedentary behaviors, and lead to weight gains during follow-up among children and adolescents. We conducted a meta-analysis to quantify the influence of neighborhood safety on childhood obesity risks.

Methods

A systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (26).

Study selection criteria

Studies that met all of the following criteria were included in the review: (1) Study designs: longitudinal studies including prospective and retrospective cohort studies; (2) Study subjects: children and adolescents aged 17 years and younger; (3) Study outcomes: weight-related behaviors including physical activity, sedentary behavior, and diet and body weight status including overweight and obesity measured by body mass index (BMI, kg/m²), waist circumference, waist-to-hip ratio, and body fat; (4) Article types: peer-reviewed publications; (5) Time window of search: from the inception of an electronic bibliographic database to January 31st, 2017; and (6) Language: articles written in English.

Studies that met any of the following criteria were excluded from the review: (1) Studies that incorporated no outcome pertaining to weight-related behavior and body weight status; (2) Computer-based simulation studies without the inclusion of human participants; (3) Controlled experiments conducted in manipulated rather than naturalistic settings; (4) Articles not written in English; or (5) Letters, editorials, study/review protocols, or review articles.

Search strategy

A keyword search was performed in four electronic bibliographic databases: Cochrane Library, PubMed, Web of Science, and Google Scholar. The search algorithm included all possible combinations of keywords from the four groups related to neighborhoods, safety or crime, children, and weight-related behaviors or outcomes (e.g., diet, physical activity, and adiposity measures). The specific search algorithm is provided in Appendix 1. Titles and abstracts of the articles identified through the keyword search were screened against the study selection criteria. Potentially relevant articles were retrieved for an evaluation of the full text. AH conducted the title and abstract screening and identified potentially relevant articles for the full-text review. Ambiguous articles were compiled by AH and screened by RA. RA and AH jointly determined the list of articles for the full-text review through a discussion. RA and AH independently reviewed the full texts of all articles in the list and determined the final pool of articles included in the review. Inter-rater agreement was assessed using the Cohen's kappa ($\kappa = 0.92$).

A reference list search (i.e., backward reference search) and cited reference search (i.e., forward reference search) were conducted based on the full-text articles that met the study selection criteria that were identified from the keyword search. Articles identified from the backward and forward reference search were further screened and evaluated using the same study selection criteria. Reference searches were repeated on all newly identified articles until no additional relevant articles were found.

Data extraction and preparation

A standardized data extraction form was used to collect methodological and outcome variables from each selected study, including authors, year of publication, country, various sample characteristics, statistical model, measures of neighborhood safety, measures of weight-related behaviors or outcomes, and key findings on the relationship between neighborhood safety and weight-related behaviors or outcomes. AH and YY independently extracted data from each study included in the review, and discrepancies were resolved by a third reviewer RA.

Meta-analysis

A meta-analysis was performed to estimate the pooled effect size of neighborhood safety on each weight-related outcome and behavior. Weight-related outcomes included BMI z-score, overweight, and obesity. Overweight (BMI at or above the 85th percentile) and obesity (BMI at or above the 95th percentile) were based on the 2000 age- and sex-specific Centers for Disease Control and Prevention Growth Charts (27). Weight-related behavior included physical activity (hours/week). Several studies were excluded from the meta-analysis due to the following reasons: neither standard error nor confidence interval was reported (28–31); effect size was unable to be transformed into a standardized coefficient (i.e., beta coefficient) due to limited information reported (32–34); the unit of effect size was inconsistent with others (35); and less than two studies reported the same outcome variable (36–40). Study heterogeneity was assessed using the I^2 index. The level of heterogeneity represented by I^2 was interpreted as modest ($I^2 \leq 25\%$), moderate ($25\% < I^2 \leq 50\%$), substantial ($50\% < I^2 \leq 75\%$), or considerable ($I^2 > 75\%$). A fixed-effect model was estimated when modest to moderate heterogeneity was present, and a random-effect model was estimated when substantial to considerable heterogeneity was present. Publication bias was assessed by a visual inspection of the funnel plot and Begg's and Egger's tests. All statistical analyses were conducted using the Stata 14.2 SE version (StataCorp, College Station, TX). All analyses used two-sided tests, and p -values less than 0.05 were considered statistically significant.

Study quality assessment

We used the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies to assess the quality of each included study (41). This assessment tool rates each study based on 14 criteria. For each criterion, a score of one was assigned if "yes" was the response, whereas a score of zero was assigned otherwise (i.e., an answer of "no", "not applicable", "not reported", or "cannot determine"). A study-specific global score ranging from zero to 14 was calculated by summing up scores across all

criteria. The study quality assessment helped measure the strength of scientific evidence but was not used to determine the inclusion of studies.

Results

Study selection

Figure 1 shows the study selection flow chart. We identified 8,943 articles total through the keyword and reference search. They underwent title and abstract screening, by which 8,868 articles were excluded. The full texts of the remaining 75 articles were reviewed against the study selection criteria. Of these, 53 articles were excluded. The remaining 22 studies that examined the longitudinal relationship between neighborhood safety and children's weight-related behaviors and/or outcomes were included in the review (28–40, 42–50).

Basic characteristics of the included studies

Table 1 summarizes the basic characteristics of the 22 included studies. Half of the studies were conducted in the U.S. ($n = 11$), and the remaining studies were conducted in other countries including Australia ($n = 4$), Canada ($n = 2$), the U.K. ($n = 2$), Germany ($n = 1$), the Netherlands ($n = 1$), and Vietnam ($n = 1$). Seven studies exclusively focused on weight-related behaviors; five studies exclusively focused on body weight status, and the remaining 10 studies examined both weight-related behaviors and body weight status. All studies adopted a prospective cohort study design. Sample sizes were generally large but varied substantially across studies, with a mean of 3,447, a median of 1,104, a standard deviation of 3,886, and a range from 171 to 12,701. The majority ($n = 15$) of studies recruited young children aged 4–11 years at baseline. One study recruited infants aged 0–1 years (and followed them until 3 years old). Three studies recruited adolescents aged 12–17 years, and the remaining three studies recruited both young children and adolescents. Study subjects were followed from one to 14 years, with a mean follow-up period of 4.5 years, a median of 3.5 years, and a standard deviation of 3.7 years. During the study period, each subject was measured 4.1 times on average, with a standard deviation of 3.7 times. Two studies exclusively recruited girls, whereas the remaining 20 studies recruited both girls and boys. A variety of statistical models was applied across studies, including a structural equation model, multilevel logistic regression, latent growth curve model, individual random-effect and/or fixed-effect model, generalized estimation equation, multiple linear and/or logistic regression, mediation model, and analysis of covariance. All studies adjusted for some individual sociodemographics in the statistical analysis. Most ($n = 20$) studies adjusted for some other neighborhood characteristics (in addition to neighborhood safety) in the statistical analysis.

Table 2 summarizes neighborhood and weight-related behavior/outcome measures of the included studies. The majority ($n = 16$) of the studies were based on subjective neighborhood safety measures reported by parents and/or children themselves, whereas two studies adopted objective neighborhood safety measures (e.g., neighborhood crime rate, road condition), and four studies used both objective and subjective neighborhood safety measures. Specific measures of neighborhood safety varied substantially across studies. Parent-perceived and/or self-reported subjective neighborhood safety measures included

both general questions (e.g., “How safe is it for children to play outside during the day in your neighborhood?”) and specific characteristics pertaining to neighborhood safety (e.g., vandalism, property damage, abandoned buildings, presence of garbage/broken glass, traffic accidents, gangs, shootings, violence, burglary or robbery, lack of sidewalks, and lack of street lights). Among the subjective safety measures, only two studies used measures or indices known to be validated in previous research (31, 32). Objective neighborhood safety measures were constructed based on government crime reports/databases (e.g., county-level non-violent and violent crime rate), geographical information system (e.g., street intersection density), and/or field observation by trained staff/researchers (e.g., neighborhood physical disorder index based on interviewers’ block observations). In addition to neighborhood safety, measures of other neighborhood characteristics included but were not limited to proximity and accessibility of sports equipment, recreational facilities, playgrounds, and parks, presence of food shops and supermarkets, green and/or shaded spaces, water features, dog signs, social cohesion of neighborhoods, distance from home to school, neighborhood income and educational level, rural/urban status, and index of neighborhood relative socioeconomic disadvantage. Weight-related behaviors included physical activity (n = 8), sedentary behavior (n = 6), active commuting from/to school (n = 6), sports participation (n = 2), and dietary intake (n = 1). Most (n = 19) studies measured weight-related behaviors using questionnaires administered to parents and/or children, whereas three studies adopted an objective measure using wearable accelerometers. Weight-related outcomes included BMI (n = 7), BMI z-score (n = 7), overweight (n = 2), obesity (n = 3), and skinfold thickness (n = 1). All BMI-related measures were based on objectively measured height and weight.

Table 3 summarizes the estimated effects of neighborhood safety on weight-related behaviors/outcomes of the included studies. Among the 13 studies that provided some quantitative estimates of the longitudinal relationship between neighborhood safety measures and weight-related behaviors, seven reported a statistically significant association in the expected direction, whereas the remaining six reported a null finding. Among the 12 studies that provided some quantitative estimates of the longitudinal relationship between neighborhood safety measures and body weight status, five reported a statistically significant association, whereas the remaining seven reported no association.

Meta-analysis of body weight status and physical activity

Table 4 summarizes the modeling results from the meta-analysis. Living in unsafe neighborhoods was typically defined as a dichotomous measure (e.g., safe versus unsafe) in the original studies. Specific cutoffs (e.g., median split, highest versus lowest quartile) were adopted in other studies to form a dichotomized comparison based on continuous or categorical neighborhood safety measures. Living in unsafe neighborhoods was found to be associated with a rather modest (but statistically significant) increase in BMI z-score and a reduction in weekly physical activity duration among children but was not found to be associated with the risk of childhood overweight and obesity. Compared to their counterparts living in safe neighborhoods, children living in unsafe neighborhoods were associated with a gain in BMI by 0.018 (95% confidence interval [CI] = 0.009, 0.026) standard deviations (Figure 2). Unsafe residential neighborhoods were not associated with childhood overweight

(pooled odds ratio [POR] = 1.016, 95% CI = 0.886, 1.164) or obesity (POR = 1.168, 95% CI = 0.948, 1.438). Compared to their counterparts living in safe neighborhoods, children living in unsafe neighborhoods were associated with a reduction in physical activity duration by 0.13 (95% CI = 0.06, 0.19) hours/week. No dose-response effect with respect to follow-up durations was found in the meta-regression with childhood obesity as the outcome. No publication bias was identified, as neither Egger's tests nor Begg's tests were statistically significant.

Study quality assessment

Table 5 reports criterion-specific and global ratings from the study quality assessment. The included studies scored 9.5 out of 14 on average, with a range from seven to 12. All the 22 studies included in the review stated the research question/objective, clearly specified and defined the study population, had a participation rate above 50%, recruited participants from the same or similar populations during the same time period, pre-specified and uniformly applied inclusion and exclusion criteria to all potential participants, and consistently defined and implemented the outcome measures (dependent variables) across study participants. Most studies measured exposures of interest (e.g., neighborhood safety and other neighborhood characteristics) prior to the outcomes ($n = 17$), had a reasonably long follow-up period that was sufficient for changes in outcomes, if any, to be observed ($n = 21$), examined different levels of the exposure as related to the outcome ($n = 16$), and measured and statistically adjusted key potential confounding variables for their impact on the relationship between exposures and outcomes ($n = 21$). In contrast, none of the studies had the outcome assessors blinded to the exposure status of the participants. Only one study provided a sample size justification using a power analysis. Six studies assessed the exposures more than once during the entire study period; seven studies implemented valid and reliable exposure measures, and eight studies had an attrition rate less than 20%.

Discussion

We systematically reviewed and identified 22 longitudinal studies that assessed residential neighborhood safety in relation to weight-related behaviors and body weight status among children and adolescents. These studies were conducted in seven countries, and half of the studies were conducted in the U.S. They varied considerably in sample size, follow-up duration, and measures. The median sample size was 1,104, and the median follow-up duration was 3.5 years. The majority ($n = 15$) of studies recruited young children aged 4–11 years old at baseline. The majority ($n = 16$) of studies used subjective neighborhood safety measures reported by parents and/or children, whereas the other six adopted some objective measures (e.g., county crime rate). The meta-analysis found children living in unsafe neighborhoods to be associated with a reduction in physical activity by 0.13 hours/week. Living in unsafe neighborhoods predicted a rather small gain in BMI but no change in childhood overweight/obesity risk. No dose-response effect with respect to follow-up duration was identified in the meta-regression. The Begg's and Egger's tests revealed no publication bias.

Overall, the identified associations between neighborhood safety and childhood obesity are weak. An estimated reduction of less than eight minutes of physical activity per week due to neighborhood safety concerns is unlikely to translate into noticeable weight gains among children and adolescents, which could partially explain the estimated minimal change in body weight status. Yu and Lippert (2016) conducted a systematic review and reported that neighborhood crime was positively associated with physical inactivity and obesity (25). However, their review did not provide quantitative estimates from a meta-analysis, covered children as well as adults, and included both cross-sectional and longitudinal study designs. If obese children were disproportionately more likely to reside in deprived neighborhoods with elevated safety concerns, cross-sectional studies would be highly likely to “detect” a spurious effect of neighborhood safety on childhood obesity that did not exist in reality. Our review exclusively focused on longitudinal studies that used baseline neighborhood safety status to predict future weight gains. Therefore, it is anticipated that the estimated impact of neighborhood safety, if any, would be attenuated compared to that based on cross-sectional studies.

A few reasons might explain the limited influence on children’s weight-related behaviors and outcomes from neighborhood safety. First, an obesogenic environment involves numerous factors from different domains, and safety serves as only one component in this complex picture (13–16). For example, consistent evidence links proximity and accessibility of exercise facilities, playgrounds, and parks to increased physical activity among both children and adults (51–54), whereas findings appear much more mixed regarding the role of neighborhood food environments (e.g., a plethora of convenience stores and fast-food restaurants and an absence of supermarkets within walking distance) on dietary quality and childhood obesity (55–57). To some extent, safety might mediate the relationship between the built environment and residents’ health behaviors/outcomes (58, 59), but this mediation effect could be quite secondary and overshadowed by the direct effect. Second, successful effect identification depends on large variations in neighborhood safety levels, which often requires surveying geographically and socioeconomically diverse residential groups. The majority of previous studies might not have the scale and variability needed to best facilitate effect identification. Third, measures on neighborhood safety were often not validated and/or standardized and predominantly relied on self-report, which inevitably increases measurement error and social desirability bias (60, 61). If parents on average over-reported their safety concerns as well as their children’s physical activity (or underreported their children’s sedentary time), the effect of neighborhood safety on children’s weight-related behavior would be underestimated. However, a counterargument could be made that it is primarily self-perceived safety, rather than objective safety, that impacts physical activity-related decisions. Therefore, overall, there is some ambiguity regarding whether self-reported neighborhood safety measures might pose a risk of bias.

This study, to our knowledge, is the first that systematically reviewed and quantitatively synthesized scientific evidence linking residential neighborhood safety to children’s weight-related behaviors and body weight status. The review exclusively focused on prospective cohort studies that used baseline neighborhood safety levels to predict future behavioral/weight change. Nevertheless, a few major limitations pertaining to this review and its included original studies should be noted. Although a longitudinal study design has some

advantages compared to cross-sectional work, it has its own limitations and does not fully address other types of biases such as those resulting from voluntary survey participation, attrition, and misreporting. Its observational nature and lack of experimental design precludes a causal interpretation of the findings from a prospective cohort study. Certain types of self-selection bias may not be adequately addressed by a longitudinal approach. For instance, if families with low socioeconomic status tend to live in unsafe neighborhoods, their children may gain weight over time for reasons that are not attributable to a lack of neighborhood safety but due to their socioeconomic circumstances. Neighborhood safety measures were rather heterogeneous, and most were not validated. The lack of validity and reliability compromised the scientific rigor and practical usefulness of these measures and cast doubt on their effect estimates on weight-related behaviors/outcomes. Due to the lack of consistency and similarity in measures and effect size reporting across studies, we were only able to include a limited subset of studies in the meta-analysis, which arguably reduced the estimation precision, compromised representativeness, and precluded subgroup analysis. Given the small number of studies included in the meta-analysis, we might be underpowered to detect publication bias, but a full-fledged investigation of the sources of heterogeneity proved infeasible. Several studies included in the review were not nationally or locally representative, and pooling results from multiple countries could further dilute the adaptability of study findings to any specific country.

To advance research on the relationship between neighborhood safety and weight-related behaviors/outcomes, future studies are warranted to improve the following aspects. If subjective neighborhood safety measures are to be adopted, their validity and reliability must be extensively tested in diverse population subgroups. Given that subjective measures and objective measures (e.g., administrative data, trained interviewers' block observations) may offer distinct insights regarding the relationship between neighborhood safety and childhood obesity, future studies are encouraged to adopt both types of measures. Studies should cover a relatively large and diverse geographical area to allow sufficient variations in neighborhood safety levels. Repeated measures on neighborhood safety and weight-related behaviors and outcomes should be collected so that the *change* in the neighborhood safety level in relation to the *change* in behavior/weight can be assessed. Whenever feasible, physical activity questionnaires should be supplemented with objective data collection (e.g., accelerometers) to reduce recall bias and improve measurement accuracy. Considering the complexity of the obesogenic environment, other neighborhood characteristics should be carefully assessed, and their potential interaction with neighborhood safety should be tested.

Conclusions

This systematic review of longitudinal studies revealed a rather modest relationship between residential neighborhood safety and weight-related behaviors/outcomes among children and adolescents. Half of the 22 studies identified were conducted in the U.S., and only one was conducted in a developing country. Compared to their counterparts living in safe neighborhoods, children living in unsafe neighborhoods had a shorter physical activity duration by eight minutes per week and a trivial gain in BMI but did not exhibit an increased obesity risk. Future longitudinal studies using validated neighborhood safety measures are warranted to advance research in this field.

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References

1. An R. Health care expenses in relation to obesity and smoking among U.S. adults by gender, race/ethnicity, and age group: 1998–2011. *Public Health*. 2015; 129:29–36. [PubMed: 25542741]
2. BehanDF, , CoxSH, , LinY, , PaiJ, , PedersenHW, , YiM. Obesity and its relation to mortality and morbidity costs2010URL <https://www.soa.org/Files/Research/Projects/research-2011-obesity-relation-mortality.pdf>
3. Danaei G, Ding EL, Mozaffarian D, Taylor B, Rehm J, Murray CJ, et al. The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. *PLoS Med*. 2009; 6:1–23.
4. Finkelstein EA, Trogon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer-and service-specific estimates. *Health Aff*. 2009; 28:822–831.
5. An R. Racial/ethnic disparity in obesity among US youth, 1999–2013. *International journal of adolescent medicine and health*. 2015; 4doi: 10.1515/ijamh-2015-0068
6. Childhood Obesity FactURL <https://www.cdc.gov/healthyschools/obesity/facts.htm>
7. FryarCD, , CarrollMD, , OgdenCL. Prevalence of overweight and obesity among children and adolescents aged 2–19 years: United States, 1963–19652013URL https://www.cdc.gov/nchs/data/hestat/obesity_child_13_14/obesity_child_13_14.pdf
8. De Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. *The American journal of clinical nutrition*. 2010; 92:1257–1264. [PubMed: 20861173]
9. Wang Y, Lim H. The global childhood obesity epidemic and the association between socioeconomic status and childhood obesity. *Int Rev Psychiatry*. 2012; 24:176–188. [PubMed: 22724639]
10. Minos D, Butzlaff I, Demmler KM, Rischke R. Economic Growth, Climate Change, and Obesity. *Current obesity reports*. 2016; 5:441–448. [PubMed: 27714641]
11. Faergeman O. Climate change, disease and public health. *Ugeskr Laeger*. 2008; 170:2667–2668. [PubMed: 18761852]
12. Boone-Heinonen J, Gordon-Larsen P. Obesogenic environments in youth: concepts and methods from a longitudinal national sample. *American journal of preventive medicine*. 2012; 42:37–46. [PubMed: 22176844]
13. Sturm R, An R. Obesity and economic environments. *CA: a cancer journal for clinicians*. 2014; 64:337–350. [PubMed: 24853237]
14. Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: The development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev. Med*. 1999; 29:563–570. [PubMed: 10600438]
15. Drewnowski A, Aggarwal A, Rehm CD, Cohen-Cline H, Hurvitz PM, Moudon AV. Environments perceived as obesogenic have lower residential property values. *American journal of preventive medicine*. 2014; 47:260–274. [PubMed: 25049218]
16. Wall MM, Larson NI, Forsyth A, Van Riper DC, Graham DJ, Story MT, Neumark-Sztainer D. Patterns of obesogenic neighborhood features and adolescent weight: a comparison of statistical approaches. *American journal of preventive medicine*. 2012; 42:65–75. [PubMed: 22176849]
17. Molnar BE, Gortmaker SL, Bull FC, Buka SL. Unsafe to play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. *American journal of health promotion*. 2004; 18:378–386. [PubMed: 15163139]
18. Carver A, Timperio A, Crawford D. Playing it safe: The influence of neighbourhood safety on children's physical activity—A review. *Health & place*. 2008; 14:217–227. [PubMed: 17662638]
19. Maec, , DavidM. Neighborhood Characteristics and Children's Physical Activity2014URL <https://www.childtrends.org/wp-content/uploads/2015/08/2014-54NeighborhoodExercise.pdf>

20. Safe, Affordable, and Accessible Physical Activity URL <https://www.hsph.harvard.edu/obesity-prevention-source/obesity-prevention/physical-activity-environment/safe-affordable-and-accessible-physical-activity-and-obesity-prevention/>
21. Dunton GF, Kaplan J, Wolch J, Jerrett M, Reynolds KD. Physical environmental correlates of childhood obesity: a systematic review. *Obesity reviews*. 2009; 10:393–402. [PubMed: 19389058]
22. Galvez MP, Pearl M, Yen IH. Childhood obesity and the built environment: A review of the literature from 2008–2009. *Current opinion in pediatrics*. 2010; 22:202–207. [PubMed: 20090524]
23. Carter MA, Dubois L. Neighbourhoods and child adiposity: a critical appraisal of the literature. *Health & place*. 2010; 16:616–628. [PubMed: 20106712]
24. Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth: a review. *American journal of preventive medicine*. 2011; 41:442–455. [PubMed: 21961474]
25. Yu E, Lippert AM. Neighborhood Crime Rate, Weight-Related Behaviors, and Obesity: A Systematic Review of the Literature. *Sociology Compass*. 2016; 10:187–207.
26. Moher D, Liberati A, Tetzlaff J, Altman DG, Prisma Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS med*. 2009; 6:1–6.
27. Overview of the CDC Growth Charts URL <https://www.cdc.gov/nccdphp/dnpa/growthcharts/training/modules/module2/text/module2print.pdf>
28. Motl RW, Dishman RK, Ward DS, Saunders RP, Dowda M, Felton G, Pate RR. Perceived physical environment and physical activity across one year among adolescent girls: self-efficacy as a possible mediator? *Journal of Adolescent Health*. 2005; 37:403–408. [PubMed: 16227126]
29. Carver A, Timperio A, Hesketh K, Crawford D. Are safety-related features of the road environment associated with smaller declines in physical activity among youth? *Journal of Urban Health*. 2010; 87:29–43. [PubMed: 19949995]
30. Veitch J, Timperio A, Crawford D, Abbott G, Giles-Corti B, Salmon J. Is the neighbourhood environment associated with sedentary behaviour outside of school hours among children? *Annals of behavioral medicine*. 2011; 41:333–341. [PubMed: 21336879]
31. McTigue KM, Cohen ED, Moore CG, Hipwell AE, Loeber R, Kuller LH. Urban neighborhood features and longitudinal weight development in girls. *American journal of preventive medicine*. 2015; 49:902–911. [PubMed: 26169131]
32. Huynh DT, Dibley MJ, Sibbritt D, Tran H, Le QT. Influence of contextual and individual level risk factors on adiposity in a preschool child cohort in Ho Chi Minh City, Vietnam. *Pediatric Obesity*. 2011; 6:487–500.
33. Burdette AM, Needham BL. Neighborhood environment and body mass index trajectories from adolescence to adulthood. *Journal of Adolescent Health*. 2012; 50:30–37. [PubMed: 22188831]
34. Allen MS, Vella SA. Are the correlates of sport participation similar to those of screen time? *Preventive medicine reports*. 2015; 2:114–117. [PubMed: 26844059]
35. Boone-Heinonen J, Guilkey DK, Evenson KR, Gordon-Larsen P. Residential self-selection bias in the estimation of built environment effects on physical activity between adolescence and young adulthood. *International Journal of Behavioral Nutrition and Physical Activity*. 2010; 7:72–79. [PubMed: 20929571]
36. Pabayo RA, Gauvin L, Barnett TA, Morency P, Nikiéma B, Séguin L. Understanding the determinants of active transportation to school among children: evidence of environmental injustice from the Quebec Longitudinal Study of Child Development. *Health & place*. 2012; 18:163–171. [PubMed: 21937255]
37. Gose M, Plachta-Danielzik S, Willié B, Johannsen M, Landsberg B, Müller MJ. Longitudinal influences of neighbourhood built and social environment on children's weight status. *International journal of environmental research and public health*. 2013; 10:5083–5096. [PubMed: 24132135]
38. Panter J, Corder K, Griffin SJ, Jones AP, van Sluijs EM. Individual, socio-cultural and environmental predictors of uptake and maintenance of active commuting in children: longitudinal results from the SPEEDY study. *International journal of behavioral nutrition and physical activity*. 2013; 10:83–94. [PubMed: 23803180]

39. Prins RG, Kamphuis CB, van Empelen P, Beenackers MA, Brug J, Mackenbach JP, Oenema A. Explaining socio-demographic differences in disengagement from sports in adolescence. *The European Journal of Public Health*. 2013; 23:811–816. [PubMed: 23302764]
40. Henne HM, Tandon PS, Frank LD, Saelens BE. Parental factors in children's active transport to school. *Public health*. 2014; 128:643–646. [PubMed: 24999161]
41. National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies URL <https://www.nhlbi.nih.gov/health-pro/guidelines/in-develop/cardiovascular-risk-reduction/tools/cohort>
42. Gable S, Chang Y, Krull JL. Television watching and frequency of family meals are predictive of overweight onset and persistence in a national sample of school-aged children. *Journal of the american dietetic association*. 2007; 107:53–61. [PubMed: 17197271]
43. Cecil-Karb R, Grogan-Kaylor A. Childhood body mass index in community context: neighborhood safety, television viewing, and growth trajectories of BMI. *Health & social work*. 2009; 34:169–177. [PubMed: 19728476]
44. Hawkins S, Pearce A, Cole TJ, Law C, Millennium Cohort Study Child Health Group. Perceived and objective measures of the neighbourhood environment and overweight in preschool children and their mothers. *International Journal of Pediatric Obesity*. 2009; 4:183–192. [PubMed: 19085539]
45. Bacha JM, Appugliese D, Coleman S, Kaciroti N, Bradley RH, Corwyn RF, Lumeng JC. Maternal perception of neighborhood safety as a predictor of child weight status: The moderating effect of gender and assessment of potential mediators. *International Journal of Pediatric Obesity*. 2010; 5:72–79. [PubMed: 19606373]
46. Crawford D, Cleland V, Timperio A, Salmon J, Andrianopoulos N, Roberts R, Giles-Corti B, Baur L, Ball K. The longitudinal influence of home and neighbourhood environments on children's body mass index and physical activity over 5 years: the CLAN study. *International journal of obesity*. 2010; 34:1177–1187. [PubMed: 20351728]
47. Pabayo R, Gauvin L, Barnett TA, Nikiéma B, Séguin L. Sustained active transportation is associated with a favorable body mass index trajectory across the early school years: findings from the Quebec Longitudinal Study of Child Development birth cohort. *Preventive medicine*. 2010; 50:59–64.
48. Datar A, Nicosia N, Shier V. Parent perceptions of neighborhood safety and children's physical activity, sedentary behavior, and obesity: evidence from a national longitudinal study. *American journal of epidemiology*. 2013; 177:1065–1073. [PubMed: 23579555]
49. Mendoza JA, Liu Y. Active commuting to elementary school and adiposity: an observational study. *Childhood Obesity*. 2014; 10:34–41. [PubMed: 24443901]
50. Schmidt SC, Slegdens EF, de Vries SI, Gubbels J, Thijs C. Longitudinal association of neighborhood variables with Body Mass Index in Dutch school-age children: The KOALA Birth Cohort Study. *Social Science & Medicine*. 2015; 135:99–108. [PubMed: 25965890]
51. Kaczynski AT, Besenyi GM, Stanis SA, Koohsari MJ, Oestman KB, Bergstrom R, Potwarka LR, Reis RS. Are park proximity and park features related to park use and park-based physical activity among adults? Variations by multiple socio-demographic characteristics. *International Journal of Behavioral Nutrition and Physical Activity*. 2014; 11:146–159. [PubMed: 25480157]
52. Sallis JF, Floyd MF, Rodríguez DA, Saelens BE. Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation*. 2012; 125:729–737. [PubMed: 22311885]
53. Godbey G, Mowen A, Ashburn VA. The benefits of physical activity provided by park and recreation services: The scientific evidence. Ashburn, VA: National Recreation and Park Association; 2010
54. An R, Yang Y, Li K. Residential neighborhood amenities and physical activity among US children with special health care needs. *Maternal and Child Health Journal*. 2016:1–11.
55. An R, Sturm R. School and residential neighborhood food environment and diet among California youth. *American journal of preventive medicine*. 2012; 42:129–135. [PubMed: 22261208]
56. Hattori A. Neighborhood food outlets, diet, and obesity among California adults, 2007 and 2009. *Preventing chronic disease*. 2013; 10:1–11.

57. Block JP, Subramanian SV. Moving Beyond “Food Deserts”: Reorienting United States Policies to Reduce Disparities in Diet Quality. *PLoS Med.* 2015; 12:1–9.
58. Maddison R, Vander Hoorn S, Jiang Y, Mhurchu CN, Exeter D, Dorey E, Bullen C, Utter J, Schaaf D, Turley M. The environment and physical activity: The influence of psychosocial, perceived and built environmental factors. *International Journal of Behavioral Nutrition and Physical Activity.* 2009; 6:19–29. [PubMed: 19331652]
59. Van Dyck D, Veitch J, De Bourdeaudhuij I, Thornton L, Ball K. Environmental perceptions as mediators of the relationship between the objective built environment and walking among socioeconomically disadvantaged women. *International Journal of Behavioral Nutrition and Physical Activity.* 2013; 10:108–117. [PubMed: 24050686]
60. Brenner PS, DeLamater JD. Social desirability bias in self-reports of physical activity: is an exercise identity the culprit? *Social Indicators Research.* 2014; 117:489–504.
61. Adams SA, Matthews CE, Ebbeling CB, Moore CG, Cunningham JE, Fulton J, Hebert JR. The effect of social desirability and social approval on self-reports of physical activity. *American journal of epidemiology.* 2005; 161:389–398. [PubMed: 15692083]

Appendix 1 Search algorithm

Search algorithm includes all possible combinations of keywords from the following four groups:

1. “neighborhood”, “neighborhoods”, “neighbourhood”, “neighbourhoods”, “environment”, “environments”, “community”, “communities”, “local area”, “local areas”, “residence”, “city”, “cities”, “county”, “counties”, “village”, “villages”, “town”, “towns”, and “obesogenic”;
2. “safe”, “safety”, “secure”, “security”, “protected”, “crime”, “offense”, and “enforcement”;
3. “child”, “children”, “childhood”, “juvenile”, “pubescent”, “pubertal”, “puberty”, “adolescent”, “adolescents”, “adolescence”, “youth”, “teen”, “teens”, “teenage”, “teen-age”, “teenaged”, “teen-aged”, “teenager”, “teenagers”, “teen-ager”, “teen-agers”, “kid”, “kids”, “youngster”, “youngsters”, “minor”, “minors”, “student”, “students”, “preschooler”, and “preschoolers”; and
4. “diet”, “diets”, “dietary”, “food”, “foods”, “energy intake”, “energy intakes”, “energy consumption”, “calorie”, “calories”, “caloric intake”, “caloric intakes”, “motor activity”, “motor activities”, “sport”, “sports”, “physical fitness”, “physical exertion”, “physical activity”, “physical activities”, “exercise”, “exercises”, “obesity”, “obese”, “adiposity”, “overweight”, “body mass index”, “BMI”, “weight”, “waist circumference”, “waist to hip”, “waist-to-hip”, and “body fat”.

Figure 1.

Figure 2.

Table 1

Basic characteristics of the studies included in the review

Study ID	First author (year)	Country	Sample size	Age at baseline (years)	Follow-up years	Number of repeated measures	Sample characteristics	Statistical model	Attrition rate	Geographical coverage
1	Motl (2005) (28)	U.S.	1,038	12 – 13	1	4	Adolescent girls	Structural equation modeling	26%	Home, playgrounds, parks, or gyms, neighborhood (State level)
2	Gable (2007) (42)	U.S.	8,459	5 – 6	4	6	School-age children	Multilevel logistic regression	5%	N/A (National level)
3	Cecil-Karb (2009) (43)	U.S.	5,886	5 – 20	14	5	Children in the National Longitudinal Survey of Youth	Latent growth curve model	N/A	N/A (National level)
4	Sherburne (2009) (44)	U.K.	8,154	0 – 1	3	8	Infants from families eligible for child benefit	Logistic & multilevel regression	19%	A mile or 20 minutes' walk around home (National level)
5	Bacha (2010) (45)	U.S.	868	8 – 9	2	2	School-age children	Multiple regression	36%	N/A (National level)
6	Boone-Heinonen (2010) (35)	U.S.	12,701	11 – 22	7	7	Adolescents in middle and high schools	Random & fixed effects models	24%	1 km for street characteristics and 3 km for PA facilities. (National level)
7	Carver (2010) (29)	Australia	446	8 – 15	2	2	School-age children	Multiple regression	59%	800 m around home (Local level)
8	Crawford (2010) (46)	Australia	314	10 – 12	5	2	School-age children	Generalized estimating equations	66%	Participants' yard or garden (Local level)
9	Pabayo (2010) (47)	Canada	1,170	6	2	2	School-age children	Latent growth curve model	21.6%	N/A (State level)
10	Huynh (2011) (32)	Vietnam	526	4 – 5	1	3	Urban preschool children	Generalized estimating equations	30%	Playgrounds or parks around homes (Local level)
11	Veitch (2011) (30)	Australia	171	8 – 9	2	3	School-age children	Linear regression models	8%	Playgrounds or parks around homes (Local level)
12	Burdette (2012) (33)	U.S.	9,115	12 – 17	14	2	Adolescents entering young adulthood	Latent growth curve model	17%	N/A (National level)
13	Pabayo (2012) (36)	Canada	710	6	3	2	School-age children	Latent growth curve model	39%	1 mile (State level)
14	Datar (2013) (48)	U.S.	8,300	4 – 5	8	4	Healthy school-age children	Generalized estimating equations	46%	N/A (National level)
15	Gose (2013) (37)	Germany	485	6	4	2	School-age children	Generalized estimating equations	73%	N/A (Local level)
16	Panter (2013) (38)	U.S.	912	10	1	2	School-age children	Multilevel logistic regression	52%	N/A (Local level)

Study ID	First author (year)	Country	Sample size	Age at baseline (years)	Follow-up years	Number of repeated measures	Sample characteristics	Statistical model	Attrition rate	Geographical coverage
17	Prins (2013) (39)	U.K.	357	11	2	2	School-age adolescents	logistic regression & mediation analysis	44%	N/A (Local level)
18	Henne (2014) (40)	U.S.	307	6 – 11	2	2	School-age children	Logistic regression	N/A	20 minutes' walk to the school (Local level)
19	Mendoza (2014) (49)	U.S.	7,938	4 – 5	5	2	Private and public school children	ANCOVA	44%	N/A (National level)
20	Schmid (2015) (50)	Netherlands	1,730	4 – 5	4	2	Healthy school-age children	Generalized estimating equations	33%	N/A(National level)
21	McTigue (2015) (31)	U.S.	2,295	11	5	10	Urban community-living girls	Generalized estimating equations	6%	N/A (State level)
22	Allen (2015) (34)	Australia	3,956	4 – 5	8	17	School-age children	Multiple regression	20.6%	N/A (National level)

Table 2
Measures of neighborhood, weight-related behavior, and body weight status in the studies included in the review

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
1	Self-perceived safety-related characteristics of residential neighborhood	<p>1 It is safe to walk or jog alone in my neighborhood during the day.</p> <p>2 It is difficult to walk or jog in my neighborhood because of things like traffic, no sidewalks, dogs, and gangs.</p>	<p>1 At home there are enough supplies and pieces of sports equipment (like balls, bicycles, skates) to use for physical activity.</p> <p>2 There are playgrounds, parks, or gyms close to my home or that I can get to easily.</p>	Physical activity	Assessed using a 3-day physical activity recall	None
2	Parent-perceived safety-related characteristics of residential neighborhood	Single question: How safe is it for children to play outside during the day in your neighborhood?	None	Physical activity and inactivity	TV hours, aerobic exercise, opportunities for activity, and family meals.	BMI based on measured height and weight
3	Parent-perceived safety-related characteristics of residential neighborhood	<p>1 How would you rate this neighborhood as a place to raise children?</p> <p>2 How much of a problem are the following in your neighborhood: "crime and violence", "abandoned or run-down buildings", "not enough police protection", "people don't care what goes on in the neighborhood", and "people</p>	None	Sedentary behavior	Mothers were asked, "How many hours of TV does your child watch on an average weekday?"	BMI z-score based on measured height and weight

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
4	Parent-perceived safety-related characteristics of residential neighborhood	<p>1 Are there any places where children can play safely?</p> <p>2 Vandalism and deliberate damage to property</p>	<p>1 Parent-perceived environment: food shops and supermarkets that are easy to get to, "how satisfied / dissatisfied are you with the area you live in," "do you have access to a garden", "noisy neighbors or loud parties", "rubbish or litter lying around", "pollution, grime or other environmental problems".</p> <p>2 Objective measures were based on Indices of Deprivation data from the Office for National Statistics</p>	None	None	BMI based on measured height and weight
5	Parent-perceived safety-related characteristics of residential neighborhood	<p>1 It is safe for my child to walk around our neighborhood.</p> <p>2 It is safe in our neighborhood.</p> <p>3 Drug dealers are a problem in our neighborhood.</p>	None	Physical activity and inactivity	Time spent outdoors, child behavior problems	BMI z-score based on measured height and weight

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
		<p>4 My child is afraid of the big kids in the neighborhood.</p> <p>5 My child feels safe playing outside of our home.</p> <p>6 I worry about people with guns and knives in our neighborhood.</p>				
6	Objectively measured crime rate	County-level non-violent and violent crime rate per 100,000 population obtained from Uniform Crime Reporting data (wave I 1995, wave III 2001)	Street connectivity, public facilities, pay facilities, landscape diversity.	Physical activity	Self-reported moderate to vigorous physical activity	None
7	Objectively measured road environment	Geographic information system of street network, total length of local roads, local road index, intersection density, residing on a cul-de-sac, pedestrian network, and re-engineering of road environment	None	<p>1 Active commuting</p> <p>2 Physical activity</p>	<p>1 Parents reported how often per week their children walked/cycled to 15 neighborhood destinations.</p> <p>2 Accelerometer for 8 days</p>	None
8	Parent-perceived safety-related characteristics of residential neighborhood	Reported agreement with 6 statements on a 5-point Likert scale about local traffic ("there is heavy traffic in our local streets"), road safety concerns ("road safety is a concern in our area"), lights/crossings ("there are no lights/crossings for my child to use"), busy roads ("my child would have to cross several roads to get to areas where he/she can play"), sporting venues ("there are few sporting venues within our local area") and public transport ("public transport is limited in my area").	Geographic Information Systems used to map features of the neighbourhood environment (e.g., destinations, road connectivity, and traffic exposure).	Physical activity	Wear a uniaxial accelerometer for 8 days to measure physical activity	BMI z-score based on measured height and weight

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
9	Parent-perceived safety-related characteristics of residential neighborhood	Mothers were asked to characterize their neighborhood for raising children as excellent, good, average, bad, or very bad.	None	Active commuting from/to school (i.e., walking or cycling from/to school)	Parent-reported active vs inactive transportation modes	BMI z-score based on measured height and weight
10	Parent-perceived safety-related characteristics of residential neighborhood	HOME-SF questionnaire and scales	1 Accessibility to restaurants or outlets selling energy-dense food, accessibility to game shops, availability of facilities for outdoor activities (e.g., playgrounds or parks)	1 Dietary intake 2 Physical activity 3 Obesogenic environments	1 A validated FFQ was modified using information from 24-hour recalls. 2 Teacher and parent answered about child's physical activity using a modified validated proxy questionnaire 3 A questionnaire to assess obesogenic environments.	1 BMI cut-off of 23 kg/m ² based on measured height and weight 2 Skinfold thickness measured by Harpenden caliper at 3 sites
11	Parent-perceived safety-related characteristics of residential neighborhood	1 There is a high crime rate in my neighborhood. 2 Stranger danger is a concern of mine.	1 Residential addresses were geocoded using GIS for public open spaces. Trained auditors measured the number of recreational facilities, playgrounds, amenities, walking/cycling paths, lighting along path, trees providing shade, water features and dog signs. 2 Parents reported on social	Sedentary behavior	1 Objective: children wore accelerometers for 8 consecutive days. 1 Subjective: Parents reported total amount of time their child usually spent watching TV/videos /DVD's and playing video games.	None

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
12	Self-perceived safety-related characteristics of residential neighborhood	Asked whether adolescents usually felt safe in the neighborhood	<p>environment factors,</p> <p>1 Parent's perception of neighborhood disorder: significance of problems in the neighborhood, including trash on the sidewalks and drug dealers/users.</p> <p>2 Measured neighborhood disadvantage based on census characteristics</p>	None	None	BMI based on measured height and weight
13	<p>1 Parent-perceived safety-related characteristics of residential neighborhood</p> <p>2 Objectively measured pedestrian-vehicle collisions</p>	<p>1 Neighborhood decay: garbage, trash or broken glass; the sale or consumption of drugs; the presence of alcohol or excessive consumption of alcohol in public; groups of youths causing problems</p> <p>2 Urgences-Sante (centralized ambulance service in Montreal) data on pedestrian-vehicle collisions were used to characterize the area of residence of</p>	<p>1 Mother's perception of neighborhood quality: asked to characterize their neighborhood for raising children as excellent, good, average, bad, or very bad.</p> <p>2 Social cohesion of neighborhood.</p> <p>3 Distance from home to school</p>	Active commuting from/to school (i.e., walking or cycling from/to school)	Parents responded to whether their child's mode of transportation was active (walking/bicycling) or inactive (school bus, public transit, driven, or uses multiple modes)	None

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
		Island of Montreal participants as being dangerous or safe for pedestrians.				
14	Parent-perceived safety-related characteristics of residential neighborhood	Single question: How safe is it for children to play outside during the day in your neighborhood?	None	Physical activity, sedentary behavior	Physical activity: number of day/week child spent at least 20 minutes of vigorous exercise Sedentary behavior: usual number of hours of television-viewing per week	BMI based on measured height and weight
15	1 Parent-perceived safety-related characteristics of residential neighborhood 2 Objectively measured crime rate	1 Parents were asked to report if they felt safe in their neighbourhood and if they were satisfied with their neighbourhood average crime rates 2	1 GIS measured street length, number of food outlets, and distance to playground and park/green space. 2 Food outlets 3 Traffic density 4 Parent-perceived physical and social characteristics of residential neighborhood	None	None	BMI-standard deviation score (BMI-SDS) based on measured height and weight
16	Parent-perceived safety-related characteristics of residential neighborhood	Route safety, neighbourhood environment score, safe to walk/play alone in neighbourhood during the day.	Urban rural status, area-level deprivation score, distance to school, social cohesion, road/street light/ junction density. Effective walkable area, land use, any walking/ cycling provisions	Active commuting from/to school (i.e., walking or cycling from/to school)	Children questionnaire determined active (by foot/bike) or inactive (by car/bus/train)	BMI based on measured height and weight
17	Self-perceived safety-related characteristics of residential neighborhood	Single question: I feel safe in my neighborhood.	Perceived availability of sports facilities and perceived neighbourhood attractiveness	Sports participation	Items on sports frequency during the past 7 days based on the Activity Questionnaire for Adolescents and Adults	None
18	1 Objectively-measured	1 Neighbourhoods were assessed for their walkability at	Distance from home to school	Active commuting from/to school (i.e., walking or cycling from/to school)	Parents reported on child active transport. They responded how many days in an average week their child walks, bicycles, goes	None

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
	neighborhood walkability 2 Parent-reported family rules	the block group level by observation and GIS. 2 Parents identified family rules that they enforce, such as: my child must stay close to or within sight of the house/parent, which acted as a proxy for stranger or crime danger			by car or bus to and from school, for a total of ten trips.	
19	Parent-perceived safety-related characteristics of residential neighborhood	Assessed in kindergarten (not in 5 th grade): (1) safety for children to play outside; (2) presence of garbage/ broken glass; (3) drug use/excessive drinking; (4) burglary or robbery; (5) violent crimes (i.e., drive-by-shootings); and (6) vacant houses/buildings	None	Active commuting from/to school (i.e., walking or cycling from/to school)	How does [child] usually get to school? Does [he/she]: (1) walk or ride a bike, (2) ride a bus, (3) is [he/she] dropped off by a parent, relative, or adult friend, or (4) is [he/ she] dropped off by [his/her] day care provider?	BMI z-score based on measured height and weight
20	Parent-perceived safety-related characteristics of residential neighborhood	1 The street has good street lighting at night 2 Pedestrians/ cyclists can easily be seen from houses 3 Nuisance and small scale crime do not make the neighborhood unsafe during daytime 4 The neighborhood is safe enough to let the child walk or play in the street	Parent-perceived physical and social characteristics of residential neighborhood	None	None	BMI z-score based on measured height and weight

Study ID	Type of neighborhood safety measures	Detailed measures of neighborhood safety	Measures of other neighborhood characteristics	Type of weight-related behavior measures	Detailed measures of weight-related behavior	Detailed measures of body weight status
		<p>without supervision</p> <p>5 Parent feels safe walking or cycling with child in the neighborhood</p> <p>6 Child feels safe walking or cycling in the neighborhood</p>				
21	<p>1 Parent perceived safety related characteristics of residential neighborhood</p> <p>2 Trained field interviewers completed block observations of neighborhood characteristics.</p>	<p>1 Caregivers assessed neighborhood problems using a 17-item "Your Neighborhood" questionnaire.</p> <p>2 A physical disorder index was derived from 5 measures based on the interviewers' block observations.</p>	<p>1 Caregivers assessed neighborhood problems using an 8 items questionnaire.</p> <p>2 2 additional questions related to loitering youth and traffic volume.</p>	None	None	BMI based on measured height and weight
22	Parent-perceived safety-related characteristics of residential neighborhood	A single item "this is a safe neighborhood" and the average score of three items (e.g., "you feel a strong sense of identity with your neighborhood") were used to assess neighborhood safety and neighborhood belonging, respectively.	Index of relative socioeconomic disadvantage and neighborhood remoteness	<p>1 Sports participation</p> <p>2 Screen time</p>	<p>1 Parent questionnaire</p> <p>2 Parent-reported</p>	BMI based on measured height and weight

Estimated effects of neighborhood safety on weighted-related behaviors and body weight status of the studies included in the review

Table 3

Study ID	Estimated effect of neighborhood safety		Main findings of study	
	Weighted-related behavior	Weighted-related outcome	Weighted-related behavior	Weighted-related outcome
1	No longitudinal association between neighborhood safety and physical activity was reported.	None	Perceived neighborhood safety did not exhibit effects on barriers to self-efficacy or physical activity among the black and white girls.	None
2	None	Children who lived in safety neighborhoods were more likely not to be overweight (OR = 0.89; 95% CI: 0.73–1.08) and persistently overweight (OR = 0.76; 95% CI = 0.65, 0.89).		Neighborhood safety is negatively correlated with childhood overweight.
3	None	Parents' perception of neighborhood safety was significantly associated with children's BMI (β = 0.10; SE = 0.08).	When parents perceive their neighborhood to be unsafe, they will restrict their children's outdoor activities and increase the likelihood of sedentary indoor activity.	None
4	None	Without any place for children to play safety is not associated with childhood overweight (OR = 1.02; 95% CI = 0.88, 1.18).	None	No statistically significant results were found between neighborhood safety and BMI in children.
5	None	Neighborhood safety ratings in the least safe tertile, compared to the safest tertile, were associated with an increased risk of obesity independent of gender, race and income (OR = 1.59; 95% CI = 1.03, 2.46). Maternal perception of neighborhood safety as being in the least safe tertile compared to the highest safety tertile was associated with an increased risk of BMI z-score (β = 0.18; 95% CI = 0.00, 0.36).	None	Maternal perception of the neighborhood as unsafe in 3 rd grade independently predicted a higher risk of obesity, and a higher BMI z-score among girls, but not boys, in the 5 th grade.
6	Crime rate was negatively associated with MVPA (boots/week) in both males (β = -0.107; 95% CI = -0.140, -0.075) and females (β = -0.046; 95% CI = -0.083, -0.009).	None	Moderate-to-vigorous physical activity was negatively associated with neighborhood crime rate.	None
7	The number of traffic/pedestrian lights was associated with active transport (AT) among younger girls (β = 0.45, p = 0.004). The total length of walking tracks (in meters) was associated with AT among younger girls (β = 0.0016, p = 0.015) and adolescent girls (β = 0.0016, p = 0.002). For adolescent boys, intersection density was associated with AT (β = 0.03, p = 0.030). Slow points were associated with MVPA among younger boys before school (β = 1.55, p = 0.021), while speed humps were associated with MVPA among adolescent boys after school (β = 0.23, p = 0.015). There were many associations for adolescent girls: for	None	Positive associations were identified between road environment variables and change in active commuting or physical activity.	None

Study ID	Estimated effect of neighborhood safety		Main findings of study	
	Weighted-related behavior	Weighted-related outcome	Weighted-related behavior	Weighted-related outcome
	example, the total length of local roads ($\beta = 0.49$, $p = 0.005$), intersection density ($\beta = 0.05$, $p = 0.036$), and number of speed humps ($\beta = 0.33$, $p = 0.020$) were associated with MVPA during non-school hours.			
8	For moderate-to-vigorous physical activity (min/day): cul-de-sacs: $\beta = 0.07$; 95% CI = 0.01, 0.13 Heavy traffic: $\beta = -8.62$; 95% CI = -17.42, 0.19	No street lights/crossings was not associated with BMI z-score ($\beta = 0.00$; 95% CI = -0.22, 0.23).	The home environment is more important than the neighborhood environment in influencing children's physical activity over 5 years of study period.	The home environment is more important than the neighborhood environment in influencing children's BMI z-score over 5 years of study period.
9	None	Neighborhood safety was not associated with children's BMI z-score ($\beta = 0.03$; SE = 0.08). Neighborhood safety was not associated with children's overweight/obesity (OR = 1.01; 95% CI = 0.70, 1.46).	None	No significant associations were found between perceived neighborhood safety and BMI.
10	None	As safety level of neighborhood increased, BMI and SSFs decreased (coefficients for BMI: $\beta = -0.59$; 95% CI = -1.16, -0.01 for girls and $\beta = -0.80$; 95% CI = -1.53, -0.08 for boys; and coefficients for SSFs: $\beta = -2.71$; 95% CI = -5.07, -0.35 for girls and $\beta = -4.16$; 95% CI = -8.28, -0.05).	None	1 Parents' perceptions of neighborhood safety were found to protect children (both girls and boys) against a significant increase in BMI over the one-year period. 2 Safety of the neighborhood assessed at baseline was shown to have a protective effect on changes in SSFs in both genders over one year of follow-up.
11	Parent's belief that there was a high crime rate in their neighborhood was not associated with TV viewing time ($\beta = 0.00$, estimation uncertainty not provided), computer/e-games time ($\beta = 0.08$, estimation uncertainty not provided), or sedentary time ($\beta = -0.01$, estimation uncertainty not provided).	None	No statistically significant results were found between neighborhood safety and children's sedentary behaviors. No associations were found between perceived social neighborhood factors and time spent in sedentary behaviors.	None
12	None	Parental perceptions of neighborhood disorder ($\beta = 0.00$; SE = 0.01) and neighborhood structural disadvantage ($\beta = 0.01$; SE = 0.00) were positively associated with BMI. Parental perceptions of neighborhood safety was not associated with BMI ($\beta = -0.03$; SE = 0.03).	None	Perceptions of neighborhood safety seem to be an important predictor for the BMI of Latino males, but less so for their Latino female counterparts and all other groups.

Study ID	Estimated effect of neighborhood safety		Main findings of study	
	Weighted-related behavior	Weighted-related outcome	Weighted-related behavior	Weighted-related outcome
13	Among children who lived in high decay neighborhoods, children from insufficient income households were 4.43 (95% CI: 1.62, 12.09) times more likely to use active commuting to/from school as they aged compared to children from sufficient income households.	None	Children from disadvantaged backgrounds and areas were significantly more likely to use active commuting to/from school in kindergarten as well as when they progress through the early school years.	None
14	Changes in parents' perception of neighborhood safety from "very safe" to "somewhat or not at all safe" were associated with fewer days per week of vigorous physical activity ($\beta = -0.127$; SE = 0.035) and 0.40 additional hours per week of television-watching ($\beta = 0.404$; SE = 0.148)	Changes in parents' perception of neighborhood safety from "very safe" to "somewhat or not at all safe" were not found to be associated with changes in BMI percentile ($\beta = -0.030$, SE = 0.215) or obesity ($\beta = 0.002$, SE = 0.003)	Children whose parents perceived their neighborhoods as unsafe watched more TV and participated in less physical activity.	Parent's perceptions of neighborhood safety do not represent a significant risk factor for obesity among school-aged children during the time frame analyzed.
15	None	The independent associations between neighborhood safety and BMI were not estimated.	None	In a multivariate model, walkability, street type, socioeconomic status of the district and perceived frequency of passing trucks/busses were associated with BMI-SDS over 4 years, but only neighbourhood SES had an effect on change in BMI-SDS. Compared to the neighborhood built and social environment, familial/social factors have a greater impact on children's BMI-SDS over 4 years.
16	Perceived rout safety was positively associated with active commuting (OR = 2.67; 95% CI = 1.42, 5.03). Perceived safety to work/play alone in neighborhood was not associated with active commuting (OR = 1.14; 95% CI = 0.68, 1.91). Street light density was positively associated with active commuting (OR = 5.54; 95% CI = 2.84, 10.78).	None	Children whose parents reported the route between home and school was safe, perceived the car as inconvenient, and lived within 1 km of school were more likely to take up active commuting.	None
17	Odds Ratios of disengaged for PA Perceived safety: OR = 0.69; 95% CI = 0.52, 0.92 Perceived attractiveness: OR = 0.69; 95% CI = 0.54, 0.86 Perceived availability of sports facilities: OR = 0.86; 95% CI = 0.48, 1.52 Odds Ratios of ceasing Fitnorm Perceived safety: OR = 0.87; 95% CI = 0.65, 1.16 Perceived attractiveness:	None	Perceived neighborhood safety partly explained the association between gender and disengagement from sports. Girls perceive their neighborhoods as less safe, which explains their higher likelihood to disengage from sports.	None

Study ID	Estimated effect of neighborhood safety		Main findings of study	
	Weighted-related behavior	Weighted-related outcome	Weighted-related behavior	Weighted-related outcome
	OR = 0.80; 95% CI = 0.64, 1.01 Perceived availability of sports facilities: OR = 1.17; 95% CI = 0.65, 2.11			
18	Parents with self-report rules such as “staying close to or within sight of the house/parent” were less likely (OR = 0.40; 95% CI = 0.18, 0.85) to have children who use active commuting to school. High neighborhood walkability was not associated with active commuting to school (OR = 1.25; 95% CI = 0.75, 2.08).	None	No association between neighborhood walkability and child’s active commuting to school was identified. Parents with self-report rules such as “staying close to or within sight of the house/parent” are less likely to have children who use active commuting to school.	None
19	None	Children from high-safe neighborhoods were more likely to have less BMI z-scores ($\beta = -0.02$, 95% CI = -0.04 , -0.01).	Overall, children who did ACS in kindergarten had lower BMI z-scores in fifth grade, compared to their peers who were passive commuters to school, regardless of BMI z-score in kindergarten.	ACS was related to lower BMI z-score among children from less-safe neighborhoods because other forms of physical activity besides ACS were limited in less-safe neighborhoods and thus ACS was an important type of physical activity that decreased children’s risk of excess adiposity.
20	None	<p>1 The streets have good lighting at night: $\beta = -0.042$; 95% CI = -0.085, 0.001</p> <p>2 Pedestrians/cyclists can easily be seen from houses: $\beta = 0.035$; 95% CI = -0.009, 0.079</p> <p>3 Nuisance and small scale crime do not make the neighborhood unsafe during daytime: $\beta = -0.008$; 95% CI = -0.044, 0.029</p> <p>4 The neighborhood is safe enough to let the child walk or play in the street without supervision: $\beta = -0.039$; 95% CI = -0.080, 0.001</p> <p>5 Parent feels safe walking or cycling with child in the neighborhood: $\beta = -0.004$; 95% CI = -0.046, 0.037</p> <p>6 Child feels safe walking or cycling in the neighborhood: $\beta = -0.001$; 95% CI = -0.041, 0.040</p>	None	No statistically significant association is found between parent-perceived neighborhood safety and body weight outcome.
21	None	White girls living in safer neighborhood environment had an annual change in BMI by 0.64 (SE = 0.031) whereas white girls living in less safe neighborhood environment had an	None	No statistically significant association is found between parent-perceived neighborhood safety and body weight outcome.

Study ID	Estimated effect of neighborhood safety		Main findings of study	
	Weighted-related behavior	Weighted-related outcome	Weighted-related behavior	Weighted-related outcome
		annual change in BMI by 0.66 (SE = 0.042). African American girls living in safer neighborhood environment had an annual change in BMI by 0.79 (SE = 0.030) whereas African American girls living in less safe neighborhood environment had an annual change in BMI by 0.80 (SE = 0.039). The effect size of neighborhood safety on BMI is $B = 0.02$		
22	Neighborhood safety level was positively associated with sports participation (hours/week) ($B = -0.34$; $SE = 0.15$) but uncorrelated with total screen time (hours/day) ($B = 0.09$; $SE = 0.06$).	None	Demographic, socioeconomic, and environmental measures taken at age 4 predict time in organized sport and screen time viewing at age 12.	None

Table 4

Meta-analysis of body weight status and physical activity

Weighted-related behavior/outcome	First author (year)	I ² index	Pooled effect size (95% CI)	Model	P-value for dose-response effect from meta-regression	Publication bias test	
						P-value for Egger's test	P-value for Begg's test
(1) BMI z-score	Cecil-Karb (2009) (43); Bacha (2010) (45); Crawford (2010) (46); Pabayo (2010) (47); Datar (2013) (48); Mendoza (2014) (49); Schmid (2015) (50)	0.0%	Beta = 0.018 (0.009, 0.026)	Fixed-effect	NA	0.544	0.879
(2) Overweight	Sherburne (2009) (44); Pabayo (2010) (47)	0.0%	OR = 1.016 (0.886, 1.164) Beta = 0.016 (-0.121, 0.152)	Fixed-effect	NA	NA	1.000
(3) Obesity	Gable (2007) (42); Bacha (2010) (45); Datar (2013) (48)	87.2%	OR = 1.168 (0.948, 1.438) Beta = 0.155 (-0.053, 0.363)	Random-effect	0.399	0.159	1.000
(4) Physical activity (hours/week)	Crawford (2010) (46); Datar (2013) (48)	0.0%	Beta = -0.128 (-0.193, -0.064)	Fixed-effect	NA	NA	1.000

Table 5

Study quality assessment

Study ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Criterion																						
1. Was the research question or objective in this paper clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the study population clearly specified and defined?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Was the participation rate of eligible persons at least 50%?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Was a sample size justification, power description, or variance and effect estimates provided?	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	N	Y
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	N	N	N	N	N	Y	Y	N	N	Y	N	N	Y	N	Y	N	N	Y	N	N	Y	N
10. Was the exposure(s) assessed more than once over time?	Y	Y	Y	N	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12. Were the outcome assessors blinded to the exposure status of participants?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
13. Was loss to follow-up after baseline 20% or less?	N	Y	N	Y	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	Y	N
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Total score	9	11	10	10	9	11	9	9	8	10	10	10	9	9	9	7	8	8	9	9	11	9

Notes: This study quality assessment tool was adopted from the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies. For each criterion, a score of one was assigned if "Y" was the response, whereas a score of zero was assigned otherwise. A study-specific global score, ranging from zero to 14, was calculated by summing up scores across all 14 criteria. Study quality assessment helped measure strength of scientific evidence, but was not used to determine the inclusion of studies.