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Neighbourhoods and child adiposity: A critical appraisal of the literature

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ABSTRACT

This paper critically appraised the published literature to determine the relationship between physical and social environmental features of neighbourhoods with child adiposity. MEDLINE, EMBASE, PsychINFO, and SCOPUS were searched from 1999 to July 2009 using a systematic search strategy. Twenty-seven primary studies were included based on a priori eligibility criteria. Socioeconomic disadvantage was consistently shown to increase child adiposity, while there was some evidence that high social capital protected against increased adiposity. It is unclear at this time if and how other neighbourhood environmental features play a role. Heterogeneity and methodological issues across studies limits our ability to draw overall conclusions.

Contents

1. Introduction

Canada and the United States have seen a dramatic rise in the prevalence of childhood obesity in the last three decades (Ogden et al., 2006; Shields, 2006; Tremblay et al., 2002; Wang and Beydoun, 2007). In 2004, 26% of Canadian children aged 2–17 years were overweight or obese, and 8% were obese (Shields, 2006). From 1978–1979 to 2004, the prevalence of overweight including obesity increased almost two-fold among 6–11- and 12–17-year-olds. Overweight and obesity rates remained relatively stable, however, among younger ages (2–5 years) (Shields, 2006). The problem appears to be more pronounced in the US where almost 34% of children aged 2–19 in 2003–2004 were overweight or obese, and 17% were obese (Ogden et al., 2006). Similar to Canada, obesity rates have more than tripled in the time period from 1976–1980 to 2003–2004 among 6–11 and 12–19-year-old American children, with a less dramatic increase among 2–5-year-olds (Wang and Beydoun, 2007).

Due to its comparatively swift onset, the rise of childhood obesity cannot solely be explained by genetic predisposition

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(Law et al., 2007; World Health Organization, 2000). Instead, it is thought that societal changes to more sedentary living and over consumption of high-fat, energy-dense diets may be potential underlying mechanisms, or the 'causes of the causes' of the obesity 'epidemic' (World Health Organization, 2000). In terms of obesity development, there has traditionally been a focus on individual behaviours while neglecting environmental influences (Law et al., 2007). Humans do not live in isolation. We live and interact with diverse elements of our surrounding environments. It is therefore likely that many different aspects of our respective socioeconomic and physical environments influence our health. This thus warrants researchers to consider place (contextual) factors and their interactions in addition to individual (compositional) factors in their aetiological research of childhood obesity. This is especially important among children since they have comparatively less control over their external environments.

There are many debates as to how to define place. Cummins et al. (2007) contrasts the 'conventional' and 'relational' understanding of place, underlining the need to move away from the traditional geographical preoccupation with scale and distance. They contend that defining context based on a fixed geographical area does not always provide an accurate representation of an environmental exposure. For example, their idea of an 'action space' takes into account spatial mobility (i.e., different settings such as work, school, commuting, neighbourhood, home, daycare, etc.), as well as temporal mobility (i.e., changes across the lifecourse). Using the concept of action space may be ideal for certain populations, but not always possible, depending on the research design. A focus on neighbourhood as the encompassing environment of interest may most relevant for children as it is a physical community in which children are placed beyond their control, as well as a community of relationships, both of which can influence child development (Barnes et al., 2006). Additionally, the action space of children, especially younger children, is likely much smaller than those of adults due to their relative lack of independence.

The definition of neighbourhood is not applied consistently and is often used synonymously with community. Usually it is defined on a geographical scale where residents share proximity and circumstance (Bernard et al., 2007; Chaskin, 1997). The 'perceived' neighbourhood may be most relevant as residents tend to define their neighbourhood as being much smaller than actual administrative boundaries (Barnes et al., 2006). Contextual factors measured at a more global scale, such as provincial/state policies and legislation are certainly of importance, but their effects are likely to be translated by more micro or local-level circumstances. For example, national and provincial anti-smoking policies in Canada are enforced through the application of municipal bylaws. Local ecological factors such as sociodemographics, geographical region, and smoking rates play a role in bylaw composition and strength (Nykiforuk et al., 2007).

Potential physical environmental influences on the development and maintenance of obesity are those neighbourhood infrastructure elements which are 'man-made' or modified, as well as services that are provided publicly or privately (Macintyre et al., 2002). Aspects of the social environment, such as the political, economic, ethnic and religious history of a neighbourhood, norms and values in regards to physical activity (PA), food consumption and body shape, degree of neighbourhood integration and trust, levels of crime and threats to personal safety, and networks of neighbourhood support are also potential obesogenic factors. The social environment, or 'collective social functioning' as described by Macintyre et al. (2002), can also include how the neighbourhood is perceived by different actors ('the reputation of the area'). Different perceptions can influence investments in the infrastructure of the area, impact the health and well-being of area residents, and influence the types of people who decide to move into or move out of the neighbourhood. Additionally, it is worth noting that in different socioeconomic and historical situations and in different population groups, physical and social environmental factors are likely to differ in terms of their relative explanatory importance, as well as in how they operate together, and with other compositional factors (Macintyre et al., 2002).

In the last 10 years, given the popularity of obesity as a research topic, and improvements made in the area of statistical modeling and geographical information systems (GIS) mapping, there has been an increase in the number of researchers examining place effects on childhood obesity. The objective of this paper therefore, was to conduct a critical appraisal of the published literature within the last 10 years to determine how features of the physical and social environments of children's residential neighbourhoods contribute to their adiposity. Adiposity is taken to mean all levels of excess weight in children because definitions of overweight and obesity are inconsistent between studies (Shrewsbury and Wardle, 2008).

2. Methods

2.1. Eligibility criteria

Research studies were considered for inclusion if they examined features of the physical and social neighbourhood environments, based on the broad definitions presented in the introduction, and related them to children's adiposity. Evaluating the effect of these environments on child adiposity had to be one of the primary objectives of the study. The exposure measure, or aspect of the environment, could either be objective, such as interviewer observed number of parks, or subjective, such as the parent's perception of safety. Any type of adiposity measure was considered, such as overweight, obesity, skinfold thickness, body mass index (BMI), percentage lean body mass etc. Studies that examined large areas such as counties, municipalities (i.e., census metropolitan areas, large zip/postal code areas), cities, 'regions,' and whole countries were excluded. As areas become larger, physical and social environmental exposures become more heterogeneous, making it harder to tease out specific place features that influence adiposity. Additionally, studies that used school location as a proxy for the child's neighbourhood of residence were included. Even though, this increases the likelihood of misclassification bias when children do not live in the same neighbourhood as their school, this assumption tends to be valid for public schools in places like Québec and in many US states where the taxation system makes it more likely that children go to the schools that are located in or close to their neighbourhood of residence (Gouvernement du Québec, 2008; Rooney et al., 2006).

'Children' were defined as being between the ages of 2 and 18 years. Thus, studies assessing those younger than 2 or older than 18 years of age were excluded. Studies that aggregated adolescents with adults (i.e., 16–24 years) were also excluded. Only primary studies and systematic reviews/meta-analyses of primary studies published in peer-reviewed scientific journals were considered for inclusion. Studies could be experimental or observational as long as they had a comparison group or groups that were either not exposed or had varying levels of exposure. Non-randomized studies, however, had to control or stratify (and report their results) for at least sex and age in order to be included. For this reason, studies were excluded if the sample sizes analyzed were less than $n=100$, as small sample sizes and including more variables in multivariate models decreases overall study power. Articles not written in French or English, and those published prior to 1999 were excluded.

Finally, studies had to have been conducted in a Western country. Those conducted in other countries were excluded because the primary interest was to determine significant factors in the neighbourhoods of the wealthiest and most developed countries of the 'Western culture.' The neighbourhood–adiposity relationship is not likely to be the same in poorer countries and in those having different cultural norms and political ideologies such as Japan.

2.2. Search strategy and identification of studies

Three electronic databases were searched using the Ovid Interface version OvidSP 10.2: MEDLINE (1996 to *July* 2009), EMBASE (1980 to *July* 2009), and PsycINFO (1806 to *July* 2009). The search strategy was developed in MEDLINE and refined as appropriate in each of the other two databases to compensate for changes in indexing from database to database. Basic search terms included indexed (exploded where appropriate) and free text terms such as 'obesity', 'overweight', 'thinness', 'body weight', 'body mass index', 'body fat distribution', 'body size', 'waist circumference', 'waist–hip ratio', 'skinfold thickness', 'adiposity', 'fatness', 'residence characteristics', 'neighbourhood', 'environment', 'census tract', 'child', 'adolescent', 'teenager', 'youth', and 'student.' The full strategy is available upon request. A fourth database, SCOPUS, was also searched using a modified search strategy.

Citations from each database were saved as text files and then imported to Reference Manager 11.0 using the appropriate filter. Potential studies first underwent a duplicate search to narrow the pool of relevant studies. The first screen was conducted using titles and abstracts and the eligibility criteria discussed previously. Studies for which it was difficult to determine eligibility based on information in the title and abstract were included in the next round of screening. After the first screen, eligibility of the remaining studies was assessed using information provided in the full-text articles and the criteria discussed previously. Handsearching the reference lists of included studies was also conducted. Eligible systematic reviews/meta-analyses were included solely for this purpose (the articles themselves were not reviewed).

Data abstraction tables were organized by the type of neighbourhood exposure being examined (physical environment, social environment, and measures incorporating both). Some studies had multiple exposure measures, either of the same or different types. Thus, some studies appear more than once in the data abstraction tables.

3. Results

3.1. Literature search

A total of 3240 unique studies were identified from the literature based on the search strategy outlined above. Of these, only 25 primary studies and 1 systematic review met the eligibility criteria. One study was added based on handsearching the reference lists of the included primary studies, and one other was added based on handsearching the reference list of the systematic review (see Fig. 1). A total of 62 exposure–adiposity associations were examined.

3.2. General overview of included studies

Of the 27 *primary* studies, the majority (n=16) were conducted in the US. From the remaining 11, six were conducted in Canada,

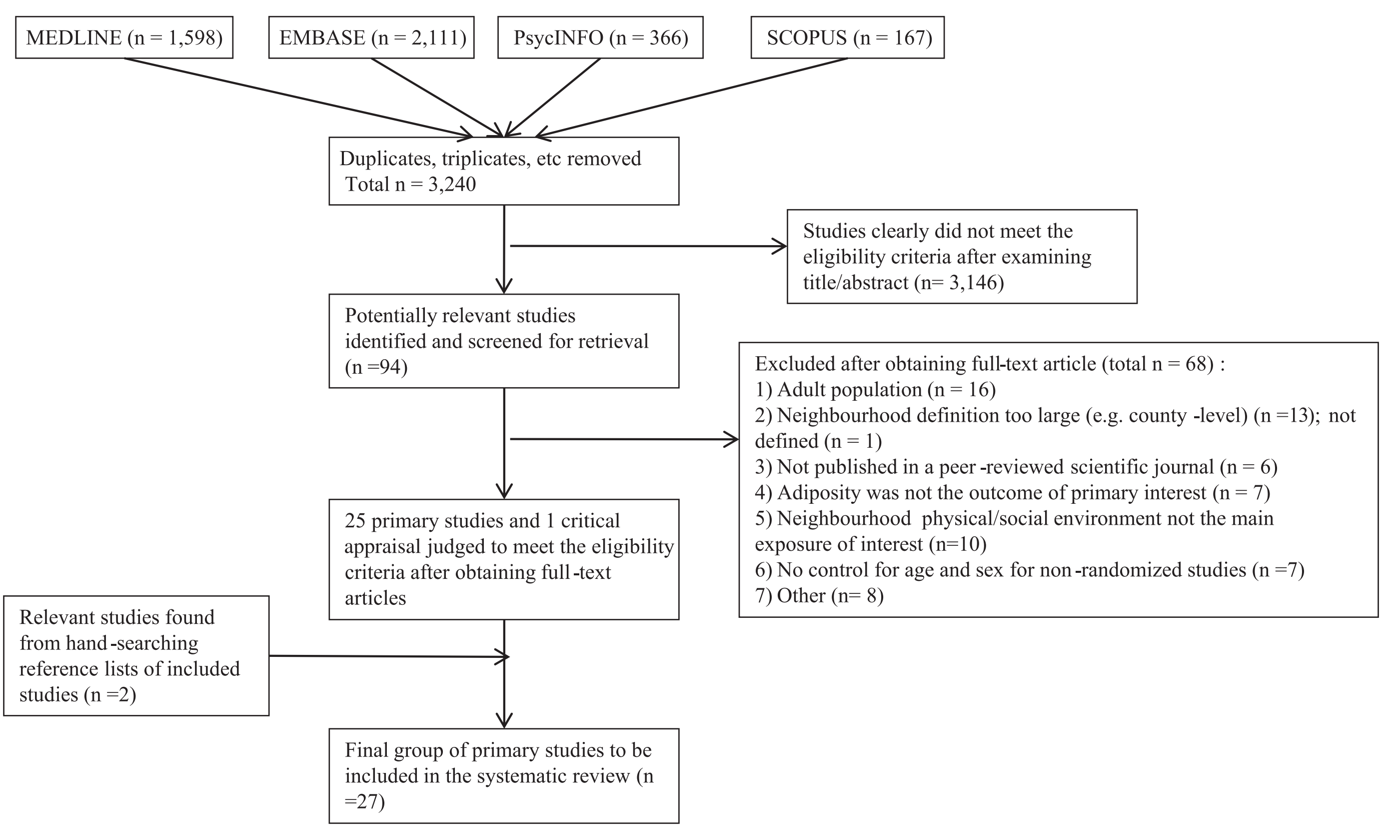

Fig. 1. Quorum flow diagram for study inclusion.

two in Australia, two in the UK, and one in Germany. Twenty-two were cross-sectional (81%), while four used the prospective cohort design and one used the retrospective cohort design. Thirteen studies examined young children between the ages of two and 11, eight examined older children between the ages of 12 and 18, and six studies examined a range of ages that spanned these two categories. Two of the 27 studies were conducted on girls only, with the remainder including both sexes. Sample sizes ranged from as few as 315, to as many as 529,367 participants. Twelve studies were based on the same or very similar samples. Three pairs of studies (Evenson et al., 2007; Scott et al., 2007), (Veugelers et al., 2008; Veugelers and Fitzgerald, 2005), and (Crawford et al., 2008; Timperio et al., 2005), were based on the same sample, consisted of at least some of the same authors, but conducted different analyses. Two pairs of studies, (Lumeng et al., 2006; O'Brien et al., 2007) and (McKay et al., 2007; Singh et al., 2008), used the same sample, conducted different analyses, but were not collaborating authors. A final pair of studies (Bell et al., 2008; Liu et al., 2007) were collaborating authors, derived their samples from the same pool of children (some children may have been the same), but had different study designs.

Of the 22 *cross-sectional* studies, only eight modeled the neighbourhood environment–adiposity relationship at multiple levels of influence (i.e., accounting for correlations between children in the same neighbourhood) (Cohen et al., 2006; Evenson et al., 2007; Janssen et al., 2006; Koller and Mielck, 2009; Oliver and Hayes, 2005; Scott et al., 2007; Veugelers et al., 2008; Veugelers and Fitzgerald, 2005). Two studies chose not to use multi-level modeling or other methods because they had small cluster sample sizes (Grafova, 2008; Spence et al., 2008). Seven used other statistical means to control for clustering (Crawford et al., 2008; Davis and Carpenter, 2009; Franzini et al., 2009; McKay et al., 2007; Nelson et al., 2006; Singh et al., 2008; Timperio et al., 2005), while five did not appear to consider clustering at the neighbourhood or other area levels (Burdette and Whitaker, 2004, 2005; Chen and Paterson, 2006; Kinra et al., 2000; Liu et al., 2007).

Only one out of the five *cohort* studies used multi-level modeling to model the neighbourhood environment–adiposity relationship longitudinally (Oliver and Hayes, 2008). Intra-neighbourhood correlations were not modeled in this study due to small sample sizes. One study attempted a group-based growth curve analysis called 'latent transition analysis,' but had to collapse categories due to small sample sizes (O'Brien et al., 2007). After derivation of the groups, they interestingly used multi-level modeling, not to account for clustering within neighbourhoods, but to model the home environment and proximal child experiences (child care, PA, neighbourhood safety) as contextual effects. Two of the five cohort studies used multi-level modeling or a population averaged approach (Lumeng et al., 2006; Wardle et al., 2006), and one adjusted the standard errors of the model parameters to account for correlations within neighbourhoods (Bell et al., 2008).

All 27 studies used BMI either as the outcome, or to derive one or more of the outcomes. Eight studies did not have BMI data based on directly measured heights and weights. Studies that exclusively examined social environmental exposures were most likely to be based on self- or parent-reported height and weight (6/8 or 75%). Most studies used overweight, obesity or BMI as the outcome, although one study also considered waist circumference (Wardle et al., 2006).

Neighbourhood definitions varied widely from study to study. Administrative boundaries such as census tracts was used by seven out of the 27 studies (26%). Seven studies relied on respondents' perceptions of their neighbourhood boundaries, while one conversely relied on the interviewer to observe the face-block of the child's residence. Six studies used a buffer (or radius) of a certain distance that was calculated from the child's address. Buffer sizes ranged from 1 to 5 km. Three studies defined the neighbourhood based on the school catchment area or school district, and three studies used multiple definitions as they examined different types of exposures.

In terms of addressing duration of exposure, only 18.5% (5/27) of studies considered residential mobility in the design or analysis. For example, three studies restricted the sample to only those children living at the same address for a certain number of years (Bell et al., 2008; Crawford et al., 2008; Lumeng et al., 2006); one study conducted a sensitivity analysis comparing those who had recently moved to those who had not (Grafova, 2008); while the last incorporated changes in the level of exposure over time into the final model (O'Brien et al., 2007).

3.3. Neighbourhood physical environment

Eleven studies in this review examined at least one feature of the neighbourhood physical environment and its relation to child adiposity (Table 1). Thirty associations were analyzed across the 11 studies. Four studies investigated the relationship between the appearance of the neighbourhood and child adiposity. Two of these four examined the degree of neighbourhood greenness using the Normalized Difference Vegetation Index, a measurement based on satellite imagery of the amount of plant life in a particular area (Bell et al., 2008; Liu et al., 2007). Both found that as the NDVI increased (indicating more plant life in the neighbourhood), adiposity significantly decreased. Evenson et al. (2007) did not find that young girl's perceptions of their neighbourhood as aesthetically pleasing was significantly related to BMI, overweight or obesity. However, Grafova (2008) determined that children living in neighbourhoods with physical disorder observed by the interviewer, such as garbage, broken glass, drug-related paraphernalia, condoms, beer containers, etc. on the streets and sidewalks, were more likely to be obese than children living in neighbourhoods without this observed disorder.

Four studies examined accessibility of PA facilities, such as parks and playgrounds (Burdette and Whitaker, 2004; Evenson et al., 2007; Scott et al., 2007; Veugelers et al., 2008), with mixed results. One study did not find that distance to the nearest playground was related to obesity (Burdette and Whitaker, 2004). Another that examined girls' perceptions of their neighbourhood, found that those who reported a high number of PA facilities within walking distance of their home (highest quartile) were less likely to be overweight than those reporting few or no facilities (lowest quartile) (Evenson et al., 2007). There was no significant association with obesity. For BMI, only the middle two quartiles of PA facility accessibility were significantly different from the lowest quartile. Scott et al. (2007) did not find that the number of parks, number of unlocked schools, or having at least one school within a half mile radius of child's residence were significantly related to BMI. Despite this, they did find that as the number of locked schools in the neighbourhood increased, BMI significantly increased. The fourth and final study found that children living in rural neighbourhoods with excellent access to playgrounds/parks, as perceived by their parents, were significantly less likely to be overweight than children who had poor access (Veugelers et al., 2008). The relationship was the same for obesity but significant in both rural and urban areas. For access to other recreational facilities, those with excellent access were less likely to be overweight, regardless of urban/rural status, and less likely to be obese if they lived in a rural area.

Five studies investigated the relationship between access to food retail establishments and child adiposity levels (Burdette and

Table 1
Characteristics of studies that examined the relationship between the neighbourhood physical environment and child adiposity.

Study basics			Physical environment		Weight Status		Analysis		Results
Reference	**Design and level of analysis**	**Population (location; age; sample size)**	**Main predictor(s)**	**Neighbourhood definition**	**Measured height and weight**	**Main weight status measure(s)**	**Confounders and other statistical adjustments**	**Addressed residential mobility**	
Bell et al. (2008)	RC I	Indianapolis, US; 3–16 years in 1996–2000, followed to 5–18 years; n=3831 *Some children may be the same as in Liu et al. (2007)	(1) Amount of greenness—Normalized Difference Vegetation Index (NDVI) (2) Residential density	(1) 1 km circular buffer around child's residence (2) Census block-group	Yes	BMI Z-score (CDC) at Time 2 (5–18 years)	Sex, Time 1 age, race/ethnicity, and Time 1 BMI Z-score, family health insurance type; area SES; index year; both predictors incl in same model; adjusted SEs for clustering of neighbourhoods	Incl only children who lived at the same address for at least 24 months	(1) – for NDVI (2) Ø for residential density
Burdette and Whitaker (2004)	XS I	Cincinnati (OH), US; 3–4 years between 1/1/98 and 6/30/01; n=7020	Distance (miles) to nearest: (1) playground, (2) FF	Based on boundaries used by Cincinnati Police Department (total=46) to report crime rates	Yes	Obesity (CDC)	Poverty ratio, race, sex	No	Ø for all predictors
Crawford et al. (2008)	XS I	Same population as Timperio et al. (2005) but 3 years later in 2004, n=137 (8–9 years), n=243 (13–15 years)	(1) At least 1 FF in neighbourhood (2) Density of FF in neighbourhood (3) Distance (km) to the nearest FF (using road network) regardless of 2 km buffer	2 km circular buffer around residential address	Yes	BMI Z-score (CDC) Overweight incl obesity (IOTF)	PA status; stratified by sex and age group; adjusted for clustering by school	Restricted analysis to children who lived at the same address for at least the previous 3 years	(1) At least 1 FF in neighbourhood: – for 13–15 years (both sexes) with BMI Z-score; – for 13–15 years girls with overweight (2) Density: Ø for both sexes and age groups with BMI Z-score; – for 13–15 years girls with overweight (3) Distance: Ø for all groups with all outcomes
Davis and Carpenter (2009)	XS I	California, US; Grades 7–12 from 2002 to 2005; n=529,367	(1) One or more FF (2) One or more 'other' restaurants	½ mile buffer around school location	Not reported	BMI, Overweight (incl obesity), Obesity (CDC)	School, urban/rural status of school; child sex, grade level, age, race/ethnicity, and PA; adjusted SEs for clustering between schools; both predictors incl in same model	No	(1) + for one or more FF with all 3 outcomes; (2) + for one or more 'other' restaurants with BMI and overweight only
Evenson et al. (2007)	XS M	US (6 States); Grade 6 females in 2003; n=1554	Child's perception of her neighbourhood: (1) Aesthetics (1 Likert item assessing agreement) (2) # of accessible PA facilities within walking distance (quartiles: 1=0–4*; 2=5–6; 3=7–8; 4=9–14)	Perceived neighbourhood	Yes	BMI, Overweight (incl obesity), Obesity (CDC)	State, school, school SES; child race/ethnicity and non-school PA; neighbourhood SES	No	(1) Ø for aesthetics with all outcomes (2) – for accessibility with BMI (2nd and 3rd quartiles); - for accessibility with overweight (4th quartile only); Ø for accessibility with obesity

Franzini et al. (2009)	XS SEM	US (3 large cities);Grade 5 in 2003; n=544	Physical environment–latent construct (interviewer observed): Scales for (i) traffic and (ii) physical disorder; low density residential area; land-use primarily residential	Face-block	Yes	Ordinal obesity status–underweight or normal weight, overweight, obese (CDC)	Child age, race/ethnicity, and sex; family type, parental income, and education; *social environment–latent construct (see Table 2);* mediation by PA (composite score); adjusted for clustering within schools	No	– for PA with weight status where physical environment Ø with PA
Grafova (2008)	XS I	US (NR); 5–18 years in 2002/03; n=2482	(1) Population density (2) Street connectivity (3) Time period of neighbourhood development (before 1950, 1950–1969*, and after 1969) (4) Interviewer observed physical neighbourhood disorder (yes/no)	Census tract (1, 2, and 3) Street block (4)	Yes	Obesity (CDC)	Child age, sex, and race/ethnicity; household SES, # of children, and female-headed household; mother's BMI and annual hours of work; primary caregiver age and education; region of residence	Residential mobility patterns did not differ by obesity status	(1) Ø for population density (2) Ø for street connectivity (3) + for neighbourhoods built after 1969 (4) – for no physical disorder observed
Liu et al. (2007)	XS I	Indianapolis, US; 3–18 years in 2000; n=7,334 *Some children may be the same as in Bell et al., 2008	(1) Amount of greenness - Normalized Difference Vegetation Index (NDVI); Distance (km) to nearest: (2) food retail store of any type, (3) grocery store, (4) convenience store, (5) FF, (6) supermarket	2 km *circular* buffer around child's residence (1) 2 km *street network* buffer around child's residence (2–6)	Yes	Ordinal obesity index—BMI categorized as, 4: > 98th %ile 3: > 95th %ile 2: > 85th %ile 1: otherwise (CDC)	Township population density (tested EM), child age, race, sex; avg block-group median family income	No	(1) – for NDVI in high pop density areas; (2) Ø for distance to any food retail, no EM; (3) Ø for distance to nearest grocery, no EM; (4) Ø for distance to nearest convenience, no EM; (5) Ø for distance to nearest FF, no EM; (6) +for distance to nearest supermarket in low pop density areas
Scott et al. (2007)	XS M	Same population as in Evenson et al. (2007)	# of: (1) parks, (2) unlocked schools with active amenities, (3) locked schools, (4) presence of at least one school	1/2 mile radius around girl's residential address	Yes	BMI	State, school, % of 6th–8th graders receiving free or reduced price lunch; child race	No	(1) Ø for # of parks; (2) Ø for # of unlocked schools; (3) + for # of locked schools; (4) Ø for at least one school
Spence et al. (2008)	XS I	Edmonton (AB), Canada 4–6 years in 2004; n=239 boys; n=262 girls	Index of walkability based on: (1) dwelling density, (2) intersection density, (3) land-use mix, and (4) # of PA facilities	Postal code (1–3) 1.5 km radius of postal code centroid (4)	Yes	Overweight incl obesity (CDC and IOTF)	Neighbourhood education level, proportion of women employed; child age, sex (tested EM), PA status, and junk food consumption	No	– for girls using either definition; Ø for boys using either definition

Table 1 (*continued*)

Study basics			Physical environment		Weight Status		Analysis		Results
Reference	Design and level of analysis	Population (location; age; sample size)	Main predictor(s)	Neighbourhood definition	Measured height and weight	Main weight status measure(s)	Confounders and other statistical adjustments	Addressed residential mobility	
Veugelers et al. (2008)	XS M	Nova Scotia, Canada; Grade 5 in 2003; n=4298	Parental perceived access to (1) shops, (2) playgrounds and parks, (3) recreational facilities—responses to each item on 5 pt scale aggregated by neighbourhood and categorized into tertiles: poor*, average, and excellent access	School catchment area based on student postal codes	Yes	Overweight (incl obesity) and Obesity (IOTF)	Residential area; child sex; parental education, household income; tested for EM by urban/rural status of school location	No	(1) Shops: − for avg and excellent access with overweight in urban areas; − for excellent access with obesity (no EM) (2) Parks and playgrounds: − for excellent access with overweight in rural areas; − for excellent access with obesity (no EM) (3) Recreational facilities: − for excellent access with overweight (no EM); − for excellent access with obesity in rural areas

BMI=body mass index; CDC=Centers for Disease Control and Prevention definitions (overweight: BMI ≥ 85th %ile for age and sex; obese: BMI ≥ 95th %ile for age and sex); EM=effect modification; FF=fast food restaurant; FS=full-service restaurant; I=individual-level; IOTF=International Obesity Task Force definitions (age- and sex-specific based on extrapolating adult overweight (BMI ≥ 20 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) definitions to a reference population; K=kindergarten; M=multi-level; NR=nationally representative sample; PA=physical activity; PC=prospective cohort; Pop=population-level; RC=retrospective cohort; SES=socioeconomic status; SEM=structural equation modeling; SE=standard error; SD=standard deviation; XS=cross-sectional; Ø=no association; +=positive association; −=negative association; *=reference group.

Whitaker, 2004; Davis and Carpenter, 2009; Liu et al., 2007; Veugelers et al., 2008). Results again were mixed. One study did not find any significant association with adiposity (Burdette and Whitaker, 2004). Another had significant but unexpected results–the availability of fast food restaurants appeared to protect against adiposity. However, this was not consistent across adiposity measures, and was complex in that age and sex modified the relationship (Crawford et al., 2008). In contrast, another study found that two availability indicators: one or more fast food restaurants and one or more non-fast food restaurants in the neighbourhood were both positively related to BMI and overweight (Davis and Carpenter, 2009). Liu et al. (2007) found that in areas of low population density, the distance to the nearest supermarket significantly predicted obesity. Other store types were not found to be important, even when considering population density. Finally, regardless of the type of store, Veugelers et al. (2008) found that average and excellent parental perceived access significantly protected against overweight in urban areas, and obesity in both rural and urban areas.

Two studies considered the potential effect of neighbourhood street layout on child adiposity (Grafova, 2008; Spence et al., 2008). Grafova (2008) found no effect of street connectivity on obesity; however, children living in neighbourhoods built after 1969 were more likely to be obese than those living in neighbourhoods built before 1969. Spence et al. (2008) developed an index of walkability that included indicators such as dwelling and intersection densities, land-use mix, and number of PA facilities in the neighbourhood. Girls, but not boys, living in highly walkable neighbourhoods were less likely to be overweight than those living in less walkable neighbourhoods.

Only two studies investigated the potential effect of population density (Bell et al., 2008; Grafova, 2008). Neither found a significant effect at the census block-group and census tract levels. Finally, one study derived a latent construct for the neighbourhood physical environment that incorporated many of the variables that have been described in this section (see Table 1) (Franzini et al., 2009). The authors of this study used structural equation modeling to determine the relationship between the latent construct and obesity through mediation by level of PA. They found that the physical environment was not significantly associated with PA, but PA was negatively associated with obesity, after controlling for individual sociodemographic factors.

3.4. Neighbourhood social environment

Twenty-one studies in this review examined at least one feature of the neighbourhood social environment and its relation to child adiposity (Table 2). Thirty-one associations were analyzed across the 21 studies. Eleven studies investigated the relationship between neighbourhood socioeconomic disadvantage and child adiposity (Chen and Paterson, 2006; Cohen et al., 2006; Grafova, 2008; Janssen et al., 2006; Kinra et al., 2000; Koller and Mielck, 2009; Oliver and Hayes, 2005, 2008; Scott et al., 2007; Veugelers and Fitzgerald, 2005; Wardle et al., 2006). They tended to find that increasing disadvantage was related to increasing adiposity levels, regardless of the disadvantage or adiposity measure employed. One out of the 11 studies, however, reported a null effect (Cohen et al., 2006). Another found that the significance of disadvantage to predict adiposity was modified by age in girls but not boys (Kinra et al., 2000).

Seven out of the 21 studies (33%) examined neighbourhood safety and child adiposity (Burdette and Whitaker, 2004, 2005; Evenson et al., 2007; Lumeng et al., 2006; O'Brien et al., 2007; Timperio et al., 2005; Veugelers et al., 2008). Only one of these reported significant results (Timperio et al., 2005), but this was for

Table 2
Characteristics of studies that examined the relationship between the neighbourhood social environment and child adiposity.

Study Basics			Social environment		Weight status		Analysis		Results
Reference	**Design and level of analysis**	**Population (location; age; sample size)**	**Main predictor(s)**	**Neighbourhood definition**	**Measured height and Weight**	**Main weight status measure(s)**	**Confounders and other adjustments in statistical analysis**	**Addressed residential mobility**	
Burdette and Whitaker (2005)	XS I	US; 3 years in 2001–2003; n=3141	Parental perceived neighbourhood safety (neighbourhood environment for Children Rating Scales) Score categorized into tertiles of low, med, and high safety	Perceived neighbourhood	Yes	BMI Z-score (CDC) Obesity (CDC)	Child race/ethnicity; household income; mothers' education and marital status	No	Ø for safety with both outcomes
Burdette and Whitaker (2004)	XS I	Cincinnati (OH), US; 3–4 years between 1/1/98 and 6/30/01; n=7020	Quintiles of neighbourhood: (1) crime rate (per 1000 residents/year); (2) 911 call rate (per 1000 residents/year)	Based on boundaries used by Cincinnati Police Dept (total=46) to report crime rates	Yes	Obesity (CDC)	Child race and sex; household poverty ratio	No	Ø for both predictors
Chen and Paterson (2006)	XS I	St. Louis, US; 14–19 years (year?); n=315	% families: (1) employed, (2) with high school education or more; median: (3) family income, (4) value of owner-occupied houses	Census block-group	Yes	BMI	Child age and sex; main predictors measured at the family-level	No	– for all 4 SES predictors
Cohen et al. (2006)	XS M	Los Angeles, US; 12–17 years; n=807	(1) Collective efficacy (based on aggregated Likert responses to 9 items by ~55 adults in 65 census tracts) (2) Tract disadvantage (based on 4 indicators from 2000 census data)	Census tract (1990)	No	BMI, overweight incl obesity, and obesity (CDC)	Census tract; Child age, sex, race/ethnicity, TV watching, and extracurricular activities; parental nativity, marital status, BMI, and education level; family income, type, working status, and health insurance status	No	(1) -for collective efficacy with all 3 measures (BMI, overweight, obesity) (2) Ø for tract disadvantage with all three measures (BMI, overweight, obesity)
Evenson et al. (2007)	XS M	US (6 States); Grade 6 females in 2003; n=1554	Child's perception of safety in her neighbourhood (scale based on 4 items)	Perceived neighbourhood	Yes	BMI, overweight (incl obesity), obesity (CDC)	State, school, school SES; child race/ethnicity and non-school PA; neighbourhood SES	No	Ø for safety with all outcomes (BMI, overweight, and obesity)
Franzini et al. (2009)	XS SEM	US (3 large cities); Grade 5 in 2003; n=544	Social environment–latent construct (perceived by parent): Neighbourhood scales for (i) social cohesion, (ii) informal social control, (iii) collective socialization of children, (iv)social exchanges, (v) social ties, and (vi) safety	Perceived neighbourhood	Yes	Ordinal obesity status–underweight or normal weight, overweight, obese (CDC)	Child age, race/ethnicity, and sex; family type, parental income and education; *physical environment–latent construct (see Table 1)*; mediation by PA (composite score); adjusted for clustering within schools	No	– for PA with weight status where social environment was+with PA
Grafova (2008)	XS I	US (NR); 5–18 years in 2002/03; n=2482	(1) Sampson Neighbourhood Deprivation Index (2) Parental perception of lack of informal social control (scale)	Census tract (1, 2, 3,and 5) Street block (4) Perceived neighbourhood (6)	Yes	Obesity (CDC)	Child age, sex, and race/ethnicity; household SES, # of children, female-headed; mother's BMI and annual hours of work; primary caregiver age and education; region of residence	Residential mobility patterns did not differ by obesity status	(1) –for economic deprivation (2) +for lack of social control
Janssen et al. (2006)	XS M	Canada (NR); Grades 6–10 in 2001/2002; n=6684	Quartiles of: (1) Unemployment rate (ref=lowest) (2) % of adults < high school education (ref=lowest) (3) average employment income from head of household (ref=highest) Data from 2001 Census	5 km radius surrounding school (postal codes)	No	Obesity (IOTF)	School; child age and sex; family affluence, perceived family wealth; all area-SES variables included in the same model	No	(1) + for highest unemployment rate quartile, Ø for middle two categories; (2) Ø for high school education (3) Ø for employment income
Kinra et al. (2000)	XS I	Plymouth, UK (all primary school		Census Enumeration	Yes		Child age (tested EM), stratified by sex	No	+ for boys in deprived quartiles 3 and 4 – no EM;+ for

Table 2 (*continued*)

Study Basics			**Social environment**		**Weight status**		**Analysis**		**Results**
Reference	**Design and level of analysis**	**Population (location; age; sample size)**	**Main predictor(s)**	**Neighbourhood definition**	**Measured height and Weight**	**Main weight status measure(s)**	**Confounders and other adjustments in statistical analysis**	**Addressed residential mobility**	
		children); 5–11 years in 1994–96 n=20,973	Townsend Material Deprivation Score (quartiles from 1=least deprived* to 4=most deprived)	District (1991 data)		Obesity (BMI > 98th percentile for age/sex of British ref population)			girls in highest quartile of age (11.8–14.6 years) that were in the most deprived quartile (quartile=4)
Koller and Mielck (2009)	XS M	Munich, Germany; all children beginning public school in 2004: n=9353	(1) % of single-parent households (tertiles: low*, medium, high); (2) % of households with ≥ 1 adult in lowest education level (tertiles: low*, medium, high)	School district	Yes	Overweight (BMI ≥ 90th percentile for age/sex of German ref population)	Mother tongue of parents (German vs other); child sex, visited a kindergarten before starting school; included both predictors in same model		(1) Ø for single-parent households; (2) + high % low education households
Lumeng et al. (2006)	PC Pop	US (ten urban and rural sites); Children born in 1991 followed until spring of Grade 1; n=768	Parental perceived neighbourhood safety: The Neighbourhood Safety Subscale Score in Grade 1 (mean of 5 Likert items–categorized into quartiles from least safe to safest*)	Perceived neighbourhood	Yes	Obesity (CDC) in Grade 1	Site; sex, race/ethnicity, PA-level, and BMI Z-score at 4.5 years; maternal education, marital status, and depressive symptoms; respondent's relationship to child and social involvement; quality of home environment	Excluded children who had moved residences in the past 12 months (at Grade 1)	Ø for safety and obesity in grade 1
McKay et al. (2007)	XS I	US (NR); 10–17 years in 2003; n=37,930	Parental perceived neighbourhood: (1) social trust, (2) mutual aid—each based on 1 item with 4-pt Likert response scale	Perceived neighbourhood	No	Overweight incl obesity (CDC)	State; child sex, race/ethnicity, and stage of adolescence (early, middle, late); family income; included predictors in same model	No	– for both predictors
O'Brien et al. (2007)	PC M	Same population as Lumeng et al. (2006); However, children were followed until Grade 6 (12 years) n=960	Same as Lumeng et al. (2006) Mean of measurements taken in grade 1, 3 and 5	Perceived neighbourhood	Yes	Patterns of overweight (CDC) from 2 to 12 years: (1) ever overweight and remained until 12 years vs never; (2) overweight after 54 months and remained until 12 years versus never	Child sex, ethnicity, TV watching, PA-level and time spent in day-care; family income and structure; maternal education; indicators of parenting quality	Used multiple measures of safety over time	Ø for average safety with both outcomes (1) and (2)
Oliver and Hayes (2008)	PC M	Canada (NR); 2–3 years (1994) followed to 10–11 years (2002); n=2152	Neighbourhood low-income (least poor, middle*, most poor)	Census Enumeration Area in 1996 (based on postal code in 1994)	No	BMI Z-score (CDC)	Time; child age and sex; family income and structure; mother's education; population density	Assumed did not move from age 2–3 years?	+ for most poor, Ø for least poor;
Oliver and Hayes (2005)	XS M	Canada (NR); 5–17 years in 2000/01; n=11,455	Neighbourhood SES (high*, mid-high, mid-low, low);	Census Dissemination Area (CDA) based on postal code	No	Overweight (incl obesity) (IOTF)	CDA, family; age and sex; family income; parental education	No	+ for all SES categories; increasing magnitude of association from mid-high to low
Scott et al. (2007)	XS M	Same population as in Evenson et al. (2007)	SES index score based on 5 indicators from 2000 Census (lower scores indicate more deprivation)	1/2 mile radius around girl's residential address	Yes	BMI	State, school, % of 6th–8th graders receiving free or reduced price lunch; child's race	No	– for area SES
Singh et al. (2008)	XS I	Same population as McKay et al. (2007); n=46,707	Parental perceived neighbourhood social capital (4 items) Index ranges 4–16 and categorized into quartiles from lowest to highest social capital*	Perceived neighbourhood	No	Obesity (CDC)	Child sex, race/ethnicity, TV watching, and PA-level; household poverty status, and highest education level; adjusted for clustered survey design	No	+ for low social capital (all three lower quartiles)

Timperio et al. (2005)	XS I	Melbourne, Australia; 5–6 and 10–12 years in 2001; *n*=292 (5–6 years), *n*=916 (10–12 years)	Parental perceived neighbourhood safety (5 items—Likert-type response)	Perceived neighbourhood	Yes	Overweight (incl obesity) and Obesity (IOTF)	School area SES; child sex; family SES, and # of cars owned adjusted for clustering by school, and stratified by age group of child	No	**5–6 years:** Ø for all predictors in unadjusted analysis, no adjusted analyses; **10–12 years:** + for perception of heavy traffic in streets with overweight; + for concerned with road safety with obesity
Veugelers et al. (2008)	XS M	Nova Scotia, Canada; Grade 5 in 2003; *n*=4298	Parental perception of safe places for children to play during the day—5 pt scale aggregated by neighbourhood and categorized into tertiles: poor*, average, and excellent access	School catchment area based on student residence	Yes	Overweight (incl obesity) and obesity (IOTF)	Residential area; child sex; parental education, household income; tested for EM by urban/rural status of school location	No	Ø for safety with both outcomes (overweight and obesity)
Veugelers and Fitzger-ald (2005)	XS M	Same population as Veugelers et al. (2008)	Average, per-school, postal-code level means of household income (2001 Census) Tertiles—lowest*, middle, highest	Same as above	Yes	Obesity (IOTF)	Frequency of school PA classes; child sex, type of lunch, PA-level; frequency of family suppers, parental education	No	− for highest income group, Ø for middle income
Wardle et al. (2006)	PC M	South London, England; 11–12 years in 1999 followed until 15–16 years; *n*=5863	Townsend Material Deprivation Score (quartiles from least deprived to most deprived)	Census Enumeration District	Yes	BMI SD scores and waist circumference SD scores (1990 UK ref norms) at school years 7–11	School and school year; child sex and ethnicity	No	+ for BMI SD scores in the most deprived group;+ for waist circumference SD scores in the most deprived group

BMI=body mass index; CDC=Centers for Disease Control and Prevention definitions (overweight: BMI ≥ 85th %ile for age and sex; obese: BMI ≥ 95th %ile for age and sex); EM=effect modification; FF=fast food restaurant; FS=full-service restaurant; I=individual-level; IOTF=International Obesity Task Force definitions (age- and sex-specific based on extrapolating adult overweight (BMI ≥ 20 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) definitions to a reference population; K=kindergarten; M=multi-level; NR=nationally representative sample; PA=physical activity; PC=prospective cohort; Pop=population-level; RC=retrospective cohort; SES=socioeconomic status; SEM=structural equation modeling; SE=standard error; SD=standard deviation; XS=cross-sectional; Ø=no association; +=positive association; −=negative association; *=reference group.

only two out of the five indicators analyzed, and was modified by age. For example, neighbourhood safety did not significantly affect overweight and obesity among 5–6-year-olds, but was positively related to overweight and obesity among 10–12-year-olds. Specifically, parental perception of heavy traffic in streets predicted overweight (but not obesity), and high parental concern with road safety in the neighbourhood predicted obesity (but not overweight).

Four studies analyzed the relationship between indicators of social capital, such as collective efficacy and social disorder, with child adiposity (Cohen et al., 2006; Grafova, 2008; McKay et al., 2007; Singh et al., 2008). All four found that as neighbourhood social capital increased, adiposity significantly decreased (or vice versa, as social capital decreased, indicated by increasing social disorder, adiposity increased).

Finally, one study derived a latent construct for the neighbourhood social environment that incorporated many of the variables that have been described in this section (see Table 2) (Franzini et al., 2009). The authors of this study used structural equation modeling to determine the relationship between the latent construct and obesity through mediation by level of PA. They found that a more favourable social environment was positively associated with PA; which was negatively associated with obesity, after controlling for individual sociodemographic factors.

3.5. *Combined measures*

Using cluster analysis, one study in this review combined measures of the physical and social environment into one overall measure of the neighbourhood environment, in order to determine neighbourhood typologies that significantly predicted childhood obesity (Table 3) (Nelson et al., 2006). Indicators describing income/wealth, race/ethnicity, crime, road type, street connectivity, and recreation facilities for PA resulted in six neighbourhood typologies which the authors labelled Rural Working Class, Exurban, Newer Suburban, Upper-middle Class, Older Suburban, Mixed-race Urban, and Low SES Inner-city. The referent typology was New Suburban which was characterized as having a high SES/low minority population, recently built housing units, low access to PA amenities, very poor street connectivity, and very few roadways overall. Children living in a Rural Working Class neighbourhood (low SES, moderate to low minority, little mobility, low connectivity, low access to PA amenities, and very low density of roadways) were 38% more likely to be obese than those in New Suburban neighbourhoods. Similarly, those in Exurban (moderate SES, low minority, high percentage of recently built housing, high percentage of population commuting to work outside their county of residence, low access to PA amenities, low street connectivity, low crime, and large number of arterial roadways) and Mixed-race Urban neighbourhoods (low SES, high poverty, moderate access to PA amenities, moderate to high street connectivity and crime, and high density of local roadways) were approximately 30% more likely to be obese than those living in New Suburban neighbourhoods.

4. Discussion

Among the studies that examined features of the neighbourhood physical environment, it was difficult to discern a clear relationship with adiposity, particularly given the variability in exposure measures used. On the other hand, from the studies that examined the neighbourhood social environment, deprivation seems to be important in explaining child adiposity, above and beyond individual socioeconomic characteristics. High social

Table 3
Characteristics of a study that examined the relationship between a combined measure of the neighbourhood physical and social environment with child adiposity.

Study basics			Combined measures of the neighbourhood environment		Weight status		Analysis		Results
Reference	Design and level of analysis	Population (location; age; sample size)	Main predictor(s)	Neighbourhood definition	Measured height and weight	Main weight status measure(s)	Confounders and other adjustments in statistical analysis	Addressed residential mobility	
Nelson et al. (2006)	XS I	US (NR); Grades 7–12 in 1995; n=19,029	6 neighbourhood patterns based on access to PA facilities, area SES indicators, crime rate, road type, and street connectivity: (1) Rural working class; (2) Exurban, mid-SES; (3) Newer suburban*; (4) Older suburban, upper-mid-SES; (5) Mixed-race urban, low SES; (6) Inner-city, low SES	3 km buffer around residential address	No	Obesity (CDC)	Child age, race/ethnicity; household income and parental education; adjusted for cluster sampling design	No	+ for (1) Rural, (2) Exurban, and (5) Mixed-race urban; Ø for (4) Older suburban, and (6) Inner-city

BMI=body mass index; CDC=Centers for Disease Control and Prevention definitions (overweight: BMI $\geq$ 85th %ile for age and sex; obese: BMI $\geq$ 95th %ile for age and sex); EM=effect modification; FF=fast food restaurant; FS=full-service restaurant; I=individual-level; IOTF=International Obesity Task Force definitions (age and sex-specific based on extrapolating adult overweight (BMI $\geq$ 20 kg/m^2) and obesity (BMI $\geq$ 30 kg/m^2) definitions to a reference population; K=kindergarten; M=multi-level; NR=nationally representative sample; PA=physical activity; PC=prospective cohort; Pop=population-level; RC=retrospective cohort; SES=socioeconomic status; SEM=structural equation modeling; SE=standard error; SD=standard deviation; XS=cross-sectional; Ø=no association; +=positive association; −=negative association; *=reference group.

capital of neighbourhoods also appears to be protective of child adiposity.

Across studies, there was much heterogeneity in terms of population age, methods employed for analysis, derivation of predictor and outcome variables, neighbourhood definition, and covariates included in statistical models, which may explain inconsistent and null results. This also made it impossible to conduct a meta-analysis. Additionally, studies have found that self-reported height and weight can yield overweight and obesity measures that act differently in associational analysis compared to those based on directly measured height and weight (Shields et al., 2008). Thus, inconsistent results may have arisen from the eight studies that relied on self-reported data.

Only five studies reviewed were cohort studies, the remaining 22 were cross-sectional, which increases the likelihood for reverse causation and residual confounding. There is a relative lack of 'true' longitudinal studies in this area of research; most of these cohort studies used cross-sectional methods in their analysis, and only one study actually used longitudinal regression methods. Even epidemiologic studies of *individual-level* characteristics and childhood obesity generally fail to examine how these factors affect adiposity over time (Reilly et al., 2007). Epidemiologic studies at individual *and* multi-levels should examine how factors relate to different adiposity trajectories (for example, always obese or never obese). This not only provides for more robust evidence of causation (given its longitudinal design) but also better illustrates how these factors influence adiposity development and maintenance, given that body weight relative to height varies tremendously in growing children (Reilly et al., 2007). The quality of both types of studies, particularly cross-sectional, if a cohort study is not feasible, can be enhanced by including measures of exposure length, accounting for change in exposure, or at least including an indicator of residential mobility. Only five studies considered this bias, and two were cohort studies. Additionally, none of these studies adjusted for early life factors known to be related to childhood obesity, such as breastfeeding, birth weight, gestational age, parental smoking during pregnancy and mother's pregnancy BMI (Dubois and Girard, 2006; Harder et al., 2005; Oken and Gillman, 2003; Power and Jefferis, 2002).

From the body of research reviewed here, it is unclear as to whether authors formulated and followed a priori theories. The general failure to account for early life factors, as well as lack of consideration for time exposed demonstrates this fact. Furthermore, many studies of the neighbourhood physical environment controlled for children's PA levels (but interestingly not dietary intake). Physical activity and dietary intake are intermediate steps in the pathway from physical environment to overweight or obesity. Even though a confounder may be related to both physical environment and to adiposity, it cannot be an intermediate step in a causal pathway. Thus, studies that controlled for PA likely over-controlled, potentially leading to null findings. Finally, very few studies investigated the possibility that the effect of the neighbourhood social and physical environments on adiposity may be moderated by age. Neighbourhood factors may become more influential as children get older; they are more independent and therefore, more able to access their surroundings. This would seem to be especially important among studies with populations containing large age ranges.

Employing ecosocial theory, which considers accumulation of risk over the lifecourse, can allow researchers to better understand, at a population level, why certain children become and remain obese and why others do not. It is a holistic perspective acknowledging that disease development, in this case child adiposity, cannot be studied in individual isolated parts–rather individual behaviours and characteristics, settings (work, school, home, neighbourhood etc.), contexts (at the local, to inter and supra-national levels), and their interrelationships must be considered simultaneously at multiple scales of time and space (Krieger, 1994, 2008). Although statistical modeling is unlikely to capture all processes involved in the development of child adiposity, multi-level modeling is a promising strategy that can incorporate ecosocial theory by helping us to better understand the extent of interactions between individual characteristics and features of place, namely the neighbourhood, over time, in relation to child adiposity. Researchers in this area should continue to use multi-level modeling, but need to better utilize theory in model development.

To aid in cross-study comparisons, future studies may consider examining multiple adiposity measures (such as BMI, overweight, and obesity), as well as include IOTF definitions for childhood overweight and obesity, in addition to national definitions. Where possible, the heights and weights of children should be directly measured instead of self-or parent-reported. As an alternative to 'reinventing the wheel,' researchers might also consider making use of previously developed exposure and neighbourhood definitions, and geographic methods. Defining neighbourhood boundaries based on participants' perceptions should also be considered. And finally, although only a few studies reviewed here used school location as a proxy for children's neighbourhood of residence, future studies should base neighbourhood exposure measurements on where the child actually lives. This reduces the likelihood for misclassification bias.

The results of this appraisal should be interpreted in light of two similar reviews that did not focus specifically on children. Papas et al. (2007) examined the relationship between the physical or built environment and obesity. They found that 85% (17/20) of studies reported a statistically significant positive association with at least one measure of the physical environment. Black and Macinko (2008) reviewed studies that examined the relationship between obesity and the neighbourhood social environment, physical environment, and food availability. The results of the 22 studies that examined the physical environment and food availability were mixed. For the social environment, their findings from the 16 studies reviewed coincide with those of this appraisal; neighbourhood-level SES, measured in a variety of ways, was inversely associated with obesity, even after controlling for individual-level characteristics.

A few limitations of this critical appraisal also bear mentioning. Drawing any type of conclusion may be somewhat premature, given the heterogeneity of the studies reviewed here and elsewhere. This may be a sign that the literature on neighbourhood and childhood adiposity (and possibly adult obesity) is not yet sufficiently extensive to support a review. Thus, a clearer picture may emerge as more studies are completed. On the other hand, considering studies that were not published in peer-reviewed scientific journals, or were written in languages other than English or French, may have further clarified relationships. This was, however, beyond the scope of this appraisal.

5. Conclusion

Twenty-seven primary studies that examined the relationship between physical and/or social environmental features of the neighbourhood with child adiposity were included in this critical appraisal. Socioeconomic disadvantage at the neighbourhood level was consistently found to relate to increased child adiposity, irrespective of exposure or outcome definition. High social capital appeared to act as a protective factor. It is unclear at this time if and how other neighbourhood environmental features, such as safety, street layout and block design, availability/accessibility of amenities etc., play a role. The heterogeneity across studies, in terms of population age, methods employed for analysis, derivation of predictor and outcome variables, neighbourhood definition, and covariates included in statistical models, may account for these mixed and null results. The general reliance on the cross-sectional study design, failure to address the potential for exposure bias, over controlling, and residual confounding should also be considered when trying to draw any overall conclusions.

Basing analytical models on a priori theories that originate from an ecosocial perspective will improve our understanding of this complex public health problem. Researchers are also encouraged to facilitate comparability across studies by analyzing multiple adiposity measures that include the IOTF definitions of overweight and obesity.

This is an exciting area of research that has only just started to ramp up within the last 10 years. By nature, it crosses many different disciplines such as epidemiology, urban planning, sociology, and geography, to name a few. Thus, research conducted by transdisciplinary teams can only add to the quality of future studies.

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