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A systematic review of neighbourhood economic context on child obesity and obesity-related behaviours

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Summary

Childhood obesity is of great importance given a third of children in the USA are overweight or obese. Previous research has examined neighbourhood economic context in relation to children's obesity and obesity-rated behaviours. However, different definitions and measures of neighbourhood context make it difficult to compare findings and make definitive conclusions. This review is to synthesize studies assessing the associations between neighbourhood economic context and children's obesity or obesity-related behaviours. The review included 39 studies investigating the relationship between residential neighbourhood economic context and children's obesity, dietary habits or physical activity after controlling for family-level economic status. Studies reported mixed results in the relationship between neighbourhood economic indicators and child obesity outcomes. Of reviewed studies, 60% showed an inverse association between higher neighbourhood economic status and obesity, and 33% and 14% showed positive associations between higher neighbourhood economic status and healthy dietary habits or physical activity. Several studies suggested gender, age, race/ethnicity, individual-level economic status, rurality and social connectedness as moderators in the neighbourhood-obesity association. Findings suggest that, in order to move towards causal inferences and inform interventions, future research should examine neighbourhood impacts longitudinally and test theory-driven mediators and moderators to clarify the mechanisms by which neighbourhoods influence child obesity.

Keywords: Child obesity, dietary habits, neighbourhood impacts, physical activity.

Introduction

Child obesity is a serious public health concern in the USA. Child obesity increases risk of developing adverse health conditions, such as heart disease, high blood pressure, diabetes, cardiovascular complications and some cancers (1–6). For example, type 2 diabetes mellitus is now increasingly identified among children with obesity although it was once classified as an adult-onset disease (7). Child obesity also negatively affects psychological development such as self-concept and self-esteem and later high-risk behaviours such as smoking and alcohol use (8–10).

One sixth of US children aged 2–19 are considered obese (11), more than double the situation three decades ago (12). Child obesity-related behaviours, such as unhealthy dietary habits and insufficient physical activity, are also highly prevalent. About one in seven children consume the recommended amount of fruits, vegetables or both (13); only four of every 10 US children aged 6–11 engage in the age-specific recommended levels of physical activity (14). Moreover, socioeconomic disparities in child obesity and obesity-related behaviours have recently increased (15). While obesity rates among high socioeconomic status children have begun to plateau in recent years, the rates among low socioeconomic status children have continued to increase (15). A similar pattern was found in the prevalence of obesity-related behaviours (15). Overall, children presented healthier behaviours – consuming fewer calories

and more physical activity – than they did before, but low socioeconomic status children showed a smaller improvement than their high socioeconomic status counterpart.

Prior review studies have examined individual-level and family-level factors related to child obesity and obesity-related behaviours (16,17) – e.g. genetic or biological factors, race/ethnicity, family socioeconomic status and family stressors (18–23). Despite the importance of individual-level and family-level factors in determining child obesity, widening socioeconomic inequalities in child obesity and obesity-related behaviours imply a role for structural determinants. Extensive literature has investigated the role of neighbourhood economic context in child obesity and obesity-related behaviours (24–26). For example, researchers have examined neighbourhood poverty rates, household median income and unemployment rates as determinants of child obesity and obesity-related behaviours (27–29).

Understanding how neighbourhood economic context affects individual child obesity is important for planning and implementing effective policy initiatives to reduce child obesity disparities. However, there are theoretical and empirical inconsistencies in how neighbourhood economic context influences individual child obesity. For example, the neighbourhood institutional resource models posit that a high level of neighbourhood affluence prevents child obesity through accessibility to health-promoting services and facilities within the neighbourhoods (30). Conversely, according to the relative deprivation model, poor children in affluent neighbourhoods may feel deprived and become psychologically distressed when comparing themselves to affluent peers in the neighbourhood, leading to higher risks of child obesity (30–32). Furthermore, the use of different definitions and measures of neighbourhood context by prior empirical studies made it difficult to compare findings and draw definitive conclusions.

Given the theoretical and empirical inconsistencies in examining the relationship between neighbourhood economic context in child obesity/obesity-related behaviours, a systematic literature review is needed for clarification. However, only one literature review has examined the effect of neighbourhood economic context on children's obesity (discussed in the next discussion). To fill the research gap, the present study reviews the empirical literature on the role of neighbourhood economic context in child obesity and obesity-related behaviours (dietary habits and physical activity, in particular) and suggests directions for future research.

Previous reviews

In recent years, a growing body of systematic review literature has documented the association between neighbourhood economic characteristics and child health. Shrewsbury and Wardle (16) conducted a systematic review of the association between individual/neighbourhood socioeconomic status and adiposity in children based on 45 studies. Seven of the studies used neighbourhood-level socioeconomic status indicators in analyses. Four of these studies showed an inverse association between neighbourhood socioeconomic status and adiposity, and three studies showed no significant association. However, this review did not describe how neighbourhood socioeconomic status was measured, what conceptual mechanisms were used to explain the role of neighbourhood socioeconomic status nor did it examine the role of potential mediators in the relationship between neighbourhood socioeconomic status and adiposity in the literature. Van Der Horst and colleagues (17) reviewed 58 studies on multilevel factors in child dietary habits. Only one of the reviewed studies included was related to neighbourhood economic context, which reported a negative association between neighbourhood economic disadvantage and healthy dietary habits.

Sellström and Bremberg (33) reviewed multilevel studies on neighbourhood context and birth weight, mental health and injuries from 1990 to 2003 and found that neighbourhood socioeconomic status had small to moderate effects on these health outcomes. However, the authors did not review studies on children's dietary habits, physical activity and obesity. Similarly, Leventhal and Brooks-Gunn (26) comprehensively reviewed literature about neighbourhood impacts on child well-being; however, the study did not include children's dietary habits, physical activity or obesity. There does not appear to be a review of studies on the role of neighbourhood economic context in child obesity and obesity-related behaviours.

The present study

The study reported here provides a systematic review of quantitative research examining the association between neighbourhood context and obesity, dietary habits or physical activity among children. The study addressed the following questions: (i) What characteristics of neighbourhood economic context have been studied? (ii) What mechanisms have been used to explain the role of neighbourhood economic context on child obesity, dietary habits or physical activity? (iii) What research methods were used? (iv) Which measures of neighbourhood economic context are consistently associated with child obesity, dietary habits or physical activity? and (v) which moderating or mediating factors are consistently associated with the association between neighbourhood economic context and child obesity, dietary habits or physical activity?

Methods

A systematic review methodology was used to comprehensively identify and synthesize research by using

predetermined, specific inclusion criteria and comprehensive and explicit search strategy (34–36).

Inclusion criteria

Quantitative published studies in English and unpublished studies found in dissertations and research reports that met search criteria were reviewed. The review was limited to studies whose samples were children aged 3 to 17 years. In addition, each article or report had to meet the following criteria: (i) primarily investigated the effect of residential neighbourhood economic context on child obesity, dietary habits or physical activity; (ii) included more than 10 neighbourhoods; (iii) controlled for family-level economic status; and (iv) focused on a developed country. Cross-sectional as well as longitudinal studies were included.

Search strategy

Several search strategies were used to create an initial pool of study candidates. First, searches in the following electronic databases were conducted: PubMed, PsycINFO, ERIC, Academic Search Complete, and Dissertations and Theses Global. Studies in these five electronic databases were searched using the terms: (neighbor OR ecological OR geographic) AND (economic OR poverty OR affluence OR inequality OR Townsend OR income OR disadvantaged OR deprivation OR employment OR built environment OR supermarket OR grocery OR street OR park OR distance OR density) AND (child OR kid OR adolescent OR youth OR student) AND (nutrition OR diet OR food OR vegetable OR fruit OR physical activity OR exercise OR sedentary OR obesity OR fat OR BMI OR adiposity) for the period up to and including 8 January 2018. The first reviewer reviewed the title of the candidate studies (first step) and excluded 1,213 that clearly did not meet one or more of the selection criteria. Then, two reviewers independently reviewed abstract (second step) and full-text (third step) of the remaining studies. Cohen's kappa for inter-reviewer agreement was 58%. When there were questions about a particular study, the reviewers discussed the eligibility of the study until consensus was reached. If the first and second reviewers were able to resolve their different opinions, a third reviewer was consulted. Two studies were brought to a third reviewer, and we included the two articles based on further examination of the articles in relationship to our selection criteria. In cases where it could not be determined from the title or abstract whether or not the article met all inclusion criteria, the study was set aside for further review.

Next, the reference lists of the remaining studies were reviewed to find studies that might not have been identified previously. Additionally, the corresponding author of all studies eligible for inclusion in the review and other authors known to work in the field were contacted to get unidentified research. Of the studies reviewed, 39 met the inclusion criteria specified for the systematic review (see Fig. 1).

Quality assessment

Independent reviewers assessed the studies on quality indicators adapted from the Newcastle–Ottawa Scale (NOS) (37) that have been recommended in systematic reviews. The NOS was designed to evaluate repetitiveness of sampling procedure, response rate, validity of measurement methods, control of important confounders and validity of statistical analysis. Cohen's kappa for inter-reviewer agreement was 0.85 (95% CI = 0.79 to 0.91), and any disagreement was resolved through discussion.

Data extraction

Data extracted from each study were recorded in a Microsoft Word file. The first coder coded all 39 studies, and the second and third coders independently coded half of the studies. Disagreements were resolved through discussion. Cohen's kappa for inter-reviewer agreement was 0.87 (95% CI = 0.85 to 0.90).

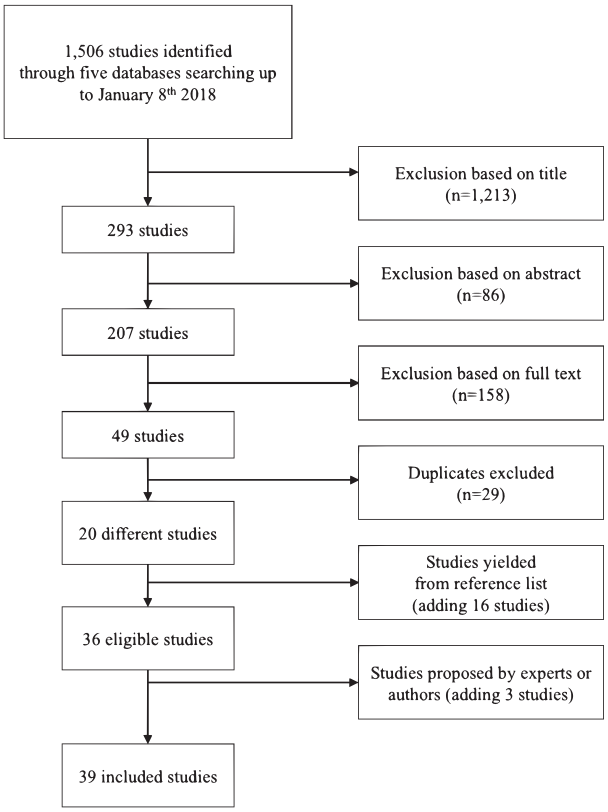

Figure 1 Flow chart of the systematic literature search.

Variables of dietary habits were categorized into healthy dietary habits and unhealthy dietary habits. Physical activity variables were categorized into physical activity, physical inactivity, sedentary behaviours and active commuting to school. Neighbourhood economic context was categorized using nine constructs: (i) poverty (e.g. the proportion of persons in the neighbourhood living below the federal poverty threshold), (ii) affluence (e.g. the proportion of persons in the neighbourhood living above specified income), (iii) general income level (e.g. median family income), (iv) home ownership, (v) unemployment rate, (vi) high-status occupation rate, (vii) income inequality (e.g. Gini index), (viii) composite indicator of disadvantaged neighbourhoods and (ix) composite indicator of advantaged neighbourhoods.

Results

Identified studies

As shown in Table 1, all studies were published after 1 January 2005. Twenty-nine studies of the studies were conducted in the USA. Sample sizes ranged from 215 to 20,745 children, and two thirds of the studies (27 studies) examined 1,000 or more children. Quality of study assessment indicated overall satisfactory study quality in ensuring enough sample size (n = 33, 85%), controlling for important individual-level confounders (n = 39, 100%) and clearly describing statistical testing and its results (n = 38, 97%). The most consistent sources of potential bias included

Table 1 Description of included studies

Author (year)	Location	Sample	Age	Data type
Alvarado (2011) (49)	USA	11,469	M = 10	Longitudinal
Alvarado (2016) (43)	USA	11,499	M = 10	Longitudinal
Bell *et al.* (2008) (63)	USA	3,831	M = 9	Longitudinal
Bell-Ellison (2008) (44)	USA	10,860	M = 16	Cross-sectional
Boone-Heinonen and Gordon-Larsen (2011) (45)	USA	12,701	M = 15	Cross-sectional
Boone-Heinonen *et al.* (2010) (40)	USA	12,701	M = 15	Longitudinal
Boone-Heinonen *et al.* (2010) (53)	USA	17,294	11–22	Cross-sectional
Carroll-Scott *et al.* (2013) (42)	USA	1,048	M = 11	Cross-sectional
Carroll-Scott *et al.* (2015) (52)	USA	811	Grade 5–6	Cross-sectional
Frost (2011) (62)	USA	308	Grade 4–5	Cross-sectional
Grow *et al.* (2010) (54)	USA	8,616	6–18	Cross-sectional
Hughey (2017) (59)	USA	13,469	M = 10	Cross-sectional
Kim and Cubbin (2017) (41)	USA	2,670	4–10	Cross-sectional
Kimbro *et al.* (2011) (55)	USA	1,822	M = 5	Cross-sectional
Kowaleski-Jones and Wen (2013) (51)	USA	1,753	M = 6	Cross-sectional
Kowaleski-Jones *et al.* (2017) (56)	USA	2,706	6–17	Cross-sectional
Lee (2009) (60)	USA	6,493	M = 15	Longitudinal
Leung *et al.* (2010) (57)	USA	215 girls	M = 7	Cross-sectional
Lovasi *et al.* (2011) (27)	USA	428	M = 4	Cross-sectional
Lovasi *et al.* (2013) (69)	USA	11,562 poor children	M = 4	Cross-sectional
McTigue *et al.* (2015) (58)	USA	2,295 girls	M = 11	Longitudinal
Nelson *et al.* (2006) (61)	USA	20,745	M = 15	Cross-sectional
Ohri-Vachaspati *et al.* (2014) (64)	USA	560	3–18	Cross-sectional
Pabayo *et al.* (2011) (47)	USA	889	M = 10	Longitudinal
Rossen (2014) (48)	USA	17,100	M = 10	Cross-sectional
Saelens *et al.* (2012) (65)	USA	681	M = 9	Cross-sectional
Salomonsen-Sautel (2011) (68)	USA	863	M = 10	Cross-sectional
Voorhees *et al.* (2009) (67)	USA	1,554 women	11–22	Cross-sectional
Yin *et al.* (2012) (70)	USA	495	M = 9	Cross-sectional
Levin (2014) (50)	UK	2,683	M = 15	Cross-sectional
Gropp *et al.* (2012) (71)	Canada	3,997	11–15	Cross-sectional
Janssen *et al.* (2006) (28)	Canada	6,684	Grade 6–10	Cross-sectional
Laxer and Janssen (2013) (72)	Canada	6,626	M = 13	Cross-sectional
Laxer and Janssen (2014) (73)	Canada	6,099	M = 13	Cross-sectional
Mecredy *et al.* (2011) (74)	Canada	8,535	11–15	Cross-sectional
Oliver and Hayes (2005) (66)	Canada	11,455	5–17	Cross-sectional
De Meester *et al.* (2012) (38)	Belgium	637	M = 15	Cross-sectional
De Meester *et al.* (2013) (46)	Belgium	637	M = 15	Cross-sectional
Timperio *et al.* (2006) (39)	Australia	912	5–6/10–12	Cross-sectional

M, mean.

self-reported or parental-reported outcome measures (n = 20, 51%) and no description of the response rate in the data (n = 20, 51%). Overall, all studies demonstrated satisfactory quality based on the NOS.

Conceptual frameworks

There was little use of theory to inform the mechanisms by which neighbourhood economic context influences child obesity and health behaviours, although a few studies (38,39) mentioned a guiding theory or model informing neighbourhood as a key determinant for individual health. Instead, in most studies, authors briefly mentioned, primarily based on prior literature, how or why variables might be associated with outcomes of interest. Several studies presented potential mediators, moderators or both in the relationship between neighbourhood economic context and child obesity and/or obesity-related behaviours. For example, built environments were described to moderate or mediate the association between neighbourhood economic context and child obesity and/or obesity-related behaviours (40,41). Economically disadvantaged neighbourhoods had fewer healthy food and physical activity resources (e.g. large grocery stores, recreational facilities and bike lanes), hazardous conditions (e.g. vacant housing and litter on roads) or unhealthy food resources (e.g. fast food restaurants and convenience stores), which may increase risks of being obese or having unhealthy behaviours. For potential mediators, social environments such as social ties or cohesion and positive health norms were reported (41,42). One study (42) illustrated that affluent residents might sustain neighbourhood social organizations (e.g. voluntary organizations) that promote social ties and positive health norms.

Several moderators were also conceptually described including age, gender, race/ethnicity and individual economic status (38,41,43–48). For example, one study (43) described that women tend to engage in sedentary behaviour as a coping strategy for the stress associated with living in a disadvantaged neighbourhood, which may imply stronger neighbourhood impacts for women than men. Other studies also argued that neighbourhood effects are more influential on women than men (45,47). While some studies illustrated that neighbourhood economic context may be more pronounced for minorities than Whites (48,49), Bell-Ellison (44) argued that a racial or ethnic minority group is less likely to be affected by neighbourhood poverty than Whites. Two studies (38,50) explained neighbourhood economic context as a moderator in the relationship between built environments or rurality and child health.

Conceptualization of neighbourhoods

Of the 39 studies, 16 (41%) measured neighbourhood economic context based on census tracts (40–45,48,49,51–58). A census unit aggregation implies a homogenous geographic area with visible boundaries and residents of similar sociodemographic characteristics. Thirteen studies were based on other census subdivisions or administrative entities such as block group, block, ZIP code, dissemination area or statistical area (38,39,46,47,50,59–66). The remaining 10 studies used buffers based on the surroundings of a place of residence or school (27,28,67–74).

Research methods

Of the types of study designs, 32 (82%) of the studies were cross-sectional, and seven (18%) were longitudinal (see Table 1). Regarding level of analysis, half (19 studies) used multilevel analysis, and the other half (19 studies) used non-multilevel analysis. One study (68) used multilevel analysis to predict factors for boys' physical activity and used non-multilevel analysis to predict factors for girls' physical activity and active transport because of insignificant between-neighbourhood variation for girls' physical activity and active transport.

Studies included family economic status in a multivariate model to examine neighbourhood impacts on child obesity or obesity-related behaviours, theoretically 'independent' of family economic status. Twelve studies controlled for family income only, several economic factors (10 studies), family wealth only (six studies), health insurance status only (three studies), parental employment status only (two studies), free/reduced school lunch only (three studies) and public assistance receipt only (one study). In the remaining two studies, the sample was limited to children from low-income families, so family economic status was not controlled (41,69).

Neighbourhood economic context and obesity

Table 2 summarized results from the 20 studies that examined the association between neighbourhood economic context and child body mass index (BMI), obesity and/or overweight. Most studies have measured obesity based on BMI, but one used skinfold thickness (27), and another used percentage of body fat via X-ray (70). Child BMI, obesity and/or overweight were assessed directly by a trained person or an equipment (measuring device) in 14 studies (27,42,43,48,51,52,54,58,59,63,65,67,69,70) and by self-reported or parent-reported in other studies (28,44,49,61,64,66).

Among the 20 studies, 13 studies showed significant findings (28,43,44,48,49,51,54,58,59,61,64,66,69). Specifically, among the six studies using neighbourhood poverty, two studies showed a significantly positive relationship with child overweight/obesity (51,58), and one study showed an inverse relationship with child obesity (69). Contrary to the two studies finding a positive relationship, the study that showed an inverse relationship focused on children in low-

Table 2 Findings on the association between neighbourhood economic context and obesity

Author (year)	Exposure measure	Outcome	Results
Alvarado (2011) (49)	Poverty	Obesity	ns
	Occupational status	Obesity	ns
	Unemployment	Obesity	Positive
Alvarado (2016) (43)	Index (deprivation)	Obesity	Positive
Bell *et al.* (2008) (63)	Median income level	BMI	ns
Bell-Ellison (2008) (44)	Index (affluence)	BMI	Inverse
	Index (disadvantage)	BMI	ns
Carroll-Scott *et al.* (2013) (42)	Index (affluence)	BMI	ns
	Index (disadvantage)	BMI	ns
Carroll-Scott *et al.* (2015) (52)	Index (affluence)	BMI	ns
	Index (disadvantage)	BMI	ns
Grow *et al.* (2010) (54)	Home ownership	Obesity	Inverse
	Median income level	Obesity	Inverse
Hughey (2017) (59)	Index (disadvantage)	BMI	Positive
Janssen *et al.* (2006) (28)	Median income level	Obesity	ns
	Unemployment	Obesity	Positive
Kowaleski-Jones and Wen (2013) (51)	Poverty	Overweight	Positive
Lovasi *et al.* (2011) (27)	Poverty	BMI/skinfolds	ns
Lovasi *et al.* (2013) (69)	Poverty	BMI/obesity	Inverse
McTigue *et al.* (2015) (58)	Poverty	Annual change in BMI	Positive
Nelson *et al.* (2006) (61)	Median income level	Overweight	Inverse
Ohri-Vachaspati *et al.* (2014) (64)	Median income level	Overweight/obesity	Inverse
Oliver and Hayes (2005) (66)	Index (socioeconomic status)	Overweight	Inverse
Rossen (2014) (48)	Index (deprivation)	Obesity	Positive
Saelens *et al.* (2012) (65)	Median income level	Overweight/obesity	ns
Voorhees *et al.* (2009) (67)	Index (Townsend deprivation)	BMI	ns
Yin *et al.* (2012) (70)	Median income level	Percentage of body fat	ns
	Poverty	Percentage of body fat	ns

BMI, body mass index; ns, non-significant.

income families (69). Among the seven studies focusing on median income level, three studies showed a significant inverse association between median income level and child BMI/overweight/obesity (54,61,64). Neighbourhood unemployment level was related to higher risks of child obesity in two studies (28,49), and home ownership was also related to lower risks of child overweight/obesity in one study (54). Of the eight studies that used composite variables, five showed that children in economically advantaged neighbourhoods had lower likelihood of BMI/overweight/obesity (43,44,48,59,66), and three showed no significant association (42,52,67).

Neighbourhood economic context and dietary habits

Table 3 shows findings of the six studies that examined the association between neighbourhood economic context and child dietary habits. Studies have measured healthy eating habits (four studies) and/or total energy intake (one study).

Table 3 Findings on the association between neighbourhood economic context and dietary habits

Author (year)	Exposure measure	Outcome	Results
Carroll-Scott *et al.* (2013) (42)	Index (disadvantage)	Healthy dietary habits	ns
	Index (affluence)	Healthy dietary habits	Positive
	Index (disadvantage)	Unhealthy dietary habits	ns
	Index (affluence)	Unhealthy dietary habits	Negative
Frost (2011) (62)	Index (socioeconomic status)	Healthy dietary habits	ns
Janssen *et al.* (2006) (28)	Median income level	Unhealthy dietary habits	ns
	Unemployment	Unhealthy dietary habits	ns
Laxer and Janssen (2014) (72)	Index (socioeconomic status)	Unhealthy dietary habits	ns
Leung *et al.* (2010) (57)	Index (deprivation)	Diets	ns
Levin (2014) (50)	Index (deprivation)	Healthy dietary habits	Inverse
	Index (deprivation)	Unhealthy dietary habits	Positive

ns, non-significant.

Child dietary habits were self-reported or parent-reported in all studies.

Of the six studies examining neighbourhood economic context, two showed a significant association. Carroll-Scott and colleagues (42) reported that a neighbourhood affluence index (based on the proportions of residents with a college education, high income and executive or professional jobs, with higher scores indicating more advantage) was positively associated with healthier eating habits among children living within those neighbourhoods. Levin (50) found that children living in disadvantaged neighbourhoods (based on 37 indicators across seven domains including income and employment (75)) displayed less healthy eating habits compared with children living in less disadvantaged neighbourhoods. As an exception, contrary to the hypothesis, the disadvantaged neighbourhood index was positively associated with regular breakfast consumption. This finding might be due to breakfast clubs (supervised provision of food to some or all pupils before the beginning of the school day, whether provided free or at a charge (76)) in Scotland. A third of primary schools and half of secondary schools provided 'breakfast clubs' for pupils in Scotland (50). In the other four studies, neighbourhood economic context was not significantly associated with child dietary habits.

Neighbourhood economic context and physical activity

Table 4 presents the findings of 14 studies examining the association between neighbourhood economic context and physical activity (11 studies), physical inactivity (two studies), sedentary behaviours (two studies) and/or active transport (two studies). Trained staff or objective equipment directly measured the outcome variables in six studies.

Of the 11 studies that examined the association between neighbourhood economic context and physical activity, only two showed a significant association between these variables. Specifically, as levels of neighbourhood deprivation increased, children exhibited a lower level of physical activity (47). By contrast, another study showed a negative association between median income and walking during leisure time among Belgian adolescents (38). On the other hand, Voorhees and colleagues (67) examined the relationship between neighbourhood economic context and physical activity type/locations. Results showed that girls in advantaged neighbourhoods were more likely to engage in physical activity at school or at a community facility (vs. at home or in their neighbourhood) and in organized activity (transportation-based/work-based physical activity) than girls in disadvantaged neighbourhoods. Two studies focused on the relationship between neighbourhood economic context and physical inactivity, but neither reported a significant association. Two studies examined the association between neighbourhood economic context and sedentary behaviours, and Carroll-Scott *et al.* (42) found that neighbourhood affluence was inversely associated with sedentary behaviours. For active commuting, two studies tested its relation to median income level and showed no significant association with active commuting from or to schools.

Table 4 Findings on the association between neighbourhood economic context and physical activity

Author (year)	Exposure measure	Outcome	Results
Boone-Heinonen *et al.* (2010) (40)	Median income level	Physical activity	ns
Boone-Heinonen and Gordon-Larsen (2011) (45)	Median income level	Physical activity	ns
Carroll-Scott *et al.* (2013) (42)	Index (disadvantage)	Physical activity	ns
	Index (affluence)	Physical activity	ns
	Index (disadvantage)	Sedentary behaviours	ns
	Index (affluence)	Sedentary behaviours	Inverse
De Meester *et al.* (2012) (38)	Median income level	Physical activity	Inverse
	Median income level	Active commuting	ns
Frost (2011) (62)	Index (socioeconomic status)	Physical activity	ns
Gropp *et al.* (2012) (71)	Median income level	Active commuting	ns
Janssen *et al.* (2006) (28)	Median income level	Physical inactivity	ns
	Unemployment	Physical inactivity	ns
Kimbro *et al.* (2011) (55)	Poverty	Physical activity	ns
	Poverty	Sedentary behaviours	ns
Laxer and Janssen (2013) (72)	Index (socioeconomic status)	Physical inactivity	ns
Leung *et al.* (2010) (57)	Index (deprivation)	Physical activity	ns
Lovasi *et al.* (2011) (27)	Poverty	Physical activity	ns
Mecredy *et al.* (2011) (74)	Index (socioeconomic status)	Physical activity	ns
Pabayo *et al.* (2011) (47)	Index (deprivation)	Weekday physical activity	Inverse
	Index (deprivation)	Weekend physical activity	ns
Voorhees *et al.* (2009) (67)	Index (Townsend deprivation)	Physical activity	ns
	Index (Townsend deprivation)	Physical activity type and location	sig.

ns, non-significant; sig., significant.

Mediators and moderators

Moderators were tested in the 22 studies that examined the relationship between neighbourhood economic context and child obesity or obesity-related behaviours (see Appendix Table 1). The table we also included variables used to stratify the sample population to explore potential moderators. Twenty-two studies tested age, gender, race/ethnicity, grade, family economic status, residential relocation, rurality, walkability, school socioeconomic status, school connectedness or weather as a potential moderator.

In terms of age, three studies examined its moderating role in the relationship between neighbourhood economic context and child obesity or physical activity. Two out of three studies showed a stronger association between neighbourhood economic context and outcomes for older children. For example, one study showed that neighbourhood deprivation was more strongly associated with obesity for adolescents than for young school-aged children (43).

Gender was the most studied moderator. Nine studies investigated the moderating effect of gender on the relationship between neighbourhood economic context and child obesity, unhealthy diets or physical activity. Four out of five studies examining the association between neighbourhood economic context and obesity consistently showed a significant interaction role with gender. Three studies showed that neighbourhood economic context is more strongly associated with obesity in girls than boys (43,51,60). For example, one study examined the longitudinal effect of neighbourhood risk factors on becoming obese separately for boys and girls and showed a significant association only for girls (60). On the other hand, Lovasi and colleagues (69) found a significant relationship between neighbourhood poverty rate and obesity only among male preschoolers, not among female preschoolers.

In the case of physical activity, two out of six studies investigating the potential moderating effect of gender on the association between neighbourhood economic context and child physical activity showed an interaction role with gender. For example, using a composite measure of economic deprivation, Pabayo and colleagues (47) found that average minutes of weekday physical activity was lower among boys living in highly economically deprived areas than boys living in economically advantaged areas whereas average minutes of weekday physical activity was higher among girls living highly economically deprived areas than girls living in economically advantaged areas.

Four studies investigated the potential moderating effect of race/ethnicity in the neighbourhood–child health association. Two out of four studies found race/ethnicity differences in such association. One study (48) showed higher risks of obesity for non-Hispanic Black children and Mexican American children in less deprived neighbourhoods compared with non-Hispanic White children in the same type of group. Alvarado (49) examined the association between the proportion of unemployed residents and obesity separately for Black and Latino children and found a significant positive association only among Latino children.

In terms of family economic status, Rossen (48) investigated the moderating role of family-level poverty in the relationship between neighbourhood deprivation and obesity and found a positive association between neighbourhood deprivation and obesity among non-poor children and an insignificant association among poor children. Using a stratified sample by family poverty status, Kim and Cubbin (41) found that neighbourhood poverty and income inequality were associated with physical activity among poor, but not non-poor, children.

Some studies investigated rurality, neighbourhood walkability, school connectedness or school-level economic status. Rurality was a significant moderator in the relationship between neighbourhood economic context and healthy eating behaviours in one study (50). Specifically, children living in the most economically deprived and remote rural neighbourhoods consumed less fruits than those living in urban neighbourhoods of equivalent deprivation (50). Among children living in affluent neighbourhoods, children in remote rural neighbourhoods consumed more fruits than their urban counterparts (50). In the case of neighbourhood walkability, two studies found that walkability was positively associated with physical activity among children living in neighbourhoods with low median household income, but not among those in neighbourhoods with high median household income (38,46). School socioeconomic status, measured by school-level parent education level, parental occupation and percentage of students not eligible for free lunch, was not a significant moderator in the relationship between neighbourhood economic context (neighbourhood deprivation and affluence) and child obesity (44). On the other hand, school connectedness was a significant moderator in another study (i.e. school connectedness was more strongly associated with lower BMI for children in highly affluent neighbourhoods than in lower affluent neighbourhoods) (52).

Two studies (41,62) investigated whether healthy and unhealthy food environments (e.g. the number of grocery stores and the number of fast-food restaurants) and physical activity environments (e.g. distance to the closest park, the number of recreation centres and street connectivity) mediate the associations between neighbourhood economic context and child obesity, fruit and vegetable intake or physical activity and found no evidence for it.

Collectively, studies are relatively scarce, and findings are inconsistent across several moderators/mediators; however, a few studies suggested that gender, age, race/ethnicity, individual-level economic status, rurality and social connectedness may moderate the relationship between

neighbourhood economic context and child obesity and/or BMI.

Discussion

This is, to our knowledge, the first systematic review to examine moderators and mediators as well as the association between neighbourhood economic context and child obesity and obesity-related behaviours. This study included a wide range of neighbourhood economic factors as correlates of child obesity and/or obesity-related behaviours, and five databases were searched along with an extensive search of cited references. This review showed the consistently significant association between neighbourhood economic context and child obesity/BMI but inconclusive results on the associations between neighbourhood economic context and child diets and physical activity. This review describes several limitations of past studies and suggests future research directions towards better understanding of the effect of neighbourhood economic context on child obesity and obesity-related behaviours, as follows.

The literature reviewed in this study lacks theories explaining the mechanisms by which neighbourhoods influence child outcomes. Most of the studies used general reasoning based on prior literature to explain the mechanisms by which neighbourhoods influence child outcomes. Studies suggested several potential mediators – such as built and social environments; however, only two studies conducted a mediation test (41,62).

There are several methodological limitations in the past studies. First, half of the studies relied on self-reported or parent-reported measures of child obesity, dietary habits and/or physical activity, which can suffer from social desirability or recall bias (77–79). Using objectively measured dietary habits, physical activity and weight would improve the quality of studies and perhaps reduce inconsistent results in prior studies. Second, for neighbourhood economic context, studies usually used neighbourhood poverty, median income or an index of neighbourhood indicators including several aspects of economic characteristics. While more comprehensive, using an index precludes interpretation of how particular economic factors affect health (80). Furthermore, neighbourhood economic factors were measured using only a point-in-time measure, which may result in lumping together neighbourhoods that have experienced different conditions over time (81). In addition, indicators representing the distribution of economic resources (i.e. relative economic context), such as income inequality, have been little examined. Future research should justify a particular economic measure for avoiding claims to have measured economic context overall (80), consider neighbourhood economic history for capturing diverse neighbourhood heterogeneous health environments (81) and investigate a variety of economic factors. Finally, most studies used cross-sectional data so that they could not verify the direction of causality in their findings. More longitudinal investigations of neighbourhood economic context on child obesity and obesity-related behaviours are warranted.

Moderators and mediators are less examined, and findings about their associations with child health behaviours were inconsistent. For example, while some showed that boys were more impacted by neighbourhood economic context (69), others showed that girls were more impacted (43,51,60). Given that a few studies showed potential moderating effects (50,51), further studies should aim to clarify the role (i.e. direction) of these moderators in the association between neighbourhood economic context and child obesity and obesity-related behaviours beyond significance. Built environments are also worthy of exploration as a moderator or a mediator. Only two studies investigated built environments as a mediator (41,62), although they are often mentioned in the conceptual frameworks of studies reviewed. In general, further replication studies are needed to investigate factors mediating or moderating the relationship between neighbourhood economic context and child outcomes.

The role of family-level socioeconomic status in child outcomes also needs to be explored. This review considered family-level status socioeconomic status as a confounder of neighbourhood effect; however, family-level socioeconomic status may be simultaneously mediating and confounding neighbourhood effects (82,83). This is because family-level socioeconomic status is partly determined by neighbourhood characteristics early in life and thus can be a mediator. Under this circumstance, including family-level socioeconomic status as a confounder will underestimate the neighbourhood health effect (82,83). Analysing neighbourhood effects with multiple repeated measures could clarify the time-dependent confounding and mediating effects of family-level socioeconomic status on child outcomes.

There are several limitations in this review. This review was limited to neighbourhood economic context. To further understanding of neighbourhood impacts on child obesity, other aspects of neighbourhood contexts such as built and social environments, racial/ethnic composition and educational level should be explored. Qualitative studies should also be reviewed to better understand the results of this review. Finally, a meta-analysis was not conducted for several reasons (84–86): (i) the studies included in this review measured neighbourhood economic status in different ways – such as poverty rates, unemployment rates, median household income and a composite index of affluence across a variety of domains including income, housing values, education and racial/ethnic characteristics; (ii) the studies conceptualized neighbourhoods at different area levels – such as buffers, census tracts, census block and census block groups; and (iii) the studies adjusted for different confounding

variables and did not report a correlation coefficient between neighbourhood economic context and an outcome measure.

Despite the limitations, this review systematically identified, organized and summarized past empirical studies in the neighbourhood–child obesity field. The review indicates that neighbourhood economic context may affect child obesity and obesity-related behaviours. The next steps for neighbourhood–child health research will be to improve research designs, measures and analytic models and replicate current findings. One way to improve studies is to longitudinally examine neighbourhood histories and its mediators or moderators in an analytic model, in alignment with their conceptual frameworks. It may provide stronger evidence for developing policies aiming to strengthen neighbourhoods and also child health.

Conflict of interest statement

The authors have no conflicts of interest to disclose.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.
https://doi.org/10.1111/obr.12792

Appendix Table 1. Findings on the role of moderators in the association between neighbourhood economic context and obesity, dietary habits, or physical activity

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