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Obesity Prevention

A systematic review of environmental factors and obesogenic dietary intakes among adults: are we getting closer to understanding obesogenic environments?

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Summary

This study examined whether physical, social, cultural and economical environmental factors are associated with obesogenic dietary behaviours and overweight/obesity among adults. Literature searches of databases (i.e. PubMed, CSA Illumina, Web of Science, PsychInfo) identified studies examining environmental factors and the consumption of energy, fat, fibre, fruit, vegetables, sugar-sweetened drinks, meal patterns and weight status. Twenty-eight studies were in-scope, the majority (n = 16) were conducted in the USA. Weight status was consistently associated with the food environment; greater accessibility to supermarkets or less access to takeaway outlets were associated with a lower BMI or prevalence of overweight/obesity. However, obesogenic dietary behaviours did not mirror these associations; mixed associations were found between the environment and obesogenic dietary behaviours. Living in a socioeconomically-deprived area was the only environmental factor consistently associated with a number of obesogenic dietary behaviours. Associations between the environment and weight status are more consistent than that seen between the environment and dietary behaviours. The environment may play an important role in the development of overweight/obesity, however the dietary mechanisms that contribute to this remain unclear and the physical activity environment may also play an important role in weight gain, overweight and obesity.

Keywords: Diet, environment, obesity, weight status.

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Introduction

Obesity is a major cause of morbidity and mortality from chronic diseases such as cardiovascular and musculoskeletal diseases, some cancers and negative psychological well-being (1,2). The prevalence of overweight and obesity is high and ranges from 40% to 60% among adults in developed countries (2,3). In the last two decades there have been marked increases in the prevalence of overweight and obesity (4). Overweight and obesity results in substantial health and economic burdens, and these negative consequences are predicted to escalate as the population ages (5,6).

Overweight and obesity are the result of positive energy balance. Low levels of physical activity and/or dietary behaviours that deviate from recommendations are thought to contribute to the epidemic of obesity. In terms of dietary factors, population trends in overweight and obesity would suggest that energy intake exceeds energy expenditure (7). High energy intakes have been associated with higher fat

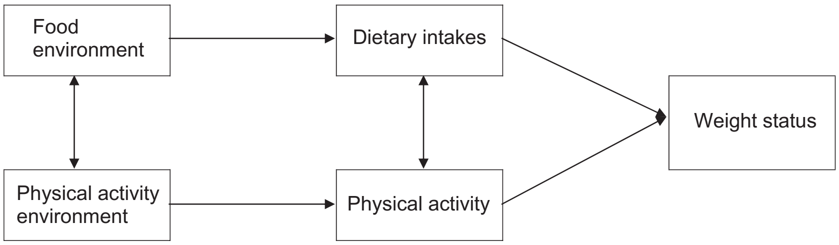

Figure 1 Hypothesized relationship between the environment and weight status.

intakes, greater intakes of energy-dense foods, including takeaway foods, higher intakes of foods providing 'empty calories' (e.g. sugar-sweetened drinks), lower intakes of foods and nutrients that may have appetite-controlling properties (i.e. fruit and vegetables, fibre) and meal patterns that interfere with the regulation of energy intakes (e.g. skipping breakfast) (7). Despite the health-related benefits of consuming a diet that promotes a healthy weight, many adults do not consume a diet consistent with these recommendations. Population-level dietary estimates show that fat intakes exceed recommendations by at least 10%, the majority of the population do not consume sufficient fruit, vegetables or fibre and a significant proportion of the population skip meals (8–11).

Given the rapid rise in overweight and obesity among populations of developed countries, many health practitioners and health researchers have postulated that the environment, rather than individual-level factors, may be driving the obesity epidemic. Policymakers are increasingly considering environments for the development of policy, however, have been limited by insufficient research documenting the role of the environment. Recent studies have shown that overweight and obesity cluster within areas, suggesting that shared environments may contribute to a positive energy balance (12–14). The postulated relationships between the environment and weight status is shown in Fig. 1. The current review primarily focuses on environmental factors that may influence dietary behaviours. 'Obesogenic' food environments are thought to facilitate high energy intakes by increasing access to stores that promote unhealthy food choices, such as takeaway and fast food shops, convenience stores and other outlets that are less likely to sell healthy food choices (15–17). Areas characterized by obesogenic food environments may also be associated with physical activity environments that promote decreased energy expenditure and sedentariness. The presumed importance of these environmental factors has resulted in a myriad of policies and interventions aimed at improving food environments (4,18,19). Despite widespread support for these policies and interventions, the discourse about their supposed importance has largely been discussed in position papers and narrative reviews, without synthesis of the evidence on how food environments are associated with overweight and obesity and the mechanisms by which environmental factors contribute to overweight/obesity.

Two systematic reviews examining environmental correlates of obesogenic dietary intakes were conducted in 2004 (20,21). At this stage, there were few replicated studies that examined associations between obesogenic dietary intakes and the food environment. Given the increased research activity on environmental determinants of health-related behaviours in recent years, we sought to review the more recent literature on how features of the food environment are associated with both dietary intakes and overweight/obesity to identify factors to be targeted in policy and interventions to reduce overweight/obesity and to ascertain how shared environments may contribute to the obesity epidemic.

Method

Study scope

This review focused on studies of dietary intakes among adults (i.e. ≥18 years). The prevalence of overweight and obesity is greatest in adulthood (especially middle-age), and significant weight gains continue to occur in early and middle adulthood (6). The review examined studies conducted among developed countries, as defined by the World Bank (22).

Environmental factors

For the purposes of this study, the environment was defined as physical and infrastructural features of areas. A framework used in previous reviews (20,21,23) was used to guide the classification of different environmental factors during the review process. The framework shares common features with ecological models (24,25), stressing the importance of multiple types of environmental influences. The four categories that form this framework are:

1. Accessibility and availability. Including physical and financial accessibility of products and shops that are needed for an (un)healthy diet (e.g. access to shops, and availability of high fat foods and less healthy snacks);

2. Social conditions. These arise from inter-personal interactions (e.g. marketing) and social support;

3. Material conditions. Including unfavourable working, housing and neighbourhood conditions (e.g. neighbourhood deprivation).

These may affect behaviour through one of the previous environmental factors. For instance, living or working in an unfavourable environment might induce stress, which may relate to indifference concerning a healthy diet.

Obesogenic dietary factors

Dietary factors influence overweight/obesity through the energy balance pathway; excess energy intake is arguably the most important dietary factor in relation to weight gain and the development of overweight/obesity (26). As there are physiological limitations on the quantity of food/drink that can be consumed by individuals, excess energy intakes are often the consequence of energy-dense diets (i.e. high in kilojoules per unit weight) (7). Population-based studies have shown that energy-dense diets are characterized by: high intakes of fat and sugar, and low intakes of water-holding factors, such as fibre, fruit and vegetables, high intakes of sugar-sweetened beverages (e.g. soft drinks) and irregular meal patterns (27–30). These factors are suspected to contribute to overriding the normal physiological regulation of appetite and food intakes, and are associated with weight gain and overweight/obesity (6,26,29,31,32). Therefore, the dietary factors examined in this review included intakes of energy, total fat, fibre, fruit, vegetables, sugar-sweetened beverages and meal patterns.

Weight status

Any measure of weight status, including absolute weight or any equivilized weight scale such as body mass index (BMI), weight for height or categorization of weight status into groups was included in the current study.

Search strategy

Databases and search terms

A review protocol based on guidelines from the Cochrane Reviewer's Handbook (33) was used. Studies conducted among human subjects between 1 January 2005 and 1 October 2008 were located by searches of several major databases (i.e. PubMed, CSA Illumina, Web of Science and PsychInfo).

Broad search terms were used in the database searches to ensure that all potentially relevant articles entered the screening process. Each database was searched using database-specific indexing terms; suitable search terms were selected from lists of the database indexing system. For databases that did not have their own indexing terms (i.e. CSA Illumina) we searched for keywords in titles. The sensitivity of searches was tested by examining whether they located several key articles. The searches yielded 6014 potentially relevant titles (3580 in PubMed, 84 in CSA Illumina, 2322 in Web of Science and 28 in PsychInfo). The search terms and syntax used for each database are available from the authors on request.

Inclusion criteria

This review only included studies published in the peer-reviewed literature. Therefore, information from web sites, reports and conference abstracts were not included. Studies must have been published in English and conducted among a population-based sample (i.e. studies examining disease or patient sub-groups were excluded) of adults (i.e. ≥18 years of age). They must have examined at least one of the in-scope dietary factors, which could be summarized either as quantity consumed (e.g. grams of fruit consumed per day), frequency of consumption (e.g. how many times fruit was consumed per week) or compliance with recommendations (e.g. whether consumed two or more portions of fruit per day) or weight status. In-scope studies were required to have assessed at least one environmental factor. Studies that combined in-scope dietary factors with out-of-scope factors into summary indices of diet (e.g. dietary outcomes derived from factor analyses) were excluded as associations with the obesogenic dietary factors could not be distinguished from other dietary factors.

Title scanning

The title screening process was performed by two reviewers (KG and FvL), and took place in three steps. First, the titles located from the search results were scanned, to exclude those out of the scope of the current study. Fifty-five studies were selected at this stage. Subsequently, the Abstracts of all titles were independently examined by the two reviewers. At this step, each reviewer read all study abstracts, and produced a list of in-scope articles. Discrepancies between reviewers in the selected articles were discussed, and a consensus was reached on whether or not the article(s) in question would be incorporated. A total of 31 articles were identified for inclusion at this stage. Third, the reference lists of these articles were scanned and literature searches on major authors in the area were performed, a further five publications were included at this step. Seven manuscripts were subsequently excluded at the data extraction phase due to not meeting scope/inclusion criteria of the study. Therefore, 28 articles were included in the current review.

Data extraction and summary

Study details (i.e. country, study name, sample size, response rate, dietary assessment method, dietary/weight status outcome variable, environmental measure and the direction and magnitude of associations found) were summarized in data extraction tables. Because each study was designed to address different outcomes and associations, we reported associations adjusted for the relevant confounders (i.e. gender, age), where available. Some studies examined associations with more than one outcome of interest, in which case they were considered in more than one data extraction table.

Differences in intakes between environmental factors were ascertained by statistical significance and clinically relevant differences. In terms of clinically relevant differences, a 3% relative difference in energy intakes between groups equates to a weight gain of 2–4 kg $year^{-1}$ for an average-sized adult (26), therefore differences of this magnitude are likely to have a marked long-term influence on BMI and overweight/obesity. Studies have shown that a 10% reduction in total fat intake is associated with a reduction in weight of 1.5–2 kg $year^{-1}$ (34). Likewise, a 10% increase in dietary fibre intakes is estimated to contribute to a weight loss of 1.5–2 kg $year^{-1}$ (26). Greater fruit and vegetable intakes are associated with a lower body weight among adults; however, there is insufficient evidence examining the magnitude of weight changes associated with intakes (35). Therefore, an arbitrary cut-off of a 10% difference in intakes of fruits and vegetables was used.

The magnitude of differences between environmental exposures was ascertained by calculating the relative difference between groups differing in their exposure to the environmental factor. This was calculated by:

$$\text{Relative difference (\%)} = \frac{(\text{value lowest group} - \text{value highest group}) \times 100}{\text{value highest group}}$$

Odds ratio estimates for differences were reported for dichotomous outcome variables.

Relative differences were considered small if they were ≤10% (or OR 0.80–1.0), moderate if relative differences were 10–20% (or OR 0.70–0.80) and large if relative differences were ≥20% (or OR ≤ 0.70).

Findings

The characteristics of the 28 studies included in the review are shown in Table 1. Twenty-three of these were conducted among separate study samples, and five studies were sourced from two study populations. The vast majority of in-scope studies ($n = 16$) were conducted in the USA, with other studies taking place in Australia or New Zealand ($n = 7$) and Japan ($n = 2$). Three Australian studies were sourced from one sample (SESAW), and two American studies were sourced from one sample (Stanford Heart Disease Prevention Program). Only three of the studies were conducted in Europe – two of these were among British samples (16,36) and one among a Dutch sample (37). With the exception of one natural experiment (16), all studies were cross-sectional. Study sample sizes ranged from 102 to 714 054 participants, with the majority of studies ($n = 22$) having sample sizes above 1000 participants. Response rates ranged from 10% to 87%, just under one half of the studies had response rates of ≥60% and one quarter ($n = 7$) did not report response rates.

Most studies ($n = 13$) examined fruit and vegetable consumption, two investigated energy intakes, six assessed fat intakes and three examined fibre intakes. Four of the in-scope studies examined takeaway or fast food consumption and three studies explored meal patterns (i.e. breakfast consumption and/or the regularity of meals). No study examined environmental factors in relation to the consumption of sugar-rich beverages. Eight studies assessed associations between environmental factors and weight status.

Most ($n = 18$) examined accessibility factors; social factors and material factors were explored in three and seven studies, respectively. Only two studies looked at associations between cultural factors and obesogenic dietary intakes. The majority of studies used food frequency questionnaires to ascertain dietary intakes and measured height and weight to assess weight status. Most ($n = 16$) measured environmental factors using objective measures, nine studies assessed environmental factors using self-reported information and the remaining three studies used a combination of objective and self-reported data.

Accessibility factors

Associations between accessibility factors and obesogenic dietary intakes or weight status are shown in Table 2.

For fruit and vegetable consumption, access to supermarkets, grocery/convenience, takeaway and fruit and vegetable stores was examined in 14 associations. The number of associations measured was greatest and most consistent for access to supermarkets; five out of six associations found that greater accessibility to supermarkets was not associated with fruit and vegetable consumption. Three out of four associations assessing access to takeaway outlets and fruit and vegetable consumption showed no significant/meaningful differences. Furthermore, there were no consistent associations between availability/shelf space of fruits and vegetables and their consumption.

Five associations measured differences in weight status by access to supermarkets; four of these found that people with greater access to supermarkets had lower BMI/prevalence of overweight/obesity compared with those with less access. These differences were small-to-moderate in magnitude (i.e. differences of between 1–35%). The majority of associations (five out of eight) examining access to takeaway food outlets and weight status found that greater access was associated with greater BMI/prevalence of overweight/obesity. However, associations with access to

Table 1 Characteristics of in-scope studies

Author (date)	Country	Study name	Sample size (response rate)	Environmental assessment method	Dietary/weight assessment method	Environmental factors examined	Outcome measure(s)	Unit of outcome measure
Alaimo *et al.* (2008) (48)	USA	Speak to Your Health! Community Survey	*N* = 766 (15% response)	Self-reported	FFQ	Community participation	Frequency of fruit and vegetable consumption	Number of times consumed per day
Ball *et al.* (2006) (49)	Australia	SESAW	*N* = 1 347 women (42% response)	Objective and self-reported	FFQ	Social support, density of supermarkets and fruit and vegetable stores	Fruit and vegetable consumption.	Mean daily servings
Beydoun *et al.* (2008) (50)	USA	CSFII 1994–1996	*N* = 7 331 (response not provided)	Objective	24-h diet recall	Price of fruit and vegetables, price of fast food	Intakes of energy, total fat, fibre, fruit and vegetables	Mean daily intakes (continuous)
Binkley (2006) (51)	USA	Diet and Health Knowledge Survey	*N* = 4 361 (response not provided)	Self-reported	24-h diet recall	Household income, hours worked, receipt of food stamps, urban/rural residence	Fast food consumption	Whether consumed fast food in previous 24 h (yes/no)
Bodor *et al.* (2008) (52)	USA	–	*N* = 102 (53% response)	Objective	24-h recall	Location of small food store and supermarket, availability of fresh fruit and vegetables	Fruit and vegetable consumption	Mean daily servings
Boutelle *et al.* (2007) (53)	USA	Project EAT	*N* = 902 (70% response)	Self-reported	FFQ	Frequency of fast food for family meal	Fruit and vegetable, breakfast and lunch consumption	Mean daily servings fruit and vegetables, days per week that breakfast/lunch is consumed
Crawford *et al.* (2007) (54)	Australia	SESAW	*N* = 1 136 (42% response)	Self-reported	FFQ	Eating takeaway/fast-food	Fruit and vegetable consumption	Consumption of ≥1 serve daily (yes/no)
Cummins *et al.* (2005) (16)	UK	–	*N* = 412 (~10% response)	Objective	FFQ	Location of supermarket	Fruit and vegetable consumption	Mean daily servings
Dubowitz *et al.* (2008) (55)	USA	NHANES III (1988–1994)	*N* = 13 300 (response not provided)	Objective	24-h recall	Neighbourhood socioeconomic characteristics	Fruit and vegetable consumption	Mean daily servings
Fukuda *et al.* (2007) (56)	Japan	2001 Comprehensive Survey of the Living Conditions of People on Health and Welfare	*N* = 30 386 (87% response)	Objective and self-reported	FFQ	Per capita income of prefecture, unemployment of prefecture	Regular meal consumption	Poor dietary score (yes/no)
Giskes *et al.* (2003) (37)	Netherlands	GLOBE	*N* = 1 339 (81% response)	Objective	FFQ (81% RR)	Neighbourhood socioeconomic characteristics	Fat and fruit intake, breakfast consumption	Highest and lowest quartile of fat and fruit intake, respectively (yes/no), skips breakfast at least once per week (yes/no)
Inagami *et al.* (2006) (17)	USA	LAFANS study	*N* = 2 620 adults (RR not provided)	Objective	Not specified	Location of closest grocery store	BMI	Continuous
Inglis *et al.* (2008) (57)	Australia	SESAW	*N* = 1 580 (42% response)	Self-reported	FFQ	Perceptions of the availability of: high-quality fresh produce, fast-food and café proximity	Fruit, vegetable and fast-food consumption	Being a high fruit/vegetable consumer (yes/no), being a frequent fast-food consumer (yes/no)
Jeffery *et al.* (2006) (58)	USA		*N* = 1 033 (RR not provided)	Objective	Self-reported height and weight	Density of fast food outlets	BMI	Continuous

Table 1 *Continued*

Author (date)	Country	Study name	Sample size (response rate)	Environmental assessment method	Dietary/weight assessment method	Environmental factors examined	Outcome measure(s)	Unit of outcome measure
Li *et al.* (2009) (59)	USA		*N* = 1 221 48% RR	Objective	Self-reported height and weight	Density of fast food outlets	Overweight/obesity	Yes/no
Mehta and Chang (2008) (60)	USA	Behavioural Risk Factor Surveillance System	*N* = 714 054 (RR not provided)	Objective	Not specified	Density of fast food and full-service restaurants	BMI, overweight/obesity	BMI (continuous), overweight/obesity (yes/no)
Mohr *et al.* (2007) (61)	Australia	–	*N* = 20 527 (60% response)	Self-reported	FFQ	TV viewing	Fast food consumption	Frequency of fast food consumption per week
Moore *et al.* (2008) (62)	USA	Multi-Ethnic Study of Athersclerosis	*N* = 2 384 (46% response)	Objective and self-reported	FFQ	Density of supermarkets, availability of healthy foods	Fat intake	Being in highest quartile of fat intake
Morland *et al.* (2006) (40)	USA	ARIC	*N* = 10 763 82% RR	Objective	Measured height and weight	Presence of: supermarket, grocery store, convenience store, restaurant, fast-food outlet	Overweight/obesity	Yes/no
Morikawa *et al.* (2008) (63)	Japan	–	*N* = 4 736 (78% response)	Self-reported	Diet History	Shift work	Intakes of energy, fat, fibre and vegetables	Mean daily intakes (continuous)
Pearce *et al.* (2008) (39)	New Zealand	New Zealand Health Survey (2002/2003)	*N* = 12 529 (RR not provided)	Objective	FFQ	Access to takeaway food outlets	Fruit and vegetable consumption	Whether meets recommendations (yes/no)
Simmons *et al.* (2005) (64)	Australia	AusDiab	*N* = 1 454 (61% RR)	Objective	Measured height and weight	Availability of takeaway outlets and restaurants	Obesity	Yes/no
Stafford *et al.* (2007) (36)	UK	Health Survey for England and the Scottish Health Survey	*N* = 12 605 RR ranged 69–81%	Objective	Measured height and weight	Presence of supermarket	BMI	Continuous
Turrell and Giskes (2008) (46)	Australia	Brisbane Food Study	*N* = 1 001 (66% response)	Objective	FFQ	Area socioeconomic characteristics, access to takeaway food outlets	Takeaway food consumption	Consumption at least once per month
Wang *et al.* (2008) (65)	USA	Standford Heart Disease Prevention Program	*N* = 5 779 (56–69% response)	Objective	FFQ, measured height and weight	Density of: supermarkets, grocery stores, convenience stores, fast-food outlets	Fat consumption	Mean daily intake (continuous)
Wang *et al.* (2007) (66)	USA	Standford Heart Disease Prevention Program	*N* = 5 779 (56–69% response)	Objective	FFQ, measured height and weight	Density of: supermarkets, grocery stores, convenience stores, fast-food outlets	BMI	Continuous
Watters *et al.* (2007) (67)	USA	–	*N* = 747 (18% response)	Self-reported	FFQ	Urban/rural residence, social support	Fruit and vegetable consumption	Mean daily servings
Zenk *et al.* (2005) (68)	USA	East Side Village Health Worker Partnership	*N* = 365 (~65% response)	Self-reported	FFQ	Type of food store participants shopped at, assortment/selection/quality of fruits and vegetables in store	Fruit and vegetable consumption	Frequency of intake

BMI, body mass index; FFQ, food frequency questionnaire.

Table 2 Summary of study findings examining associations between accessibility factors, dietary behaviours and weight status*†‡

Author (date)	Energy	Fat	Fibre	Fruit/vegetables	Weight status	Other
Access to supermarkets (high vs low)						
Ball *et al.* (2006) (49)				(=) F (=) V		
Bodor *et al.* (2008) (52)				(=) F (=) V		
Cummins *et al.* (2005) (16)				(=) FV		
Moore *et al.* (2008) (62)		(–) 85%				(–) 85% processed meat
Morland *et al.* (2006) (40)					(–) 10% overweight (–) 35% obese	
Stafford *et al.* (2007) (36)					(–) <1% BMI	
Wang *et al.* (2007) (66)		(=)				
Wang *et al.* (2008) (65)					(=) men (–) <1% BMI women	
Zenk *et al.* (2005) (68)				(+) 19% FV		
Access to grocery or convenience store (high vs low)						
Bodor *et al.* (2008) (52)				(–) 25%F (–) 38%V		
Inagami *et al.* (2006) (17)					(–) 3% BMI	
Morland *et al.* (2006) (40)					Grocery store: (=) overweight (+) 17% obesity Convenience store: (=) overweight (+) 12% obesity	
Wang *et al.* (2007) (66)	(+) 20–32%					
Wang *et al.* (2008) (65)					Grocery store: (=) men (+) <1% women Convenience store: (=) men (=) women	
Access to takeaway food outlets (high vs low)						
Inglis *et al.* (2008) (57)				(=) FV		(=) fast food
Jeffery *et al.* (2006) (58)					(=) BMI	
Li *et al.* (2009) (59)					(+) 7% overweight/obesity	
Mehta and Chang (2008) (60)					(+) <1% BMI (+) 5% obesity	
Morland *et al.* (2006) (40)					(+) 6% overweight (+) 14% obesity	
Pearce *et al.* (2008) (39)				(=) F (=) V multinational (–) OR 0.85 (0.73 to 1.00) V local		
Simmons *et al.* (2005) (64)					(=) overweight/obesity	
Turrell and Giskes (2008) (46)						(=) takeaway
Wang *et al.* (2007) (66)		(–) 20–32%				
Wang *et al.* (2008) (65)					(=) BMI	
Access to restaurants and cafes (high vs low)						
Inglis *et al.* (2008) (57)				(=) FV		(=) fast food
Mehta and Chang (2008) (60)					(–) 1% BMI (–) 11% obesity	
Morland *et al.* (2006) (40)					(=) overweight (=) obesity	
Simmons *et al.* (2005) (64)					(=) obesity	
Access to fruit and vegetable stores (high vs low)						
Ball *et al.* (2006) (49)				(=) FV		
Availability/shelf space of healthy foods in stores (high vs low)						
Bodor *et al.* (2008) (52)				(=) F (+) 47%V		
Inglis *et al.* (2008) (57)				(+) OR 0.70 (0.56 to 0.93) F (+) OR 0.60 (0.46 to 0.81) V		(=) fast food
Moore *et al.* (2008) (62)		(–) 28%				
Zenk *et al.* (2005) (68)				(=) FV		
Prices (high vs low)						
Beydoun *et al.* (2008) (50)	(=)	(=)	(–) 14%	(=)	(=)	(=) fast food

*Differences reported are relative to the reference group (i.e. '+' refers to higher intakes relative to the reference group, '–' refers to lower intakes relative to the reference group and '=' refers to no differences). Differences were reported as higher or lower if they were statistically significant ($P < 0.05$) or if relative differences in intakes were ≥10%.

†Relative difference (%) in intakes between lowest and highest socioeconomic groups calculated by: ([value lowest group – value highest group]/value highest group) × 100.

‡Odds ratios (OR) were reported where outcome variable were dichotomous.

F, fruit; FV, fruit and vegetables (combined); V, vegetables.

grocery/convenience stores were found to be mixed. Five associations looked at takeaway consumption in relation to takeaway outlets, shelf space and prices of healthy foods, and also found no association with takeaway consumption. Another five associations examined access to restaurants/cafes and weight status, three of these found no differences in weight status by access.

Social factors

Table 2 summarizes associations between social factors and dietary intakes or weight status. There were mixed associations found between social support and fruit and vegetable consumption. Only one study examined community participation, and found no association with fruit and vegetable consumption.

Cultural factors

Associations between cultural factors and obesogenic dietary intakes are summarized in Table 3. Only two studies were located, and these found mixed associations with TV viewing and consumption of fruit and vegetables or takeaway foods (Table 4).

Material factors

Study findings examining associations between material factors and obesogenic dietary intakes are shown in Table 5.

The two studies examining area deprivation and fruit and vegetable consumption found that living in a socioeconomically advantaged area was associated with greater fruit and vegetable consumption or a higher likelihood of their consumption. Only two studies looked at fruit and vegetable consumption in relation to urban/rural residence and shift work; these found that residing in a rural area and not being a shift worker were associated with higher fruit and vegetable intakes.

There was only one study examining associations in takeaway consumption with each of the following material factors: area deprivation, urban/rural residence and receipt

Table 3 Summary of study findings examining associations between social factors, dietary behaviours and weight status*†‡

Author (date)	Energy	Fat	Fibre	Fruit/vegetables	Weight status	Other
Social support (high vs. low)						
Ball *et al.* (2006) (49)				(+) 13 to 18% F		
				(+) 11 to 19% V		
Watters *et al.* (2007) (67)				(=) FV		
Community participation (high vs. low)						
Alaimo *et al.* (2008) (48)				(=) FV		

*Differences reported are relative to the reference group (i.e. '+' refers to higher intakes relative to the reference group, '–' refers to lower intakes relative to the reference group and '=' refers to no differences). Differences were reported as higher or lower if they were statistically significant ($P < 0.05$) or if relative differences in intakes were ≥10%.
†Relative difference (%) in intakes between lowest and highest socioeconomic groups calculated by: ([value lowest group – value highest group]/value highest group) × 100.
‡Odds ratios (OR) and 95% confidence intervals were reported where outcome variable were dichotomous.
F, fruit; FV, fruit and vegetables (combined); V, vegetables.

Table 4 Summary of study findings examining associations between cultural factors, dietary behaviours and weight status*†‡

Author (date)	Energy	Fat	Fibre	Fruit/vegetables	Weight status	Other
TV viewing (high vs. low)						
Crawford *et al.* (2007) (54)				(–) OR 0.70 (0.50 to 1.0) F		
				(–) OR 0.60 V		
Mohr *et al.* (2007) (61)						(+) 12% takeaway food

*Differences reported are relative to the reference group (i.e. '+' refers to higher intakes relative to the reference group, '–' refers to lower intakes relative to the reference group and '=' refers to no differences). Differences were reported as higher or lower if they were statistically significant ($P < 0.05$) or if relative differences in intakes were ≥10%.
†Relative difference (%) in intakes between lowest and highest socioeconomic groups calculated by: ([value lowest group – value highest group]/value highest group) × 100.
‡Odds ratios (OR) were reported where outcome variable were dichotomous.
F, fruit; FV, fruit and vegetables (combined); V, vegetables.

Table 5 Summary of study findings examining associations between material factors, dietary behaviours and weight status*†‡

Author (date)	Energy	Fat	Fibre	Fruit/vegetables	Weight status	Other
Area deprivation characteristics (advantaged vs. deprived)						
Dubowitz *et al.* (2008) (55)				(+) 24%FV		
Fukuda *et al.* (2007) (56)						(–) 9–12% irregular meal pattern
Giskes *et al.* (2003) (37)	(=)			(+) OR 1.18 (0.79 to 1.72) F		(–) OR 0.67 (0.43 to 1.05) skipping breakfast
Turrell and Giskes (2008) (46)						(=) takeaway purchase
Urban/rural residence (urban vs rural)						
Binkley (2006) (51)						(+) 14% takeaway consumption
Watters *et al.* (2007) (67)				(+) 21%FV		
Shift work (yes vs no)						
Morikawa *et al.* (2008) (63)	(+) 7–10%			(–) 22%V		

*Differences reported are relative to the reference group (i.e. '+' refers to higher intakes relative to the reference group, '–' refers to lower intakes relative to the reference group and '=' refers to no differences). Differences were reported as higher or lower if they were statistically significant ($P < 0.05$) or if relative differences in intakes were ≥10%.

†Relative difference (%) in intakes between lowest and highest socioeconomic groups calculated by: ([value lowest group – value highest group]/value highest group) × 100.

‡Odds ratios (OR) were reported where outcome variable were dichotomous.

F, fruit; FV, fruit and vegetables (combined); V, vegetables.

of welfare. Only living in an urban area was associated with higher takeaway consumption. Two associations that examined area deprivation and meal patterns found that living in a socioeconomically advantaged area was associated with more regular meal patterns.

Discussion

We conducted a systematic review of the literature examining environmental factors associated with obesogenic dietary intakes and overweight/obesity. Weight status was most consistently associated with features of the environment; residents of areas with greater access to supermarkets or lower accessibility to takeaway outlets had a lower prevalence of overweight/obesity compared with those living in areas with limited supermarket access or a greater accessibility to takeaway outlets. Paradoxically however, the findings of studies examining environmental factors in relation to obesogenic dietary behaviours were less consistent, with mixed associations reported. The only exception to this was area-level deprivation, with residents of socioeconomically deprived areas having a greater likelihood of obesogenic dietary intakes than their counterparts in advantaged areas.

The current review updated two systematic reviews conducted in 2004 that examined environmental correlates of energy, fat, fruit and vegetable intakes (20,21). These previous reviews found that most studies focussed on work conditions and seasonal/day-of-the-week variations in dietary intakes. However, the current review found an increasing amount of research that examined accessibility factors (i.e. locations of supermarkets, takeaway food stores, availability of healthy food choices within stores) and area-level socioeconomic deprivation than reported in previous reviews. Furthermore, we found a greater number of studies that examined these environmental factors in relation to the distal outcome, weight status, rather than the more 'intermediate' outcome of dietary intakes.

Greater access to takeaway outlets may increase the ease at which people make food choices less consistent with dietary recommendations by minimizing barriers to making these choices (15,38). A limited access to supermarkets may result in reliance on convenience stores or takeaway outlets; these stores tend to sell foods less consistent with long-term health (16,39,40). Living in a socioeconomically deprived area may influence dietary behaviours by limiting access to supermarkets (through lower servicing of these areas by supermarkets or lower access to transport) and increasing access to corner/convenience stores (40). This later association is predominantly seen in the USA, however, is not consistently observed in other countries (41). Despite an increase in research examining accessibility factors, relatively few studies have examined other environmental factors implicated in the obesity epidemic, such as: portion sizes and the marketing of energy-dense foods (4,18).

We found more consistent evidence of associations between environmental factors and *weight status* than studies examining associations between environmental factors and *dietary intakes*. If the environment is hypothesized to influence weight status, we would expect to find an association between environmental factors and diet, and between environmental factors and weight status. A potential explanation of this finding is that environmental factors may influence BMI through a more complex interplay of factors, including physical activity, which has not been well explored in other studies. However, this is difficult to ascertain as no known studies have assessed features of the environment, dietary intakes, physical activity and weight status simultaneously. This may also be due (in part) to the complexity in measuring dietary intakes and physical activity; calculating these requires accurate recall and description of dietary intakes and physical activity (42). This is particularly difficult to achieve in studies of population-representative samples, where the self-administered data collection methods frequently used generally involve a high degree of participant burden (42). Furthermore, obesogenic food and physical activity environments may co-exist, making it difficult to attribute which feature of the environment contributes to the development of overweight and obesity. This is an area that requires increased research activity to disentangle the pathways that contribute to the spatial patterning in weight status in urban areas that has been documented in a number of studies from North America (13,43,44), Europe (45) and Australia (12).

The majority of studies included in the current review were conducted in the USA, UK or Australia/New Zealand. It is therefore unclear whether findings from this review can be generalized to other regions. Previous research has shown that the USA represents an anomaly with respect to the geographic size of urban areas and the residential segregation of socioeconomic and ethnic groups compared with other developed countries (41,46). This has raised the issue of whether the associations seen between environmental factors and dietary behaviours in the USA are relevant to other developed countries, especially in the European region (41).

This study considered a number of dietary outcomes; however, the findings showed that associations between obesogenic dietary behaviours and environmental factors have been studied most frequently for fruit and vegetable intakes. This may be because fruit and vegetable consumption is positively associated with other healthy dietary intakes and behaviours, such as intakes that are less energy dense, lower in fat, higher in fibre and less frequent consumption of fast food (20,47). However, it is likely that environmental factors are associated with each nutrient, food group or dietary intake pattern differentially (18,20). For example, accessibility to fruit and vegetable shops may influence fruit, vegetable and fibre consumptions; however, it is less plausible that accessibility to fruit and vegetable shops may influence the consumption of sugar-rich beverages or meal patterns. Therefore, it is important for future research to investigate environmental influences on all dietary factors that may contribute to obesogenic dietary intakes.

Several limitations of our review must be considered in light of our findings. Our search strategy only located studies that were published in peer-reviewed journals and referenced in electronic databases, excluding 'grey' literature. We tried to minimize any potential bias that may be induced from only examining peer-reviewed literature by also performing searches in smaller and more specialized databases (e.g. CSA Illumina). There was also great variation between studies included in the current review in terms of the conceptualization, measurement and summary of both the environmental factors and dietary behaviours which may have contributed to heterogeneous findings. Furthermore, although strict inclusion criteria were used, environmental or dietary intake measures sometimes differed markedly between studies. Little is known about appropriate confounders to adjust for when examining associations between environmental factors and dietary intakes/weight status (20). Some studies may have 'over-corrected' for such factors, which may diminish the magnitude or significance of associations with environmental factors. Whereas other studies that did not correct for appropriate individual-level confounders and therefore may over-estimate the strength or significance of these associations. Furthermore, most of the studies included in this review were cross-sectional, making it difficult to ascertain causality between environmental factors and obesogenic dietary intakes.

The current review suggested that accessibility to supermarkets/takeaway outlets or residing in a socioeconomically deprived area are environmental factors that may contribute to overweight or obesity and/or obesogenic dietary behaviours. These factors need to be targeted in multilevel health promotion interventions and policies aimed at decreasing overweight/obesity. The role of other environmental factors, however, should not be discarded without further investigation, namely those whose associations with dietary behaviours/weight status were not examined or are not possible to infer from the limited number of studies. Despite the limitations in the evidence base to date, we should not refrain from policies and interventions promoting healthy environments because waiting for such evidence to emerge before action is taken may simply represent a delay to addressing the obesity epidemic. To understand the role of environmental factors, studies are required that simultaneously examine a broad range of environmental factors, obesogenic dietary behaviours and physical activity and that utilize prospective study designs.

Conflict of Interest Statement

No conflict of interest was declared.

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