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The influence of the urban food environment on diet, nutrition and health outcomes in low-income and middle-income countries: a systematic review

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ABSTRACT

Introduction Diet and nutrition are leading causes of global morbidity and mortality. Our study aimed to identify and synthesise evidence on the association between food environment characteristics and diet, nutrition and health outcomes in low-income and middle-income countries (LMICs), relevant to urban settings, to support development and implementation of appropriate interventions.

Methods We conducted a comprehensive search of 9 databases from 1 January 2000 to 16 September 2020 with no language restrictions. We included original peer-reviewed observational studies, intervention studies or natural experiments conducted in at least one urban LMIC setting and reporting a quantitative association between a characteristic of the food environment and a diet, nutrition or health outcome. Study selection was done independently in duplicate. Data extraction and quality appraisal using the National Heart Lung and Blood Institute checklists were completed based on published reports using a prepiloted form on Covidence. Data were synthesised narratively.

Results 74 studies met eligibility criteria. Consistent evidence reported an association between availability characteristics in the neighbourhood food environment and dietary behaviour (14 studies, 10 rated as good quality), while the balance of evidence suggested an association with health or nutrition outcomes (17 of 24 relevant studies). We also found a balance of evidence that accessibility to food in the neighbourhood environment was associated with diet (10 of 11 studies) although evidence of an association with health outcomes was contradictory. Evidence on other neighbourhood food environment characteristics was sparse and mixed. Availability in the school food environment was also found to be associated with relevant outcomes. Studies investigating our other primary outcomes in observational studies of the school food environment were sparse, but most interventional studies were situated in schools. We found very little evidence on how workplace and home food environments are associated with relevant outcomes. This is a substantial evidence gap.

Key questions

What is already known?

- There is growing evidence from high-income settings that food environments drive behaviour, nutrition and health outcomes.
- We don't know how, or which aspects of, food environments may be impacting populations in low-income and middle-income countries.

What are the new findings?

- This systematic review is the largest known compilation of evidence on the impact of the food environment on health in low-income and middle-income countries, compiling experimental and observational studies to illuminate areas where the evidence is consistent, where it is contradictory, and where it is lacking.
- The balance of evidence suggests that availability and accessibility domains of the food environment are associated with diet, nutrition and/or health outcomes, while evidence on the impact of prices, vendor and product properties, marketing and regulation is sparse and mixed.

What do the new findings imply?

- Our synthesis can be used to support policy and practice activities to change the availability of healthy and unhealthy food in the neighbourhood environment, particularly in middle-income countries; examples would be zoning laws or healthy food carts.
- Affordability and social environment ('desirability') interventions appear to be potentially interesting and worthwhile avenues to pursue (little but consistent evidence).
- More research is required to understand the impact of workplace and home food environments, vendor and product properties in neighbourhoods and schools, and intervention studies in lower middle-income and low-income countries.

Conclusion 'Zoning' or 'healthy food cart' interventions to alter food availability may be appropriate in urban LMIC.
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INTRODUCTION

Diet and nutrition are among the leading causes of global illness, disability and death; in 2017, 1 in 5 deaths and 255 million disability-adjusted life-years were attributed to dietary risk factors.[1] This is largely due to the contribution of dietary risk factors to development of non-communicable diseases (NCDs). The health and economic impacts of NCDs in low-resource settings are disproportionally high[2–4]; around 80% of NCD deaths occur in low-income and middle-income countries (LMICs).[5] Diet also plays a role in wider morbidity and mortality, including from infectious diseases.[6 7]

The food environment includes 'physical, economic, policy and sociocultural surroundings, opportunities and conditions' that are likely to drive dietary behaviour, nutrition and health.[8] Systematic reviews of evidence from high-income countries (HICs) have found evidence of associations between availability of specific categories of food outlets and dietary and health outcomes,[9–12] as well as evidence suggesting associations between other characteristics of the food environment (eg, affordability, marketing and regulation) and dietary and health outcomes.[12 13] These have driven policy-makers to intervene and attempt to regulate the food environment to improve health outcomes.[14 15]

Globalisation and international trade are homogenising environments and infrastructure worldwide, however, there are still important differences in the food environments, and the way that populations interact with these, between HICs and LMICs.[16] For this reason, despite an existing evidence base on the association between the food environment in HICs and diet, nutrition and health outcomes, it is important to also investigate and synthesise evidence from LMICs.

Fifty-five per cent of the world population lives in urban settings, and this figure is projected to rise to 70% by 2050.[17] There are differences between urban and rural LMIC settings relating to the food environment, dietary behaviour and health. In urban LMIC, individuals are more likely to buy than grow food for their own consumption and a number of distinct barriers exist which may reduce access to healthy food, such as more expensive fresh food.[18] There is evidence that diets, dietary behaviour and related health outcomes may be poorer in urban LMIC settings than in rural LMIC settings. The global burden of disease study noted a marked difference between obesity prevalence in rural and urban populations[19] and a more recent review highlights higher prevalence of central obesity in urban residents.[20] A systematic review and meta-regression found an association between urbanicity and obesity prevalence in Southeast Asia.[21] Further systematic reviews and meta-regression analyses have found that in sub-Saharan Africa, urban residents are more likely to consume salt and less likely to consume vegetables than rural residents.[22 23] A 2015 study of 74 Latin American countries found that sales of ultraprocessed products were larger in more urbanised countries.[24]

Context-specific research is required to understand how the food environment in urban LMIC can support or hinder the diet and health of LMIC populations, to support development of appropriate interventions. LMIC policy-makers need to see evidence that resonates with them to justify taking steps to intervene in the food environment.

Aim

The aim of our study is to identify and synthesise evidence that reports associations between the characteristics of the food environment and diet, health and nutrition outcomes or effects of food environment interventions on these outcomes, in LMICs that are relevant to urban settings.

METHODS

A theoretical framework for conceptualising the LMIC food environment

We have adopted Turner *et al*'s[16] conceptual model of the food environment, developed through a series of iterative, international congregations with experts in nutrition and public health. In this conceptual model, the food environment is situated within the broader food system. The model relates four external domains (food availability, prices, vendor and product properties, marketing and regulation) to four personal domains (food accessibility, affordability, convenience and desirability).[16] For this review, we are most interested in the external domains of the food environment. However, we also conceive of accessibility (which in Turner's model includes physical distance to food vendors and individual activity spaces) and affordability (purchasing power) as concepts of interest. This is reflected in our study eligibility criteria and further details are in tables 1 and 2.

Search strategy and selection criteria

For this systematic review, we conducted a comprehensive search of nine databases: MEDLINE, EMBASE, Global Health, Econlit, Web of Science, Scopus, CINAHL, PsycINFO and Applied Social Sciences Index and Abstracts on 16 September 2020 to identify relevant studies. We did not apply any language restrictions, but restricted the search to studies published since the year 2000. The search strategy was based on those published in Turner *et al*,[25] adapted by two researchers (OO and SW) and an academic librarian. The search terms used in MEDLINE are presented in online supplemental table 1).

After completion of searches, retrieved records were exported to an EndNote library, duplicates were removed and records were then imported and managed using the

Table 1 Eligibility criteria

Domain	Inclusion criteria	Exclusion criteria
Population/setting	Must feature one or more urban LMIC setting according to the World Bank Data (2020) classification of countries.[106]	High-income country settings or high-income country and LMIC settings in which it is impossible to disaggregate the LMIC findings. Exclusively rural settings.
Exposure/intervention	One or more of six food environment characteristics defined in table 2 (Availability, Price, Vendor and Product Properties, Marketing and Regulation, Accessibility and/or Affordability). We also collected data on quantitative associations between two further food environment characteristics (Convenience or Desirability) and our outcomes of interest. However, if papers reported associations between these food environment characteristics and our outcomes of interest only, they were excluded.	Do not include relevant exposures.
Outcomes	Must report a quantitative association between a food environment characteristic (as described in exposure/intervention) and: Any health outcome (eg, prevalence of obesity, hypertension, diabetes or any other health outcome) or Diet/ dietary behaviour outcome (eg, foods bought or consumed) or Nutrition outcome (energy intake, macronutrients or micronutrients consumed)	Do not include relevant outcomes or do not include associations between the exposure/intervention of interest and relevant outcomes.
Study design	Quantitative or mixed-methods observational studies (cross-sectional, case–control, longitudinal cohort and mixed-methods studies) or intervention studies (including trials, interrupted time series or other intervention study designs) and natural experiments will be included.	Reviews including systematic reviews Qualitative studies
Publication type	Original peer-reviewed published articles	Protocols, full theses, case series and case reports. Conference abstracts.

LMIC, low-income and middle-income country.

online platform Covidence. A predefined list of inclusion and exclusion criteria (table 1) was used to sift titles and abstracts in duplicate (SW, IG, HMJ, DM, NA, LA-K and OO), with any study assessed as potentially relevant by either reviewer (or both) retrieved in full for text assessment. Formal eligibility assessment was done in duplicate (SW, IG, AI, HMJ, DM, NA, RI and OO) with disagreements resolved by a third reviewer (OO or SW). Further screening of the reference lists of included studies was also completed by one reviewer (SW).

The protocol for this study was registered online with the PROSPERO database: (CRD42020207475).[26]

Data analysis

We extracted data into a predetermined and piloted data extraction form on Covidence. We extracted data on study characteristics (citation; study design, duration and timing; setting), participant characteristics, details of the food environment characteristics examined including how these were assessed, details of the health, details of the diet or nutrition outcomes including definition and assessment method and key findings including statistics such as effect sizes as reported.

We conducted quality appraisal using the National Heart Lung and Blood Institute checklists relevant to the study design pertaining to the outcomes of interest (eg, for a mixed-methods study which reported a cross sectional association between a food environment characteristic and a health, diet or nutrition outcome, we would use the checklist for cross sectional studies). Quality was rated good, fair or poor.

Seven studies were abstracted and quality appraised in duplicate, with any variation between extractions resolved by one reviewer (OO). There were no inconsistencies between extractions and so the majority of data extraction and quality appraisal were completed by one reviewer (SW, IG, HMJ, FS, AI or OO) and checked by a second reviewer (SW or OO).

We synthesised identified literature by subdividing the studies into groups first into observational studies and interventional studies. For the synthesis of observational studies, we grouped them based on the food environment characteristics examined, and within these groups, we further subdivided studies into those reporting health, nutrition or diet outcomes respectively. We did not try to standardise the exposures or outcomes of the observational studies. Instead we were most interested in whether an association was reported between the characteristic and an outcome. For the interventional studies we synthesised the findings by comparing the outcomes from studies with elements targeting similar food environment characteristics. We did not apply Grades of Recommendations, Assessment, Development and

Table 2 Characterisation of the food environment, adopted from Turner *et al*[16]

	External				Internal			
Turner concept	**Availability**	**Prices**	**Vendor and product properties**	**Marketing and regulation**	**Accessibility**	**Affordability**	**Convenience**	**Desirability**
Turner definition	Presence of food sources or products	Monetary value of food products	Vendor properties (typology, opening hours, services) and product properties (food quality, composition, safety, level of processing, shelf-life, packaging)	Promotional information, branding advertising, sponsorship, labelling, policies	Physical distance, time, space and place, individual activity spaces, daily mobility, mode or transport	Purchasing power	Relative time and effort of preparing, cooking and consuming food product, time allocation	Preferences, acceptability, tastes, desires, attitudes, culture, knowledge and skills
	Primary outcomes						**Secondary outcomes**	
Examples from the identified literature	Density of food retail outlets of various types. Counts of food retail outlets. Presence of food retail outlets of various types. Availability of specific food items at school or home.	Monetary value of fruit, vegetables, sugar-sweetened beverages, ultraprocessed food, apples.	Quality of fruit and/or vegetables. Commercial vendor within a school or non-commercialised food environment.	Billboard advertising of various types. Advertising within food retail locations. Provincial school policies. Individual school policies. School status as a health promoting school. Workplace policy	Living near a fast-food outlet. Perceived local food availability of various types. Perceptions of ease of access to retail outlets of various types.	'I can buy fruit and veg even when they are expensive' The cost of two servings of fruit and three of vegetables per day relative to household income.	'I have time to prepare and eat Fruit and veg' 'Fruit and veg are easy to prepare for me'	Preferences measured using Likert scales 'I like it very much' to 'I have not tried it' Culture ► Survey questions such as: 'Parents remind me to eat' 'Parents pressure me to eat' 'everyday we eat on time' 'We watch TV during a meal' ► Family support ► Attitude of manager
No of times this appears	54	4	3	15	22	2	3	11

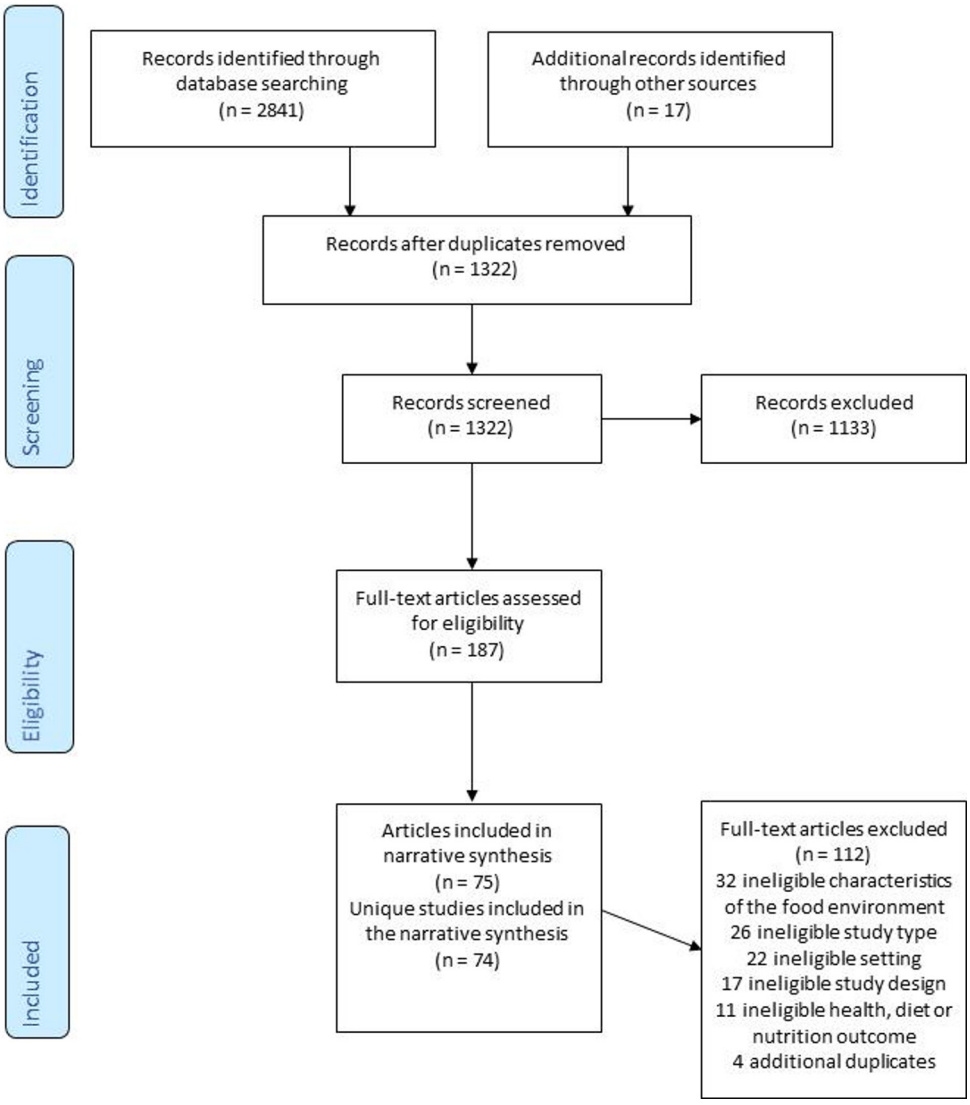

Figure 1 PRISMA flow diagram. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Evaluation to assess the certainty of the evidence from the identified trials, because of the heterogeneous nature of the complex interventions in these, and the type of recommendations we were seeking to make.

We reported the study according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[27]

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation or writing of the report. The corresponding author had full access to all the data in the review and had final responsibility for the decision to submit for publication.

RESULTS

Search results

Figure 1 provides the PRISMA diagram and reasons for exclusion. Searches identified 2858 records. Titles and abstracts of 1322 were screened, including 1305 deduplicated records identified through database searching and 17 records identified through reference screening of included studies. We identified 187 articles for full-text review of which 75 articles met eligibility criteria and were included in this systematic review. For a full list of excluded studies, please see online supplemental table 3).

Description of included studies

Tables 2 and 3 describe the characteristics of the observational and interventional articles included, respectively. Identified studies were published between 2010 and 2020 and included data collected from the year 2000 onwards (although a few studies did not report when data collection occurred). In total 29 countries were represented in the data included in this systematic review, including both higher and lower middle income countries (26 and 20 represented, respectively), as well as low-income countries (three represented: Malawi, Sudan and Syria, all included within multicountry studies).

Sixty-seven included articles reported 67 unique observational studies, comprised of 6 multicountry studies and

Table 3 Characteristics of included observational studies

Study ID	Study setting	Dates of data collection	Population	Food environment characteristic/s	Outcome
Cohort studies					
Seto, 2020[71]	Kunming, China, Neighbourhood	Not reported	12 adults aged 18–31 (mean age 24.6). With average BMI of 21.0. 17% with overweight.	Acc	D
Wang, 2012[34]	China, Neighbourhood	2004 and 2006	185 children aged 6%–18. 51% female.	Av	N
Xu, 2013[35]	9 provinces, China, Neighbourhood	2000–2009	13 993 male and 15 125 female person-years. Mean age ranged between 44 and 51 over the period 2000–2006.	Av	H
Case–control studies					
Setiyaningsih, 2019[36]	Surakarta, Indonesia, School	April 2019	225 children from 15 schools including 75 with obesity and 150 normal weight.	Av	H
Cross-sectional studies					
Alves, 2019[76]	Florianopolis, Brazil, Neighbourhood	September 2012–June 2013	2484 children aged 7–14 (mean age 10.4). 56.5% female. 66.8% normal weight.	Acc	D
Assis, 2019[50]	Juiz de Fora, Brazil, Neighbourhood	July 2011– December 2021	661 children aged 7–14 (median age 11). 51.7% female.	Av	H
Azeredo, 2016[89]	Brazil; School	2012	109104 students majority aged 11%–14. 52.2% female.	Av	D
Backes, 2019[51]	Sao Leopoldo, Brazil, Neighbourhood	2015	1096 women aged 20–69 years. 33.1% with obesity.	Av	H
Barrera, 2016[84]	Cuernavaca and Guadalajara, Mexico, School	October 2012–March 2013	725 children aged 9–11 (median age 10). 56.8% female. 24.8% with overweight and 20.7% with obesity.	Av	H
Bekker, 2017[30]	Bloemfontein, South Africa, School	Not reported	257 students aged 7–14 took part in the quantitative data collection. 61.1% female.	Av	D
Camargo, 2019[62]	Campinas, Brazil, Neighbourhood	July 2014– December 2014	Residents aged 18+ of two low-income areas.	Av	H
Charoenbut, 2018[29]	Samutprakarn province, Thailand, Workplace	March–June 2011.	924 workers from 26 industrial factories. 39.1% aged 31%–40. 56.5% female.	Av, M&R, D	D
Chor, 2016[72]	6 cities, Brazil, Neighbourhood	August 2008– December 2010	14749 civil servants at teaching and research institutions aged 35–74 (median age 51 years). 54.4% women.	Acc	D

Continued

Table 3 Continued

Study ID	Study setting	Dates of data collection	Population	Food environment characteristic/s	Outcome
Corrêa, 2018[52]	Florianopolis, Brazil, Neighbourhood	September 2012–June 2013	2195 children aged 7%–14. 47.7% female. The prevalence of overweight/obesity was 29.0% for girls, 37.6% for boys.	Av	H
Cunningham-Myrie, 2020[53]	Jamaica, Neighbourhood	2008	2529 participants in a nationally representative survey, aged 18–74 (Mean age of men=37.0 years, mean age of women=36.7 years). 68.5% female. Mean BMI for women 28.4. Mean BMI for men 24.8.	Av; Acc	H
Curioni, 2020[37]	Rio de Janeiro, Brazil, Neighbourhood	2012–13	2032 civil servants of a university. 46% aged 45–54 years. 60% women.	Av	D
da Silva, 2019[66]	Minas Gerais, Brazil; Neighbourhood	June 2012–July 2016	965 women and men aged 20–59 years old (mean age: 34.2). 55.2% female. 13.8% with obesity.	Av	H
Dake, 2016[54]	Accra, Ghana, Neighbourhood	2011–2013	657 participants (mean age 31.5). 54.0% female. 23.29% with overweight, 18.6% with obesity.	Av	H
Darfour-Oduro, 2020[91]	24 countries: Malawi, Jordan, Egypt, Maldives, Dominica, Grenada, Jamaica, Fiji, Malaysia, Mongolia, Indonesia, Phillippines, Thailand, Benin, Mauritania, Sudan, Algeria, Libya, Morocco, Syrian Arab Republic, Pakistan, Argentina, Honduras, Tonga, School	2004–2013	89843 children aged 13–17.	M&R	D
de Freitas, 2019[60]	Belo Horizonte, Brazil, Neighbourhood	2013	2810 participants, majority aged 30–59 (54.1%). 88.4% female. Mean BMI 27.8. The majority with overweight (62.6%).	Av; V/P; Price; M&R	H
Duran, 2015[38]	Sao Paulo, Brazil, Neighbourhood	2010–2011	1842 adults aged 20–59 (mean age 36.5). 53% female.	Av; Acc; Price	D
Fernandes, 2017[31]	Ghana, School	2013–2014	4258 children aged 5–17 years. 46.9% female.	Av	D
Gonçalves, 2019[87]	Brazil, School	2013–2014	73399 children aged 12–17 years (mean age 14.4 years) from 1247 schools.	Av; V/P	H

Continued

Table 3 Continued

Study ID	Study setting	Dates of data collection	Population	Food environment characteristic/s	Outcome
Goryakin, 2015[39]	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia and Ukraine, Neighbourhood	2010–2011	17998 adults aged 18–95 years.	Av; Acc; M&R	D
Guo, 2018[64]	12 provinces, China, neighbourhood	2011–2013	1416 children aged 7–17.	Av; M&R	H
Guo, 2019[65]	China, Neighbourhood	2000–2013	4803 children aged 7–17.	Av; M&R	H
Hall, 2020[55]	China, Neighbourhood	November 2016–August 2017	1388 women aged 18–67 (median age 41). Mean BMI 24.5% and 64.0% with overweight or obesity.	Av	H
Hua, 2014[63]	Macau, China, Neighbourhood	2011	575 children aged 13–18 from one high school. Mean BMI 21.1.	Av	H
Jaime, 2011[40]	Sao Paulo, Brazil, Neighbourhood	2003	2122 adults aged 18+.	Av	H, D
Kelly, 2014[70]	Thailand, Neighbourhood	2012	1516 students enrolled at an Open University (studying by correspondence and living all over the country). Aged 18–87 (mean age 29).	Av; Acc	H, D, N
Kivuyo, 2020[73]	Punjab, India, Neighbourhood	Not reported	120 African emigrant students in Pubjab. Age range 18->28 years 64.9% aged 23–27.	Acc; D	D
Kroll, 2019[48]	Khayelitsha, South Africa and Ahodwo, Ghana, Neighbourhood	September–November 2017	327 households in Khayelitsha, South Africa and 309 households in Ahodwo, Ghana.	Av	D
Leite, 2017[41]	Santos, Brazil, Neighbourhood	January 2010–June 2011	513 children aged under 10.	Av	D
Leme, 2017[93]	Sao Paulo, Brazil, Home	2014	253 adolescent girls aged 14%–18. 70.4% Hy weight, 18.3% overweight and 8.3% obese.	Acc; D	D
Li, 2011[85]	Xi'an City, China, School	May–November 2004	1792 children aged 11–17 years (mean age 13.9). 49.8% female.	Av; M&R	H
Liu, 2014[47]	nine provinces, China, Neighbourhood	2006	No sample size reported. Aged 18–95 mean age 49.4 for urban and 48.7 for rural participants. 53% female in urban sample, 52% female in the rural sample.	Av; Acc; Conv	D
Liu, 2020[74]	Shenyang, China, Neighbourhood [68]	May 17th–June 23rd 2017	3670 children (mean age 10.8) from 26 schools. 49% female.	Acc	H, D

Continued

Table 3 Continued

Study ID	Study setting	Dates of data collection	Population	Food environment characteristic/s	Outcome
Machado, 2017[82]	Brazil, Neighbourhood	2008–2009	55970 households from a nationally representative survey	Price, Conv	D
Matozinhos, 2015[56]	Belo Horizonte, Brazil, Neighbourhood	2008–2010	5273 adults aged 18–93 (mean age 43.6). 56.5% female. 12.1% with obesity.	Av	H
Mendes, 2013[67]	Belo Horizonte, Brazil, Neighbourhood	2008–2009	3404 adults aged 18+ (mean age 39.7).	Av	H
Mendonça, 2019[42]	Belo Horizonte, Brazil, Neighbourhood	2013/2014	3414 adults aged 20+ (mean age 56.7). 88.1% female. 62.7% with overweight or obesity.	Av; V/P	D
Menezes, 2018[77]	Belo Horizonte, Brazil, Neighbourhood	February 2013–June 2014	3414 adults aged 20+ (mean age 56.7). 88.1% female. 62.7% with overweight or obesity.	Acc; Aff; Conv	D
Menezes, 2018[43]	Belo Horizonte, Brazil, Neighbourhood	2015	2944 adults aged 20+ (mean age 56.8). 88.4% female.	Av	D
Miller, 2016[83]	Bangladesh, India, Pakistan, and Zimbabwe, China, Colombia, Iran, Occupied Palestinian Territory, Argentina, Brazil, Chile, Malaysia, Poland, Turkey, South Africa (and three high-income countries: Canada, Sweden, United Arab Emirates, however we extracted data from LMICS only), Neighbourhood	January 1 2003–December 31 2013	128112 adults. UMIC median age 51.0, 60% female, mean BMI 28.4. LMIC median age 51.0, 58% female, mean BMI 25.2. LIC median age 47.0, 57% female, mean BMI 23.3	Aff	D
Nogueira, 2018[44]	Sao Paulo, Brazil, Neighbourhood	February 2015– February 2016	521 adolescents aged 12–19 (mean age 15.5). 49.3% female. 70.4% did not have overweight.	Av	D
Nogueira, 2020[57]	Sao Paulo, Brazil, Neighbourhood	Feb 2015–2016	504 adolescents aged 12%–19. 48.6% female. 29.6% with overweight or obesity.	Av	H
Norbu, 2019[92]	Pemagatshel District, Bhutan, School	Not reported	392 children aged 13–17 (mean age 14.5) from six schools.	Unknown	H
Ochoa-Meza, 2017[28]	six cities, Mexico, School and Home	Nor reported	1434 children aged 10%–12. 49.5% female.	Acc; D	D
Oyeyemi, 2012[79]	Maiduguri, Nigeria, Neighbourhood	August 2010– September 2011	1818 adults aged 20–65 (mean 32.2). 39.9% female. 22.8% with overweight and 8.1% with obesity.	Acc	H

Continued

Table 3 Continued

Study ID	Study setting	Dates of data collection	Population	Food environment characteristic/s	Outcome
Opal, 2018[45]	Delhi, India, Neighbourhood	2010–2011	5364 adults mean ages 43.7–45.6 across three categories of restaurant density. 50% female.	Av	H, D
Pessoa, 2015[46]	Belo Horizonte, Brazil, Neighbourhood	2008–2010	5611 adults aged 18+ (mean age 39.7). 54.8% female.	Av	D
Rossi, 2018[81]	Florianopolis, Brazil, Neighbourhood	September 2012 –June 2013	2152 children aged 7%–14. 21.5% had overweight and 12.7% had obesity	Acc	H
Trinh, 2020[61]	Vietnam, Neighbourhood	2010–2014	Not reported.	Av	D, N
Vedovato, 2015[75]	Santos City, Brazil, Neighbourhood	January– December 2010	538 dyads, children aged 1–10 and mothers 62.1%	Acc	D
Velásquez-Meléndez, 2013[68]	Belo Horizonte, Brazil, Neighbourhood	2008–2009	3425 adults age 18+ (mean age 39.7). 49.9% female. 44% with overweight or obesity.	Av	H
Watson, 2013[69]	Azerbaijan, Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia and Ukraine, Neighbourhood	2010	2899 adults. 55.3% female. Male participants mean age 42.0 and mean BMI 25.4. Female participants mean age 43.7 and mean BMI 25.3.	Av; Acc; Price; M&R	H
Wertheim-Heck, 2019[32]	Hanoi, Vietnam, Neighbourhood	2017–2018	400 women of “childbearing age”	Acc	D
Widiyanto, 2018[88]	Java, Indonesia, School	December 2017	200 children in junior high school (age not reported). 72% female. 58% with BMI <23	Av; D	H
Wijnhoven, 2014[107]	Bulgaria (and other HIC countries—results for Bulgaria extracted for our review), School	September 2007–December 2008	179 schools, at least 15 children per school.	Av	H
Yazdi Feyzabadi, 2017[90]	Iran, School	February–March 2015.	1242 14 year olds. 47.8% female.	Av; M&R; Acc; D	D
Zhang, 2012[49]	China, Neighbourhood	2006	9788 adults. 52.7% female. 23.2% with overweight, 4.9% with obesity.	Av	D
Zhang, 2016[80]	China, Neighbourhood	2009 and 2011	348 children aged 6–17 (mean age 10.9). 49.7% female.	Acc	H
Zhang, 2020[58]	China, Neighbourhood	2013–2014	170872 adults aged 18+. 57.3% female.	Av	H
Zheng, 2013[94]	China, Home	2008–2009	5662 children aged 6%–18. 50.5% female.	Av; D	H
Zhou, 2017[59]	Wuhan, China, Neighbourhood	2010	189 adults aged 35–49. Mean BMI for men 25.5 and mean BMI for women 23.9.	Av	H

Continued

Table 3 Continued

Study ID	Study setting	Dates of data collection	Population	Food environment characteristic/s	Outcome
Zhou, 2020[86]	Beijing, China, School	May–June in 2016.	2201 students from 37 schools (mean age 10.2).	Av	H
Zuccolotto, 2015[78]	Brazil, Neighbourhood	May–November 2012	282 pregnant women in the second-trimester living in Brazil. Most between 20–29 years.	Acc; D	D

Acc, Accessibility; Aff, Affordability; Av, Availability; Conv, Convenience; D, Desirability; D, Diet; H, Health; M&R, Marketing and regulation; N, Nutrition; V/P, Vendor or product properties.

61 focused on one country (table 3). Of those focusing on one country, 28 were based on data from Brazil, 16 from China, two from each of Vietnam, Ghana, Mexico and India. The multi-country studies included two focused on nine countries of the former Union of Soviet Socialist Republics, one examining data from South Africa and Ghana, one study of multiple European countries, from which we extracted data from Bulgaria (the only LMIC included), and two studies of multiple LMICs (one of which also included HICs). Figure 2 shows the countries covered by observational studies included in our review.

The observational studies covered the food environment in the home (n=2), school (n=13) and neighbourhood (n=50) setting. With one additional study examining both the home and school environment[28] and one further study investigating the food environment in the workplace setting.[29] Most used a cross sectional design for investigating the association between the food environment and health, diet or nutrition outcomes (n=63) although these were sometimes nested in a cohort study, or one part of a mixed-methods study.[30–32] Three studies used cohort study designs, all from Chinese settings.[33–35] One study used a case–control design.[36]

Study populations included adults and children. Associations were presented between food environment characteristics and diet (n=35), health (n=36) and nutrition (n=3) outcomes, in which three studies examined both diet and health outcomes, one study examined diet and nutrition outcomes and one study examined all three.

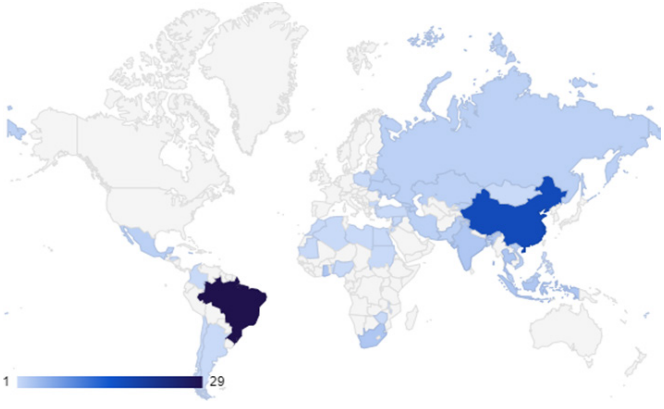

Figure 2 Map to show countries covered by observational studies included in our review.

The eight interventional articles reported seven unique studies. These include two studies from Iran (one cross-sectional study and one cluster randomised controlled trial (RCT)), one cluster RCT from Brazil, one controlled study from South Africa and one cluster RCT from Thailand (table 4). Additionally, there were two reports of the same cluster RCT carried out in Mexico and a further Mexican cluster RCT. All of these studies are from upper-middle-income countries. All of the included articles report interventions based in schools, except the study in Brazil which evaluates a workplace intervention. Interventions ranged in duration from 4 weeks to ~4 years (in the Iranian cross-sectional study which examined the Iranian Health Promoting Schools programme which was set up in 2011 and the evaluation data collected in 2015). All studies reported the effect of the intervention on dietary outcomes except for one Mexican study which reported health outcomes only.[33] The second Mexican study and the Thai study additionally reported health outcomes, and the Iranian cluster RCT and South African study additionally reported nutrition outcomes.

Of the included observational studies 42 were rated good, 17 were rated fair and 8 were rated poor (table 5). Further details of our quality appraisal are included in online supplemental table 2. The intervention studies were rated poor (n=3) and fair (n=4) (table 6). Further details on the quality appraisal are presented in online supplemental table 2.

Associations reported in the literature

Fifty observational studies reported associations between neighbourhood food environment characteristics and diet, nutrition or health outcomes. Forty-seven of these were cross-sectional and three were cohort studies.

Neighbourhood availability

Thirty-six of the observational studies (2 cohort studies and 34 cross-sectional studies) examined the association between an availability variable and outcome of interest, of which 26 examined availability alone. The majority of these were investigating the presence, density or number

Table 4 Characteristics of included interventional studies

Study ID	Study setting (country, setting)	Study design	Dates of data collection	Population (n, description, age)	Food environment characteristic/s	Length of intervention	Outcome
Aghdam, 2018[96]	Tabriz, Iran; School	cRCT	2015	4 control and four intervention schools. 436 children (mean age 9.6). 55.6% female.	Av; M&R; D	4 weeks	D; N
Bandoni, 2011[100]	Sao Paulo, Brazil; Workplaces	cRCT	Not reported	15 intervention and 14 control companies. 1296 and 1214 workers aged 18+ per round of data collection (independent samples). Male majority.	M&R	6 months	D
Bonvecchio-Arenas, 2010; Safdie, 2013[95 108]	Mexico City, Mexico; School	3-arm cRCT	2006–2008	8 basic intervention schools, 7 intervention-plus schools and 11 control schools. 830 students (mean age 9.7 years). 50% females. Mean BMI 19.8 and prevalence of overweight/obesity 43%.	Av; M&R; D	18 months	H, D
Chawla, 2017[99]	Bangkok, Thailand; School	cRCT	Not reported	2 intervention and two control schools. 452 children aged 10–12 (mean age 9.7 (intervention) 10.0 (control)). 53.5% females. 19.7% overweight or obese in the control group, 16.6% in the intervention group at baseline.	Av;	6 months	H, D
Shamah Levy, 2012[33]	State of Mexico, Mexico; School	cRCT	2010–2011	30 intervention and 30 control schools. 997 children mainly aged 10–13 (modal age 10). 51.6% females and 49.7% females in intervention and control group respectively. Mean BMI 18.6–18.8.	Av; M&R	6 months	H
Steyn, 2015[98]	Western Cape, South Africa; School	Controlled study	2009–2011	8 intervention and eight control schools. 998 children (mean age 9.9 in 2009, 12.3 in 2011)	Av; M&R	3 years	D, N
Yazdi-Feyzabadi, 2018[97]	Kerman, Iran; School	Cross-sectional study	2015	40 schools 1242 children. 47.8% female	M&R	~4 years	D

Study design cRCT: food environment characteristics.
Given the heterogeneity in study design, methodology, exposure and outcomes, we have performed a narrative synthesis.
The characteristics of the food environment investigated in the included studies are further described in table 2.
Av, availability; BMI, body mass index; cRCT, cluster randomised controlled trial; D, desirability; M&R, marketing and regulation; N, nutrition; outcome H, health; V/P, vendor or product properties.

of food retail outlets of various types with their outcomes of interest.

Two cohort studies, both fair-quality, found significant associations between an availability variable and relevant outcome, one with a nutrition outcome,[34] and one with a health outcome.[35] Of those cross-sectional studies investigating an availability variable, 10 good studies found significant associations between availability and dietary outcomes[37–46] as did one poor study.[47] Two further fair quality studies reported associations between availability and dietary outcomes although without presenting whether this was statistically significant.[48 49]

Further, 10 good studies found a significant association between an availability characteristic and a health outcome[50–59] as did 2 fair studies[60 61] and 1 further poor study.[62] Additionally, one poor study reported that prevalence of overweight and mean body mass index (BMI) trended in the same direction as the number of 'western-style' restaurants and convenience stores, however, no statistics were presented.[63] Two further good studies suggested that availability characteristics were important for childhood obesity prevalence.[64 65] In contrast, five good studies did not find an association between availability and health outcomes[40 45 66–68] and one additional fair study did not find an association between availability and health outcomes.[69] Further, one poor study did not identify an association between availability and health (hypertension or diabetes).[70]

In summary, identified studies provide good evidence that the food available in the neighbourhood is associated with diet, and the preponderance of evidence suggests that the food available in the neighbourhood is also associated with nutrition and health outcomes.

Table 5 Results of included observational studies

Setting	Q	Food environment characteristic†								Outcome and significance*		
		Av	Price	V/P	M&R	Acc	Aff	Conv	D	Diet	Nutrition	Health
Neighbourhood												
Cohort studies												
Wang, 201235	F	X									Y	
Xu, 201336	F	X										Y
Seto, 201934	F					X				Y		
Cross-sectional studies												
Assis, 201940	G	X										Y
Backes, 201942	G	X										Y
Corrêa, 201846	G	X										Y
Curioni, 202048	G	X								Y		
da Silva49	G	X										N
Dake, 201650	G	X										Y
Hall, 202058	G	X										Y
Jaime, 201160	G	X								Y		N
Leite, 201764	G	X								Y		
Matozinhos, 201570	G	X										Y
Mendes, 201371	G	X										N
Menezes, 201874	G	X								Y		
Nogueira, 201876	G	X								Y		
Nogueira, 202077	G	X										Y
Patel, 201880	G	X								Y		N
Pessoa, 201581	G	X								Y		
Velasquez-Melendez, 201385	G	X										N
Zhang, 202092	G	X										Y
Zhou, 201794	G	X										Y
Cunningham-Myrie, 202047	G	X				X						Y
Duran, 201553	G	X	X			X				Y		
Goryakin, 201555	G	X			X	X				Y		
Guo, 201856	G	X			X							O
Guo, 201957	G	X			X							O
Mendon√ßa, 201972	G	X		X						Y		
Chor, 201645	G					X				Y		
Liu, 202068	G					X				Y		N
Oyeyemi, 201279	G					X						Y
Vedovato, 201584	G					X				Y		
Wertheim-Heck, 201933	G					X				N		
Kivuyo, 202062	G					X			X	Y		
Machado, 201769	G		X					X		Y		
Miller, 201675	G						X			Y		
Kroll, 201963	F	X								O		
Trinh, 202083	F	X								Y		Y
Zhang, 201290	F	X								O		
deFreitas, 201952	F	X	X	X	X							Y
Watson, 201386	F	X	X		X	X						N
Alves, 201939	F					X				Y		
Rossi, 201882	F					X						N

Continued

Table 5 Continued

Setting	Q	Food environment characteristic†								Outcome and significance*		
		Av	Price	V/P	M&R	Acc	Aff	Conv	D	Diet	Nutrition	Health
Menezes, 201873	F					X	X	X		Y		
Zuccolotto, 201596	F					X			X	Y		
Camargo, 201944	P	X										Y
Hua, 201459	P	X										O
Kelly, 201461	P	X				X				N	N	N
Liu, 201467	P	X				X		X	X	Y		
Zhang, 201691	P					X						Y
Setting	**Q**	**Food environment characteristic**								**Outcome**		
		Av	**Price**	**V/P**	**M&R**	**Acc**	**Aff**	**Conv**	**D**	**Diet**	**Nutrition**	**Health**
School												
Case–control studies												
Setiyaningsih, 201937	P	X										
Cross-sectional studies												
Azeredo, 201641	G	X								Y		
Barrera, 201643	G	X										
Zhou, 202095	G	X										
Wijnhoven, 201488	G	X										
Yazdi-Feyzabadi, 201789	G	X			X	X				Y		
Li, 201166	G	X			X							
Darfour-Oduro, 202051	G				X					Y		
Ochoa-Meza29	G					X				Y		
Bekker, 201731	F	X								Y		
Fernandes, 201732	F	X								Y		
Goncalves, 201954	F	X		X								
Widiyanto, 201887	F	X										
Norbu, 201978	P	Unknown										
Workplace												
Cross-sectional studies												
Charoenbut, 201830	G	X										
Home												
Cross-sectional studies												
Leme, 201765	G											
Ochoa-Meza, 201729	G											
Zheng, 201393	P	X										

*Outcome Y: yes, at least one significant outcome was reported; N: no a significant outcome was not reported; O: other.
†Quality: G: good, F: fair, P: poor.

Neighbourhood accessibility

The next most investigated aspect of the neighbourhood food environment was accessibility included in 18 studies, 1 cohort and 17 cross-sectional. Identified studies provide good evidence that food accessibility is associated with diet, but conflicting evidence of the association between accessibility and health, with no evidence of the association between accessibility and nutrition.

One cohort study of fair quality found an association between accessibility and dietary outcomes.[71]

Six good cross-sectional studies found accessibility was associated with diet[38 39 72–75] as did a further three fair studies[76–78] and one poor study.[47] However, one further good cross-sectional study found no association between dietary quality and geographical proximity to different formal retail outlets.[32]

Just two good studies, both cross-sectional, found accessibility was associated with health. A 10 km increase in the distance from a supermarket was associated with a 1.7 kg/m^2 higher means BMI (p=0.02) in the middle class in

Table 6 Results of included interventional studies

Setting	Q	Food environment characteristic								Modified outcome and significance*		
		Av	Price	V/P	M&R	Acc	Aff	Conv	D	Diet	Nutrition	Health
Schools												
Chawla, 2017[99]	F	X								N		Y
Bonvecchio-Arenas, 2010[108]; Safdie, 2013[95]	F	X			X				X	Y		Y
Shamah Levy, 2012[33]	F	X			X							Y
Yazdi-Feyzabadi, 2018[97]	F				X					N		
Aghdam, 2018[96]	P	X			X				X	Y	Y	
Steyn, 2015[98]	P	X			X					N	N	
Workplace												
Bandoni, 2011[100]	P				X							Y

Quality: G: good, F: fair, P: poor.
*Outcome Y: yes, a significant outcome was reported; N: no a significant outcome was not reported; O: other.
Acc, accessibility; Aff, affordability; Av, availability; Conv, convenience; D, desirability; M&R, marketing and regulation; V/P, vendor or product properties.

Jamaica[53] and participants who did not report commercial places such as shops, stores and markets to be within walking distance of their homes were 49% more likely to be overweight than those who reported proximal facilities in Maiduguri, Nigeria.[79] However, one additional poor study found an association between accessibility and health.[80] In contrast one good study,[74] two fair studies[69 81] and one poor study[70] found no association between accessibility variables and health outcomes.

Neighbourhood price

Price was examined in four studies all of which were cross-sectional. One good study did not find that price was associated with fruit and vegetable consumption or sugar-sweetened beverage consumption.[38] Two further fair studies did not find an association between price and health outcomes. One of these found that fruit and vegetable price or ultraprocessed food price was not associated with overweight[60] and the other that the price of apples was not associated with obesity.[69] In contrast, one good study found that an 1% increase in the price of ultraprocessed foods acquired at supermarkets would lead to a 0.59% decrease in purchases and this price-elasticity was significant.[82]

Neighbourhood marketing and regulation

Marketing and regulation characteristics were examined at the neighbourhood level in five cross-sectional studies. One good study found billboard advertising of snacks was negatively related to daily fruit or vegetable consumption for men and women, although the same study found that women's daily fruit and vegetable consumption was higher in areas with more billboards advertising soft drinks.[39] However, two fair studies did not find this translated to an association with health outcomes.[60 69] One did not find an association between fruit and vegetable advertising or ultraprocessed food advertising within food retail locations situated in each neighbourhood and overweight.[60] The other did not find an association between unhealthy food advertising and obesity. Two good studies found that provincial school policies were important factors for modelling prevalence of childhood obesity.[64 65]

Neighbourhood vendor and product properties

Two cross-sectional studies examined vendor and product properties at the neighbourhood level. One good study found that the quality of vegetables in commercial establishments was associated with higher consumption of fruit and vegetables,[42] while one fair study found that the quality of fruit and vegetables on offer in local food retail outlets was not associated with overweight.[60]

Neighbourhood affordability

Affordability was examined at the neighbourhood level in two studies both of which found an association with dietary outcomes. One good study found that combined fruit and vegetable intake decreased as the relative cost of two servings of fruits and three servings of vegetables per day increased in communities across 15 LMIC.[83] One fair study found that participants perception of affordability (the answer to 'I can buy FV even when they are expensive') was associated with fruit and vegetable intake.[77]

Neighbourhood convenience

Three cross-sectional studies examined convenience characteristics all of which found an association between convenience and dietary outcomes. In one good study, a convenience variable examined the number of food items purchased at supermarkets and found that an increase was associated with an increase in calorie acquisition from ultraprocessed foods and beverages. Responses to 'I have time to prepare and eat' and 'Fruit and vegetables are easy to prepare for me' were associated with higher

fruit and veg consumption in one fair study.[77] One poor study found refrigerator ownership is positively correlated with dietary variety.[47]

Neighbourhood desirability

Two cross-sectional studies examined desirability at the neighbourhood level, one good and one fair, both of which found an association with diet.[73 78]

School availability

Fourteen observational studies examined an association between a school food environment characteristics and diet, nutrition or health outcome, 1 case–control study and 13 cross-sectional studies.

One poor case–control study[36] found that availability was associated with health outcomes. Ten cross-sectional studies examined the association between availability and an outcome of interest. Three good cross-sectional studies[84–86] and two fair cross-sectional studies[87 88] found an association between an availability characteristic and a health outcome.

One good study found an association between availability and dietary outcomes[89] with two additional fair studies that found an association with a dietary outcome.[30 31] However, one good study did not find an association between availability (presence of a school canteen) and dietary behaviour (unhealthy snacking).[90]

School marketing and regulation

The second most common aspect of the school environment studied was marketing and regulation, investigated by three good studies. One found an association between presence of a school fruit and vegetable policy and fruit and vegetable consumption across schools from 24 countries,[91] however, another found no association between the schools status as part of the Iranian Health Promoting Schools programme and unhealthy snacking behaviour.[90] The third study found no association between school food policy and BMI.[85]

School vendor and product properties

One fair study examining vendor and product properties was looking specifically at vendor properties, finding that students of schools that offered meals prepared on the premises had lower prevalence of obesity than those who studied where meals were not offered (summarised under availability above). However, where the food was commercialised, obesity prevalence was significantly higher than where there was no commercialisation of foods with a similar association with prevalence of hypertension.[87]

School accessibility

Two good cross-sectional studies examined accessibility. One found an association with a dietary outcome[90] while the other found no association.[28]

School desirability

Three studies investigated desirability. Two examined associations with diet: One good study found the social norms pressure was associated with unhealthy snacking[90] and one good study found an association between 'preferences' and vegetable intake. One poor study found peer influence was associated with a health outcome: overweight.[88]

Other school environment

Finally, there was one poor study of the school food environment in which we were unable to categorise the characteristics investigated as the methodology simply stated that the researchers used 10 questions to collect data on school environment without giving details of the questions.[92] This study reported no association between the 'school environment' and BMI.

Workplace environment

A single cross-sectional study examined the workplace food environment and dietary outcomes.[29] The study found no association between workplace policy ('Marketing and Regulation') or the attitude of management (considered part of workplace 'culture' and therefore classified as 'Desirability') and eating practices across 26 factories. However, they did find an association between workplace nutrition environment ('Availability' and 'Marketing and Regulation') and individual worker attitude and dietary behaviour suggesting that the more supportive workplace nutrition environment alongside a positive individual attitude to health, the less frequently unhealthy food is consumed.

Home environment

Finally, three cross-sectional studies examined the home food environment. Two good studies found that accessibility and desirability elements were associated with dietary behaviour in adolescents.[28 93] One of these additionally found that convenience was associated with dietary behaviour.[28] Desirability was also associated with obesity in adolescents in one poor study, as was availability.[94]

Effects reported in the literature

All of the interventional studies identified were complex interventions with more than one element, sometimes multiple elements altering more than one characteristic of the food environment, and sometimes additional elements which did not target the food environment (eg, educational components). One fair[95] and one poor quality study[96] evaluating school interventions with elements of availability, marketing and regulation, and desirability found that these improved diet, nutrition and/or health.

Four studies examined school interventions with elements of availability and/or marketing and regulation without desirability elements. One fair[97] and one poor-quality study[98] found no effect on diet and/or nutrition of these interventions, while similar interventions were

found to have an effect on health in one fair quality study,[33] and on health but not diet in an additional fair quality study (table 6).[99]

A study of an intervention which included a marketing and regulation approach, among other elements, in a workplace found that this had a beneficial effect on health (table 6).[100]

DISCUSSION

This review identified 74 studies including data from 29 countries, investigating the association between food environment characteristics and diet, nutrition and health outcomes in LMICs. All the intervention studies identified were carried out in upper-middle-income countries, observational studies also covered lower-middle and low-income countries (three countries included within multi-country studies). With the great majority of evidence coming from middle-income countries, it is worth considering the extent to which the findings can be generalised to low-income countries. The strongest recommendations from this review arise from the consistent evidence identified (14 studies, 10 of which were rated as good quality) of an association between availability characteristics in the neighbourhood food environment and dietary behaviour, as well as a balance of evidence suggesting an association with health or nutrition outcomes (17 out of 24 relevant studies). This suggests that interventions to increase the availability of healthy food options at the neighbourhood level, or to decrease the availability of unhealthy food are promising and worth investigating. It might be that availability of healthy and unhealthy food options in the neighbourhood is more important in LMIC than in some HIC, as a recent review on this topic focused on the USA and Canada only, included 71 studies and found that associations between food outlet availability and obesity were predominantly null.[11] However, they did also find some patterns in the non-null studies suggesting an association between certain food outlets and adult obesity, and more recent studies (including longitudinal studies) support an association between availability and relevant outcomes.[101 102] If there is a difference between HIC and LMIC settings, it may be due to differences in socioeconomics factors as well as mobility (due to ownership of motorised vehicles or efficient public transport) which makes it easier to access food outside the neighbourhood local to an individual's residence in HIC than LMIC. No interventional study examining this element of the neighbourhood food environment relevant to urban LMIC settings was identified by our search. Interventions that have been implemented in HIC include 'zoning powers' given to local authorities to enable them to control the food environment through regulating land use—for example, limiting certain food outlets from trading in specific areas. In addition, 'healthy food carts' have been used to increase availability to healthy food in deprived urban neighbourhoods with some success.[103] Therefore, a key implication for research and policy would be to begin to implement and evaluate similar interventions in LMIC.

We also found a balance of evidence that accessibility to food in the neighbourhood environment was associated with diet (10 out of 11 studies) although there was no evidence of an association with nutrition outcomes and the evidence of an association with health outcomes was contradictory. Again, we did not identify any interventional studies focused on this element of the neighbourhood food environment and would suggest that there is enough evidence that this may be promising and worth further investigation. Interventions are likely to be similar to those addressing availability (eg, 'zoning' and 'healthy food carts') but could also include increasing accessibility to healthy food outlets, for example, by rerouting public transport links.

Evidence on vendor and product properties, price, and marketing and regulation at the neighbourhood level was sparse and mixed; while evidence on affordability examined at the neighbourhood level was sparse but consistent, two studies both found an association with dietary outcomes. Literature from HIC does support affordability as important for driving dietary and health outcomes, for example, in quantitative studies[104] and reported by participants in the qualitative literature.[13] Further research is recommended to expand the evidence base on the association between these aspects of the neighbourhood food environment and diet, nutrition and health outcomes.

In keeping with the neighbourhood-level results, 12 observational studies examining availability elements in the school food environment and relevant outcomes found a balance of evidence in favour of an association. Twelve studies consistently identified an association between availability and a health outcome, three out of four studies reported an association between availability and a dietary outcome. The second most common aspect of the school food environment studied was marketing and regulation, investigated by three good studies, but with conflicting findings. Studies investigating our other primary outcomes in observational studies of the school food environment were sparse. We also identified six studies evaluating interventions in the school food environment. All the interventions studied were complex consisting of multiple elements. Two studies that evaluated interventions with elements of availability, marketing and regulation, and desirability found that these improved relevant outcomes whereas four studies investigating similar interventions without desirability elements had mixed results. A systematic review and meta-analysis of school food environment policies identified 91 interventions from the USA, Canada, Europe and New Zealand. This study reported that direct provision of healthy food and drinks (ie, availability interventions) were able to improve some dietary behaviours as were implementation of food, beverage or meal standards (ie, marketing and regulation intervention) although there were mixed findings on health and nutrition outcomes.[14] A meta-analysis of six studies

investigating multicomponent behavioural and environmental interventions in schools in LMIC suggested an overall effect on change in BMI, whereas meta-analysis of five studies which examined BMI found no observed effect.[105] Certainly our findings suggest that further research is needed, but it is also likely that interventions to increase availability of healthy food or to reduce availability of unhealthy food in schools would have a beneficial effect on diets, with the effect on health requiring further investigation.

We found very little evidence from either observational or intervention studies on how workplace food environments and the home food environments are associated with health, diet or nutrition outcomes. This is a substantial evidence gap.

Although we rated many identified studies as 'good', the majority of observational studies did take a cross-sectional approach, so due to study design there are inherent weaknesses, even if they were well conducted. Future studies with longitudinal designs, and more controlled intervention studies (including cluster randomised designs) would provide stronger evidence to support future policy decisions.

We used a framework developed through a series of iterative, international congregations with experts in nutrition and public health.[16] However, our own research team did not feel that the 'convenience' and 'desirability' concepts mapped well to our own concept of the food environment. Although we have synthesised evidence on convenience and desirability elements in the papers identified, we did not prioritise papers focused on these elements for inclusion so cannot draw strong conclusions. However, at the neighbourhood level both convenience and desirability characteristics were consistently associated with relevant outcomes in six included observational studies, and in school and home food environments a consistent association was seen between desirability and relevant outcomes. Further, two school food environment interventions with elements of desirability have a beneficial effect on outcomes. This does suggest that it might be worth considering desirability as a future target for intervention, suggesting an important role of the social environment on diet, nutrition and health outcomes in LMIC populations.

The major strength of this study is the rigorous systematic approach to identifying literature, including a search strategy developed with an academic librarian and careful reference screening of all included studies. The chances of reviewing bias are low because we did not limit by language and although we limited by year (to studies published from the year 2000 onwards) the earliest published study we found was published in 2010 so we are unlikely to have missed many earlier studies. The sensitivity of our approach is clear as we have identified more than thrice the number of articles of a recent scoping review on this topic.[25] We conducted selection of studies in duplicate by two independent reviewers, with data extraction and quality appraisal conducted by one reviewer and checked by a second, which will have improved the reliability of the data synthesised.

In conclusion, interventions that increase the availability of healthy food and/or decrease the availability of unhealthy food are promising and are likely to have beneficial effects on dietary behaviour and healthy of LMIC populations and there is enough evidence to justify policy and practice implementation on this theme, with evaluation of the outcomes alongside these if possible. More longitudinal and interventional studies are required to inform further recommendations, with affordability and the social environment potentially interesting and worthwhile avenues to pursue.

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Supplementary Table 1: Search strategy, Ovid MEDLINE

		Results
1	(Afghanistan or Benin or {Burkina Faso} or Burundi or {Central African Republic} or Chad or Comoros or {Democratic Republic of Congo} or Eritrea or Ethiopia or Gambia or Guinea or {Guinea Bissau} or Haiti or Liberia or Madagascar or Malawi or Mali or Mozambique or Nepal or Niger or Rwanda or Senegal or {Sierra Leone} or Somalia or {South Sudan} or Tanzania or Togo or Uganda or Zimbabwe or Angola or Armenia or Bangladesh or Bhutan or Bolivia or {Cabo Verde} or Cambodia or Cameroon or Congo or Djibouti or Egypt or {Ivory Coast} or {Cote d ivoire} or {El Salvador} or Georgia or Ghana or Guatemala or Honduras or India or Indonesia or Jordan or Kenya or Kiribati or Kosovo or {Kyrgyz Republic} or Lao or Lesotho or Mauritania or Micronesia or Moldova or Mongolia or Morocco or Myanmar or Nicaragua or Nigeria or Pakistan or {Papua New Guinea} or Philippines or {Sao Tome Principe} or {Solomon Islands} or {Sri Lanka} or Sudan or Swaziland or Eswatini or {Syrian Arab Republic} or Syria or Tajikistan or {Timor Leste} or Tunisia or Ukraine or Uzbekistan or Vanuatu or Vietnam or {West Bank Gaza} or Yemen or Zambia or Albania or Algeria or {American Samoa} or Argentina or Azerbaijan or Belarus or Belize or Bosnia or Bosnia or Herzegovina or Botswana or Brazil or Bulgaria or China or Colombia or {Costa Rica} or Cuba or Dominica or {Dominican Republic} or Ecuador or {Equatorial Guinea} or Fiji or Gabon or Grenada or Guyana or Iran or Iraq or Jamaica or Kazakhstan or Lebanon or Libya or Macedonia or FYR or FYROM or Malaysia or {Marshall Islands} or Mexico or Montenegro or Namibia or Nauru or Panama or Paraguay or Peru or {Russian Federation} or Russia or Samoa or Serbia or {South Africa} or {St Lucia} or {St Vincent the Grenadines} or Suriname or Thailand or Tonga or Turkey or Turkmenistan or Tuvalu or Venezuela).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	95303
2	(LIC* or {low income econom*} or {low* income countr*} or LMIC* or {low middle income countr*} or {upper middle income econom*} or {upper middle income countr*} or {developing countr*} or {developing econom*} or {developing world countr*} or {global south}).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	229516
3	Developing Countries/	77387
4	Poverty Areas/ or slum*.mp.	8253
5	({Food Environment*} or {Food desert*} or {Food swamp*} or {Foodscape*} or {Obesogenic environment*} or {Nutrition* environment*}).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	4249
6	1 or 2 or 3 or 4	327302
7	5 and 6	214
8	limit 7 to yr="2000 - 2020"	195

Supplementary Table 2: Quality appraisal – National Heart, Lung and Blood Institute (NHLBI) checklists

NHLBI Checklist: Cross Sectional and Cohort Studies[1]

Article	Score	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Alves, 2019	Fair	Y	Y	N/R	Y	N	N/A	N/A	Y	N	N/A	C/D	N/A	N/A	Y
Assis, 2019	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Azeredo, 2016	Good	Y	Y	Y	Y	N	N/A	N/A	N/A	Y	N/A	Y	N/A	N/A	Y
Backes, 2019	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Barrera, 2016	Good	Y	Y	N	N	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Bekker, 2017	Fair	Y	Y	N/R	Y	N	N/A	N/A	N/A	Y	N/A	Y	N/A	N/A	N
Camargo, 2019	Poor	Y	N	N/R	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Charoenbut, 2018	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Chor 2016	Good	Y	Y	Y	Y	Y	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Corrêa, 2018	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Cunningham-Myrie,2020	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Curioni, 2020	Good	Y	Y	Y	Y	N	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Dake, 2016	Good	Y	Y	N/R	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Darfour-Oduro, 2020	Good	Y	Y	Y	Y	N	N/A	N/A	N/A	Y	Y	Y	N/A	N/A	Y
Da Silva	Good	Y	Y	Y	N	Y	N/A	N/A	N/A	Y	N/A	Y	N/A	N/A	Y
deFreitas, 2019	Fair	Y	Y	N/R	Y	N	N/A	N/A	N/A	Y	N/A	Y	N/A	N/A	Y
Duran, 2015	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Fernandes, 2017	Fair	Y	Y	N/R	Y	N	N	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Goncalves, 2019	Fair	Y	Y	Y	Y	Y	N/A	N/A	N/A	N	N/A	Y	N/A	N/A	Y
Goryakin, 2015	Good	Y	Y	N	N	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Guo, 2018	Good	Y	Y	N/R	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Guo, 2019	Good	Y	Y	N/R	Y	N	N/A	N/A	Y	Y	Y	Y	N/A	N/A	Y
Hall, 2020	Good	Y	Y	N/R	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Hua, 2014	Poor	Y	Y	N/R	Y	N	N/A	N/A	Y	Y	N/A	C/D	N/A	N/A	N
Jaime, 2011	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	C/D	N/A	N/A	Y
Kelly, 2014	Poor	Y	Y	N	Y	N	Y	N/A	C/D	Y	N/A	Y	N/A	N/A	N

Kivuyo, 2020	Good	Y	Y	Y	C/D	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Kroll, 2019	Fair	Y	Y	Y	Y	N	N/A	N/A	N	Y	N/A	Y	N/A	N/A	N
Leite, 2017	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Leme, 2017	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Li, 2011	Good	Y	Y	Y	Y	N	N/A	N/A	N/A	Y	N/A	Y	N/A	N/A	Y
Liu, 2014	Poor	Y	N	N/R	N/A	N	C/D	N/A	Y	C/D	N/A	Y	N/A	N/A	Y
Liu, 2020	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Machado, 2017	Good	Y	Y	C/D	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Matozinhos, 2015	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Mendes, 2013	Good	Y	Y	Y	Y	N	N/A	N/A	N/A	C/D	N/A	Y	N/A	N/A	Y
Mendonvßa, 2019	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Menezes, 2018	Fair	Y	Y	Y	Y	N	N/A	N/A	Y	C/D	N/A	Y	N/A	N/A	N
Menezes, 2018	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Miller, 2016	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Nogueira, 2018	Good	Y	Y	Y	Y	Y	N/A	N/A	N/A	Y	N/A	Y	N/A	N/A	Y
Nogueira, Luana Romao, 2020	Good	Y	Y	Y	Y	Y	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Norbu, 2019	Poor	Y	N	N/R	Y	N	N/A	N/A	C/D	C/D	N/A	Y	N/A	N/A	N
Ochoa-Meza, 2017	Good	Y	Y		Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Oyeyemi, 2012	Good	Y	Y	Y	Y	N	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Patel, 2018	Good	Y	Y	Y	N/R	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Pessoa, 2015	Good	Y	Y	Y	Y	Y	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Rossi, 2018	Fair	Y	Y	Y	Y	N	N/A	N/A	N	C/D	N/A	Y	N/A	N/A	Y
Seto, 2019	Fair	Y	Y	C/D	Y	N	N/A	Y	Y	Y	Y	Y	N/R	Y	Y
Trinh, 2020	Fair	Y	N	N/R	N/R	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Vedovato, 2015	Good	Y	Y	Y	Y	Y	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Velasquez-Melendez, 2013	Good	Y	Y	Y	Y	N	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Wang, 2012	Fair	Y	Y	Y	Y	N	C/D	Y	Y	Y	Y	Y	N/R	N	Y
Watson, 2013	Fair	Y	Y	N	Y	N	N/A	N/A	N	Y	N/A	Y	N/A	N/A	Y
Wertheim-Heck, 2019	Good	Y	Y	Y	Y	Y	N/A	N/A	N/A	Y	N	Y	NA	N/A	Y
Widiyanto, 2018	Fair	Y	Y	Y	Y	N	N/A	N/A	N	N	N/A	Y	N/A	N/A	Y

Wijnhoven, 2014	Good	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	N
Xu, 2013	Fair	Y	Y	Y	Y	N	Y	Y	Y	C/D	Y	Y	N/A	N	Y
Yazdi-Feyzabadi, 2017	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Zhang, 2012	Fair	Y	Y	Y	Y	N	N/A	N/A	N	Y	N/A	Y	N/A	N/A	N
Zhang, 2016	Poor	Y	Y	N/R	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	C/D
Zhang, 2020	Good	Y	Y	Y	N	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Zheng, 2013	Poor	Y	C/D	C/D	C/D	N	N/A	N/A	Y	N	N/A	Y	N/A	N/A	N
Zhou, 2017	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Zhou, 2020	Good	Y	Y	Y	Y	N	N/A	N/A	Y	Y	N/A	Y	N/A	N/A	Y
Zuccolotto, 2015	Fair	Y	Y	Y	Y	Y	N/A	N/A	N	N	N/A	Y	N/A	N/A	Y

[1]**NHBLI Checklist: observational and cohort studies** (1. Was the research question or objective in this paper clearly stated? 2. Was the study population clearly specified and defined? 3. Was the participation rate of eligible persons at least 50%? 4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants? 5. Was a sample size justification, power description, or variance and effect estimates provided? 6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? 7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? 8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? 9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? 10. Was the exposure(s) assessed more than once over time? 11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? 12. Were the outcome assessors blinded to the exposure status of participants? 13. Was loss to follow-up after baseline 20% or less? 14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?). **Abbreviations**: C/D, cannot determine; N, no; N/A, not applicable; N/R, not reported; Y, yes.

NHLBI Checklist: Case-control studies[2]

Article	Score	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Setiyaningsih, 2019	Poor	Y	N	N	N	N/R	Y	N/R	Y	N	N	N/R	Y

[2]**NHBLI Checklist: case-control studies** (1. Was the research question or objective in this paper clearly stated and appropriate? 2. Was the study population clearly specified and defined? 3. Did the authors include a sample size justification? 4. Were controls selected or recruited from the same or similar population that gave rise to the cases (including the same timeframe)? 5. Were the definitions, inclusion and exclusion criteria, algorithms or processes used to identify or select cases and controls valid, reliable, and implemented consistently across all study participants? 6. Were the cases clearly defined and differentiated from controls? 7. If less than 100 percent of eligible cases and/or controls were selected for the study, were the cases and/or controls randomly selected from those eligible? 8. Was there use of concurrent controls? 9. Were the investigators able to confirm that the exposure/risk occurred prior to the development of the condition or event that defined a participant as a case? 10. Were the measures of exposure/risk clearly defined, valid, reliable, and implemented consistently (including the same time period) across all study participants? 11. Were the assessors of exposure/risk blinded to the case or control status of participants? 12. Were key potential confounding variables measured and adjusted statistically in the analyses? If matching was used, did the investigators account for matching during study analysis? **Abbreviations**: C/D, cannot determine; N, no; N/A, not applicable; N/R, not reported; Y, yes.

NHLBI Checklist: Controlled intervention studies[3]

Article	Score	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Aghdam, 2018	Poor	Y	C/D	N/R	N	N	N	C/D	Y	Y	N/R	Y	N/R	C/D	Y
Bandoni, 2011	Fair	Y	C/D	N/R	N	N/R	Y	Y	Y	N/R	N/R	Y	Y	N/R	Y
Bonvecchio-Arenas, 2010*	Poor	Y	C/D	N/R	CD	N/R	C/D	C/D	C/D	C/D	C/D	C/D	C/D	C/D	C/D
Chawla, 2017	Fair	Y	C/D	N/R	N	N	Y	N	N	N/R	Y	Y	C/D	N/R	Y
Safdie, 2013	Fair	Y	C/D	N/R	N	N/R	N	C/D	C/D	Y	Y	Y	Y	C/D	Y
Shamah Levy, 2012	Fair	Y	C/D	N/R	N	Y	N	Y	Y	Y	N/R	Y	N	Y	Y
Steyn, 2015	Poor	Y	C/D	N/R	N	N/R	N/R	Y	Y	N/R	N/R	Y	N	N/R	Y
Yazdi-Feyzabadi, 2018	Poor	N	C/D	N/R	N	N/R	N/R	N/A	N/A	N	N	Y	Y	Y	N

[3]**NHBLI Checklist: controlled intervention studies** (1. Was the study described as randomized, a randomized trial, a randomized clinical trial, or an RCT? 2. Was the method of randomization adequate (i.e., use of randomly generated assignment)? 3. Was the treatment allocation concealed (so that assignments could not be predicted)? 4. Were study participants and providers blinded to treatment group assignment? 5. Were the people assessing the outcomes blinded to the participants' group assignments? 6. Were the groups similar at baseline on important characteristics that could affect outcomes (e.g., demographics, risk factors, co-morbid conditions)? 7. Was the overall drop-out rate from the study at endpoint 20% or lower of the number allocated to treatment? 8. Was the differential drop-out rate (between treatment groups) at endpoint 15 percentage points or lower? 9. Was there high adherence to the intervention protocols for each treatment group? 10. Were other interventions avoided or similar in the groups (e.g., similar background treatments)? 11. Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants? 12. Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power? 13. Were outcomes reported or subgroups analysed pre-specified (i.e., identified before analyses were conducted)? 14. Were all randomized participants analysed in the group to which they were originally assigned, i.e., did they use an intention-to-treat analysis?). **Abbreviations**: C/D, cannot determine; N, no; N/A, not applicable; N/R, not reported; Y, yes.

*Note this study is a second report of the study reported in Safdie, 2013. These are counted as one study in the narrative synthesis and awarded a “fair” based on quality appraisal of Safdie 2013.

Supplementary Table 3: Excluded articles from full-text screening

1.	Almeida LB, Scagliusi FB, Duran AC, et al. Barriers to and facilitators of ultra-processed food consumption: perceptions of Brazilian adults. *Public health nutrition* 2018;21(1):68-76. doi: https://dx.doi.org/10.1017/S1368980017001665
2.	Anggraini R, Februhartanty J, Bardosono S, et al. Food Store Choice Among Urban Slum Women Is Associated With Consumption of Energy-Dense Food. *Asia-Pacific journal of public health* 2016;28(5):458-68. doi: https://dx.doi.org/10.1177/1010539516646849
3.	Anzo A, Klassen-Wigger P, Luna-Carrasco J, et al. Impact of a digital facebook campaign on the purchase and consumption of food in Mexican families with children under 12 years: A social marketing strategy. *Annals of Nutrition and Metabolism* 2017;71(Supplement 2):331-32. doi: http://dx.doi.org/10.1159/000480486
4.	Arifin NA, Majid HA, Zainol R. The association of food outlets surrounding schools with obesity profiles among Malaysian adolescents. *Medical Journal of Malaysia* 2017;72(Supplement 1):86.
5.	Athar P. The silent sheep revolution. *Rural 21* 2019;53(2):25-26.
6.	Bae SG, Kim JY, Kim KY, et al. Changes in dietary behavior among adolescents and their association with government nutrition policies in Korea, 2005-2009. *Journal of Preventive Medicine & Public Health* 2012;45(1):47-59. doi: 10.3961/jpmph.2012.45.1.47
7.	Batis C, Rodrıguez-Ramırez S, Ariza AC, et al. Intakes of Energy and Discretionary Food in Mexico Are Associated with the Context of Eating: Mealtime, Activity, and Place. *Journal of Nutrition* 2016;146(9):1907S-15S. doi: 10.3945/jn.115.219857
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12.	Boone-Heinonen J, Diez-Roux A, Goff DC, et al. The neighborhood energy balance equation: Does food environment + physical activity environment = obesity? The cardia study. *Obesity* 2011;19(SUPPL. 1):S53. doi: http://dx.doi.org/10.1038/oby.2011.222
13.	Bridle-Fitzpatrick S. Food deserts or food swamps?: A mixed-methods study of local food environments in a Mexican city. *Social Science & Medicine* 2015;142:202-13. doi: 10.1016/j.socscimed.2015.08.010
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15.	Cerdan CDC, Medina IPP, Salazar CSC, et al. Evaluation of the nutritional quality of refreshments and nutritional status of an elementary school student population in Veracruz, Mexico. *Nutricion Clinica Y Dietetica Hospitalaria* 2018;38(3):85-92. doi: 10.12873/383caballero
16.	Choudhury S, Headey DD, Masters WA. First Foods: Diet Quality among Infants Aged 6-23 Months in 42 Countries. *Food Policy* 2019;88
17.	Cochrane T, Yu Y, Davey R, et al. Associations of built environment and proximity of food outlets with weight status: Analysis from 14 cities in 10 countries. *Preventive Medicine* 2019;129:N.PAG-N.PAG. doi: 10.1016/j.ypmed.2019.105874

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