



City Research Online

City, University of London Institutional Repository

Citation: Shaw, S. C., Ntani, G., Baird, J. & Vogel, C. A. (2020). A systematic review of the influences of food store product placement on dietary-related outcomes. *Nutrition Reviews*, 78(12), pp. 1030-1045. doi: 10.1093/nutrit/nuaa024

This is the published version of the paper.

This version of the publication may differ from the final published version.


Permanent repository link: <https://openaccess.city.ac.uk/id/eprint/29343/>

Link to published version: <https://doi.org/10.1093/nutrit/nuaa024>

Copyright: City Research Online aims to make research outputs of City, University of London available to a wider audience. Copyright and Moral Rights remain with the author(s) and/or copyright holders. URLs from City Research Online may be freely distributed and linked to.

Reuse: Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge. Provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

A systematic review of the influences of food store product placement on dietary-related outcomes

Sarah C. Shaw , Georgia Ntani , Janis Baird , and Christina A. Vogel 

Context: Product placement strategies have been used to influence customers' food purchases in food stores for some time; however, assessment of the evidence that these techniques can limit unhealthy, and promote healthy, food choices has not been completed. **Objective:** This systematic review aimed to determine how product placement strategies, availability, and positioning, in physical retail food stores located in high-income countries, influence dietary-related behaviors. **Data Sources:** From a search of 9 databases, 38 articles, 17 observational studies, and 22 intervention studies met the study inclusion criteria. **Data Extraction:** Two reviewers independently extracted data relating to study design, study population, exposures, outcomes, and key results. Each study was also assessed for risk of bias in relation to the research question. **Data Analysis:** Meta-analysis was not possible owing to heterogeneous study designs and outcomes. As recommended by Cochrane, results were synthesized in effect direction plots using a vote-counting technique which recorded the direction of effect and significance level according to the expected relationship for health improvement. **Conclusions:** The majority of studies showed that greater availability and more prominent positioning of healthy foods, or reduced availability and less prominent positioning of unhealthy foods, related to better dietary-related behaviors. A large number of results, however, were nonsignificant, which likely reflects the methodological difficulties inherent in this research field. Adequately powered intervention studies that test both the independent and additive effects of availability and positioning strategies are needed. **Systematic Review Registration:** PROSPERO registration no. 42016048826

INTRODUCTION

The current food environment is obesogenic and encourages individuals to habitually overconsume foods in a way that is inconsistent with dietary recommendations.¹ In the late 1990s, it was identified that modern

food environments heavily promote the sale and intake of energy-dense, nutrient-poor foods and beverages.² It took until 2007 for the first significant government document, the Foresight report, to highlight the key role of food environments in fueling obesity.^{3,4} Although published in the United Kingdom, this report has had

Affiliation: S.C. Shaw, J. Baird, and C.A. Vogel are with the MRC Lifecourse Epidemiology Unit, Faculty of Medicine, University of Southampton, Southampton General Hospital, Southampton, UK. S.C. Shaw, J. Baird, and C.A. Vogel are with the NIHR Southampton Biomedical Research Centre, Faculty of Medicine, University of Southampton and University Hospital Southampton NHS Foundation Trust, Southampton, UK. G. Ntani is with the UK Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work, Faculty of Medicine, University of Southampton, Southampton, UK

Correspondence: S. Shaw, MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton General Hospital, Tremona Rd, Southampton SO16 6YD, UK. E-mail: Ss@mrc.soton.ac.uk.

Key words: diet, food stores, placement, sales, systematic review.

© The Author(s) 2020. Published by Oxford University Press on behalf of the International Life Sciences Institute.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

international impact. Yet now, more than a decade later, food environments remain obesogenic and obesity levels continue to rise worldwide.⁵

Human behavior is often responsive to environmental stimuli in settings frequently visited.⁶ Food stores, such as supermarkets and corner stores, are the main sources of food for many people living in high-income countries; they are likely having a significant influence on the food choices of their consumers.⁷ Marketing strategies are used extensively in food stores and commonly comprise the 4 Ps of marketing: product, price, promotion, and placement.⁸ Product placement strategies have been used to influence customers' purchases in these stores for some time, and their successful effects have been documented in the marketing literature.^{9,10} Assessment of the evidence that these techniques can be successfully used to limit unhealthy, and promote healthy, food choices has not yet been completed. Gray literature suggests that two-thirds of placement strategies are used to promote unhealthy food and beverages in supermarkets.¹¹ Comprehensive assessment of academic research examining the health-related effects of placement strategies on store-level food sales, household-level food purchasing, or individual-level dietary outcomes would help guide future government intervention across the world. Some governments are already taking, or considering taking, legislative actions against food and beverage placement promotions. For example, Chapter 2 of the UK government's Childhood Obesity Plan, released in 2018, included a population-level proposal to ban marketing strategies used in food outlets that promote the overconsumption of unhealthy foods and beverages.¹²

A number of systematic reviews have narratively summarized the influence of supermarket interventions on diet-related outcomes. Existing reviews have largely examined the evidence for intervention strategies related to product price and healthier product promotion, including product swaps, product signage, and product labeling.^{13–18} Only a very small number of studies included in these reviews assessed the role of product placement on dietary and food purchasing behaviors, and no quantitative evidence synthesis has been conducted to date. Reviews of observational research investigating the association between in-store food retail environments and dietary-related outcomes have not exhaustively examined product placement either – primarily because the literature in this area has grown rapidly since 2012, when 2 critical reviews on this topic were published.^{19,20} Policy makers would benefit from a systematic review of recent observational and intervention research investigating the role of product placement strategies in retail food stores on outcomes related to health, such as food sales, purchasing, dietary intake, or BMI.

According to the Typology of Interventions in Proximal Physical Micro-Environments (TIPPE), product placement consists of 2 distinct intervention types: availability and position.²¹ Availability describes the addition or removal of products to increase or decrease their variety, number, or range. Position refers to altering the position, proximity, or accessibility of products, rendering them easier or harder to engage with.

There is some evidence to indicate that public health strategies that alter environmental influences on health behaviors may be more equal in their effectiveness across socioeconomic groups than those requiring conscious or reflective engagement, which appear most beneficial for more advantaged groups.²² Assessing whether product placement strategies in retail food stores has a differential effect on dietary-related behaviors could provide important evidence to help address dietary inequalities. Thus, this systematic review aims to adopt a quantitative approach to answer the following questions:

1. Does an association exist between the availability of healthier and/or unhealthy food products in retail food stores and BMI, dietary behaviors, purchasing, and sales of these foods?
2. Does an association exist between the prominent positioning of healthier and/or unhealthy food products in retail food stores and BMI, dietary behaviors, purchasing, and sales of these foods?
3. Do these associations differ according to socioeconomic position?

METHODS

Recommendations made by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) group were followed throughout this review.²³ Table S1 (please see the Supporting Information online) shows the PRISMA checklist for the review. This systematic review was registered with the Prospective Register for Systematic Reviews (PROSPERO) CRD: 42016048826.

Data sources

Nine electronic databases were searched (Medline, DARE, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, EBSCOhost, PsycINFO, Science Direct, EconLit, and Scopus). A combination of medical subject headings (MeSH) and free-text terms relating to “diet,” “feeding behavior,” “food,” “beverages,” “food supply,” and “food industry” were used to identify studies that described the association between in-store food environments and diet, sales, purchasing, and BMI outcomes in adults. All studies were published in English between

Table 1 PICOS criteria for inclusion and exclusion of studies

Parameter	Inclusion criteria	Exclusion criteria
General	Published in English Published between 2005 and February 2019	
Study design	Intervention studies Observation studies	Ecological studies
Population	Studies with individuals aged 18+ years as primary population High-income countries	Low-income countries
Exposure/ intervention	Positioning of food/ beverage items of foods which have clear association with health Availability of food/ beverage items	Studies that focus solely on price, food labelling and portion size Inadequate description of in-store placement measures
Setting	Supermarkets Convenience stores	Non-permanent location (outdoor/ farmers' markets, pop-up stalls) Cafeterias Speciality food stores, eg, greengrocers, butchers
Outcomes	Dietary intake Food sales data Body composition	Food/ beverage outcomes (intake/sales) that do not clearly align with healthy eating guidelines

January 2005 and February 2019. A landmark article describing different types of food environments in relation to diet and health was published in 2005, prior to this date little research was published in this area.²⁴ The inclusion of this time frame captures the most recent literature in the research field, reflects current food store layouts and provides useful and applicable evidence for policy makers. The complete search strategy and list of search terms can be found in [Table S2](#) (please see the Supporting Information online). All titles and abstracts were screened by one author (S.C.S.) against the study PI(E)COS (population, intervention/exposure, comparison, outcome, and study design) criteria to ensure eligibility for inclusion ([Table 1](#)). Observational and intervention studies were included if they involved adult participants (aged 18 years and older), were conducted in high-income countries, included an exposure/intervention that investigated either the positioning or availability of food items in physical food stores and had an outcome relating to food sales, purchasing, dietary intake, or BMI. If it was unclear from the abstract alone whether an article was eligible for inclusion, the full text was reviewed. The bibliographies of the included studies were also screened for additional articles.

Data extraction and risk-of-bias assessment

Data were extracted to capture the relevant information for the research questions. Separate data extraction forms were created for observational studies and intervention studies. The full text for each article was assessed independently by 2 reviewers (S.C.S. and C.A.V.). Details regarding the study characteristics (study design, setting, participant details, exposures, outcomes, results, and funding sources) were extracted.

Concurrent with the data extraction, risk of bias was assessed for each eligible article to determine the risk of bias in relation to the research questions. This process was conducted using predefined assessment criteria based on those described by the NHS Centre for Reviews and Dissemination.²⁵ Separate risk-of-bias assessment criteria were used for observational and intervention studies. Thirteen domains in observational studies and 18 domains in intervention studies assessed the elements of study design, participant selection, attrition, assessment methodologies, statistical analyses, and handling of confounding effects ([Tables S3 and S4](#); please see the Supporting Information online). A risk-of-bias score of +1 (low risk of bias), 0 (medium risk of bias), or −1 (high risk of bias) was allocated for each domain. If, for any reason, an element of the assessment criteria was not applicable, a score of 0 was applied for that domain. For example, a 0 rating was applied for the “cohort follow-up percentage” domain if the study was cross-sectional. The reviewers (S.C.S. and C.A.V.) compared the risk-of-bias assessment ratings for consistency. Any discrepancies were discussed in depth until a quality score was agreed. An overall risk-of-bias score was allocated to each study based on the number of “−1” ratings a study received. Intervention studies with 6 or more −1 ratings, and observational studies with 5 or more −1 ratings, were classed as having a high risk of bias overall. If the number of −1 scores was ≤2 for intervention studies or ≤1 for observational studies, the overall risk-of-bias score was classified as low. Intermediate ratings were allocated a moderate overall risk-of-bias score.

Data synthesis

Separate summary tables were created for observational and intervention studies ([Tables S5 and S6](#); please see

the Supporting Information online). Each study was categorized according to the placement strategy (availability or positioning) of the exposure or intervention. Availability and positioning were defined according to the TIPME recommendations.²¹

Studies were further classified to reflect whether the exposure/intervention focused on the “placement of healthy foods” or “placement of unhealthy foods.” These categorizations were based on the Eatwell Guide (Public Health England).²⁶ Foods that were inadequately described or did not clearly align with this guide were excluded from this review. For example, popcorn, vegetarian pepperoni, and wheat-square cereal – covered in the study by Holmes et al²⁷ – were not included in the quantitative assessment as an expected direction for health outcomes could not be determined. Exposures/interventions that considered both healthy and unhealthy food items together were categorized under “placement of healthy and unhealthy food.”

Meta-analysis was not possible owing to the heterogeneity of the study designs, exposures/interventions, and outcomes. A vote-counting method was therefore used to summarize the findings of this review. Cochrane’s advice for accurate vote counting was followed throughout this review and requires that each study’s effect estimates are categorized according to their direction in terms of showing a health benefit or harm, in order to produce a standardized binary metric.²⁸ This systematic review hypothesized that greater availability and/or more prominent positioning of healthy foods resulted in a benefit for health through greater sales/purchasing/consumption of the healthy food, reduced sales/purchasing/consumption of unhealthy food items, or lower BMI. In addition, this review also hypothesized that reduced availability and/or no prominent positioning of unhealthy foods resulted in a benefit for health through decreased sales/purchasing/consumption of the unhealthy foods, increased sales/purchasing/consumption of healthy foods, or lower BMI. Each outcome result from an article was classified as either positive (supports hypothesis) or negative (rejects hypothesis). In cases where the direction of the outcome result could not be determined, results were categorized as inconclusive. Each article’s results were further classified according to the significance level (significant $P \leq 0.05$ or nonsignificant $P > 0.05$). Only results that were deemed to be relevant to the research question were extracted during the data synthesis process. The vote-counting results were summarized visually using bar charts and in detail using effect direction plots, as recommended by Cochrane.²⁸ Effect direction plots indicate studies that report on more than one similar outcome (diet, sales, purchasing, BMI) in a way that is not captured by a bar chart.

Arrows were used in effect direction plots to represent the combined direction and significance level of outcomes for each study. The method of combining results was based on previous criteria for variation in effect and significance²⁹:

If $\geq 70\%$ of outcomes report similar direction use an arrow (▲ [positive] or ▼ [negative]) to represent the direction.

- If $< 70\%$ of outcomes report a similar direction, use a diamond (◇) to represent inconsistent results.
- If effect direction similar AND $> 60\%$ outcomes are statistically significant, use a solid arrow (▲) to represent a significant result.
- If effect direction similar AND $< 60\%$ of outcomes are statistically significant, use a hollow arrow (△) to represent a nonsignificant result.

RESULTS

Search results

Figure 1 is a PRISMA diagram representing the literature search process. After removal of duplicates, 16 342 references were identified from the 9 databases searched. A further 2 articles were included from bibliographic review. All titles and abstracts were screened and 69 full-text articles were reviewed for eligibility. Thirty-one articles were excluded because of insufficient detail or inappropriate population, exposure/intervention, or outcome. Overall, 38 articles were deemed appropriate for inclusion. These articles described 17 observational studies and 22 intervention studies. Two of the intervention studies were reported in the same article but used different data sources and addressed different research questions. This article was therefore treated as 2 separate studies in this review (these studies are presented throughout as ‘Ejilerskov et al 2018a1’ and ‘Ejilerskov et al 2018a2’).³⁰

Study characteristics

Observational studies. Publication dates of the included observational studies ranged from 2008 to 2017. In total, 13 769 participants and over 1487 food stores were studied in the included observational literature. All but one of the observational studies had a cross-sectional design ($n = 16$; 94%). Table S5 (please see the Supporting Information online) provides a detailed summary of the study design, study setting, participant demographics, key findings, and quality for all observational studies.

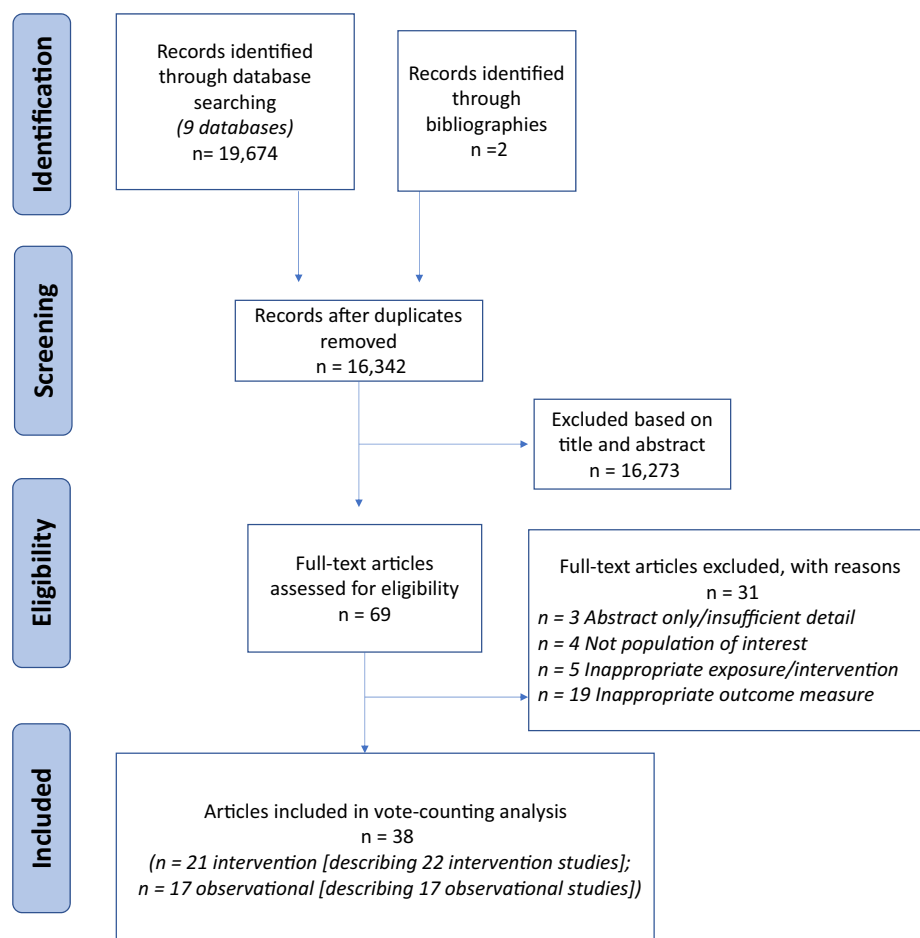


Figure 1 Flow diagram of the literature search process

Intervention studies. The intervention studies were published between 2009 and 2019. In total, over 40 571 participants and 289 food stores were included. The study designs varied greatly between the intervention studies: 4 studies (18%) described randomized control trials,^{31–34} 4 (18%) a quasi-experimental design,^{35–38} 7 (32%) a repeated cross-sectional design,^{30,39–45} and 4 (18%) alternating treatment designs,^{46–49} while 2 (9%) used time-series analyses^{27,30} and 1 (5%) was a natural experiment.³⁰

Table S6 (please see the Supporting Information online) provides a detailed summary of the study design, study setting, participant demographics, key findings, and quality for all intervention studies.

Exposures/interventions and outcomes

Observational studies. Of the 17 observational studies, 9 (53%) focused on supermarkets,^{50–58} 6 (35%) on convenience stores,^{59–64} and 2 (12%) on both supermarkets and convenience stores.^{65,66} Fourteen observational articles (82%) assessed availability.^{50,52–54,57–66} While

heterogeneous measures were used, all observational studies conducted in-store audits to assess food placement strategies. Five studies (29%) assessed availability by measuring the shelf space dedicated to specific food items.^{50,59,60,64,66} Length of shelf space (m) was the most common measure of shelf space, but total shelf space (length \times depth, m²) was also used in 2 studies (n = 2/5; 40%).^{50,64} Eight observational studies (47%) used cumulative scoring techniques to assess in-store availability.^{52–54,60–62,64,65} Five studies (n = 5/8; 75%) used modified versions of the Nutrition Environment Measures Survey in Stores (NEMS-S).^{52–54,62,65} NEMS-S assesses the availability, price, and quality of healthy food items within stores. The modifications varied greatly between studies, with each study assessing different items; none reported validity testing on these modified NEMS-S tools. The “healthy food supply” score was used in 2 studies (n = 2/8; 25%).^{60,61} This score is similar in structure to the NEMS-S tool, assessing availability, variety, price, and quality, but focuses on subsidized items approved for the US Women, Infants, and Children program. Six studies (n = 6/14; 43%) assessed product variety as a measure of

availability,^{50,57,59,60,62,63} 5 studies (n = 5/6; 83%) tallied the number of different varieties of fruit and vegetables available,^{50,59,60,62,63} and 1 study (n = 1/6; 17%) assessed the number of different varieties of chocolate and confectionery available.⁵⁷

Five observational studies (29%) examined food positioning strategies.^{51,55,56,60,63} Of these, all 5 (100%) measured store positioning – namely, checkout areas (n = 3/5; 60%),^{51,55,60} store entrances (n = 2/5; 40%),^{60,63} special floor displays (n = 1/5; 20%),⁵¹ and end-of-aisle displays (n = 3/5; 60%).^{51,55,56} One of these studies (n = 1/5; 20%) additionally measured shelf positioning by assessing whether bottled water was placed at eye level.⁶³ One study described the development, reliability, and validity of the GroPromo tool.⁵⁵ This tool assesses the presence of food items in 9 locations within food stores which vary in their level of prominence. It was the only validated tool identified in this review to assess positioning. Four other studies (n = 4/5; 80%) used dichotomized variables (Yes/No) to record whether specific types of food items were positioned in prominent store or shelf locations.^{51,56,60,63}

Sales-related outcome measures were used in 6 observational studies (35%),^{55–57,60,62–64} 8 studies (47%) assessed dietary-related outcomes,^{50,52,53,58,59,61,65} and 4 studies (24%) assessed BMI.^{51,53,54,66} For those evaluating sales and purchasing, objective store-level sales data was the outcome in only one study (n = 1/7; 14%).⁵⁶ The remainder (n = 6/7; 86%) recorded individual-level purchases via store exit interviews and shopping bag audits. Self-reported dietary data were collected using a number of different dietary tools. The majority of studies (n = 6/7; 86%) that examined dietary data used fruit and vegetable measures as the primary outcome.^{50,52,53,58,59,61} Other dietary measures included sugar-sweetened beverages (n = 3/7; 43%),^{51,52,61} chocolate and confectionery (n = 1/7; 14%),⁵⁸ and biscuits and cakes (n = 1/7; 14%).⁵² One study (n = 1/7; 14%) reported a 120-item food frequency questionnaire used to produce 2 dietary pattern scores: one score described a high-quality diet (high intakes of whole grains and fruits) and the other described a low-quality diet (high intakes of high-fat foods and processed meats).⁶⁵ One study (n = 1/7; 14%) used a novel measure – reflection spectroscopy – to objectively assess skin carotenoids as a marker of fruit and vegetable consumption in addition to self-reported fruit and vegetable consumption.⁶¹ Four studies considered BMI as an outcome.^{51,53,54,66}

Intervention studies. In accordance with this review's inclusion criteria, all interventions were conducted in physical food retail stores; 13 articles (n = 13/22; 59%) reported interventions taking place in supermarkets,^{27,30,32,35,38,39,42,45–49} 8 (n = 8/22; 36%) in

convenience stores,^{31,34,37,40,41,43,44} and 1 (n = 1/22; 5%) in both supermarkets and convenience stores.³⁶ Overall, the 22 intervention studies involved 243 intervention stores and 43 control stores. Eight studies (n = 8/22; 36%) did not include a control group.^{27,41,44–49} None of the intervention studies mentioned sample size calculations. Of the 14 studies (n = 14/22; 64%) that included a comparator group, 1 study (n = 1/14; 7%) had one control checkout per store to act as a comparison,³⁹ another study (n = 1/14; 7%) included delayed treatment controls,³¹ 4 (n = 4/14; 29%) used unmatched control stores,^{34,36–38} and 8 (n = 8/14; 57%) used matched control stores based on store characteristics, geographic location, and food product sales.^{30,32,33,35,40,42,43} Nine intervention studies (n = 9/22; 41%) incorporated availability in the treatment condition,^{31,32,36–38,41,43,44,49} and 18 (n = 18/22; 82%) included positioning components.^{27,30–35,38–42,45–49} Thirteen studies (n = 13/22; 59%) were not solely placement interventions and contained additional intervention features such as social marketing campaigns, staff training, shelf labeling, food demonstrations, signage, and financial incentives.^{27,31–34,36–38,40,41,44,47}

The majority of intervention studies (n = 7/9; 78%) examining availability focused on increasing the availability of healthy foods.^{31,36,37,41,43,44} One study (n = 1/9; 11%) increased the availability of crisps,⁴⁹ and 2 studies (n = 2/9; 22%) manipulated the availability of both healthy and unhealthy items.^{32,38} Of the 18 studies that focused on positioning, 4 (n = 4/18; 22%) manipulated shelf positioning, particularly the role of positioning food at eye level.^{32,35,46,49} The majority (n = 13/18; 72%), however, focused on product position within the store.^{27,30,31,33,38–40,42,45,47–49} The most common store position tested was the checkout, investigated in 7 studies (n = 7/13; 54%)^{30,38,39,42,45,47,48}; 3 studies (n = 3/13; 23%) examined front-of-store positioning,^{33,38,40} and 4 (n = 4/13; 29%) investigated island displays.^{27,31,38,49} One study assessed both shelf and store positioning.³⁴

The majority of intervention studies (n = 20/22; 91%) used sales-related outcomes.^{27,30,32–35,37–49} Only 4 studies (n = 4/22; 18%) measured diet-related outcomes,^{31,36,40,43} and 1 (n = 1/22; 5%) assessed BMI.⁴³ Most studies (n = 15/20; 75%) that used sales-related outcomes collected data at the store level. Of these, 9 (n = 9/15; 60%) used objective store sales data,^{27,32,35,38,45–49} 3 studies (n = 3/15; 20%) conducted bag checks and checkout observations,^{39,43,44} 2 studies (n = 2/15; 13%) relied on store manager reported sales,^{34,37} and 1 study (n = 1/15; 7%) used store sales provided by the state department relating to women, infants, and children.³³ Self-reported household-level purchasing data from Kantar Worldpanel were applied in 3 studies (n = 3/20; 15%).^{30,42} Another 3 studies

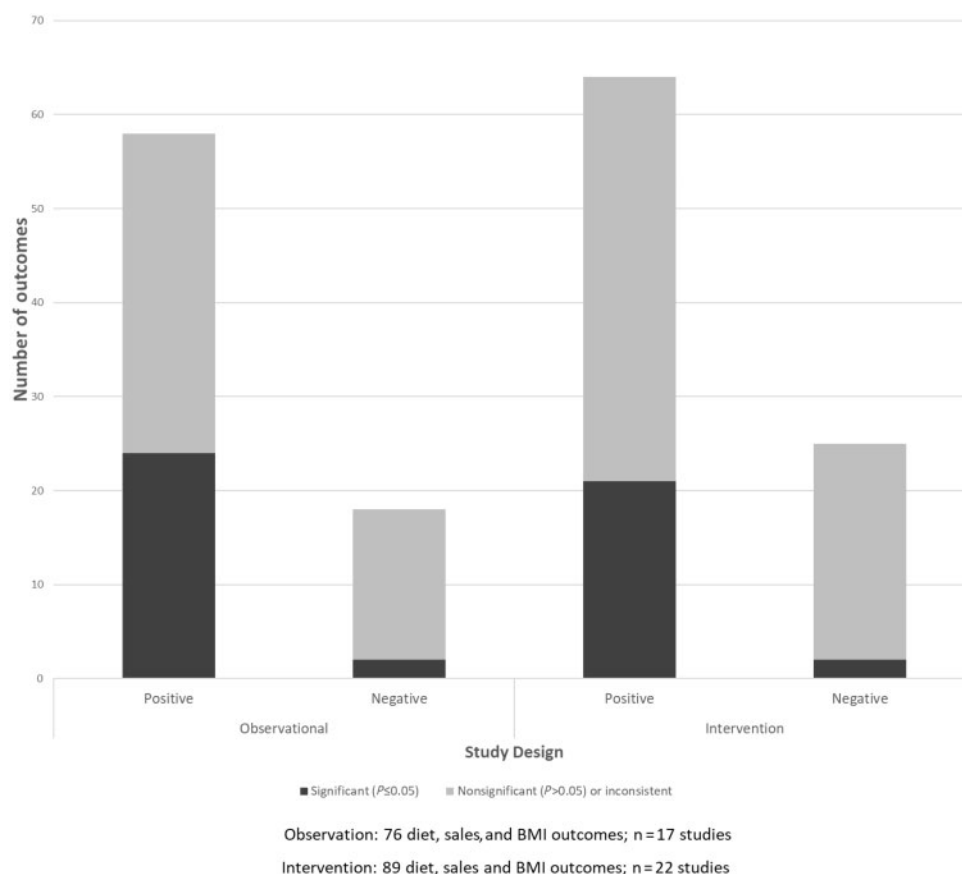


Figure 2 Summary of placement strategy vote-counting results from observational and intervention studies in relation to the review hypothesis

(n = 3/20; 15%) relied on self-reported purchases of food items.^{33,40,41}

Of the 4 studies that assessed dietary outcomes, 1 (n = 1/4; 25%) used a “healthy food getting” variable that assessed self-reported consumption of 26 healthy foods over the past 30 days.³⁶ The 3 remaining studies (n = 3/4; 75%) assessed self-reported fruit and vegetable consumption,^{31,40,43} with 1 also including self-reported sugar-sweetened beverage consumption.⁴³ A validated questionnaire was used in only one study³¹; however, another used reflection spectroscopy to objectively assess skin carotenoids as a marker of fruit and vegetable consumption.⁴³

Key findings

Figure 2 visually presents the quantitative vote-counting results, incorporating 76 diet, sales, and BMI outcomes from 17 observational studies, and 89 outcomes from 22 intervention studies. More than three-quarters of the observational outcomes (76%) showed positive findings supporting the review hypotheses; approximately one-quarter (24%) showed negative findings that did not support the review hypotheses. Of all observational

findings, 66% were nonsignificant (59% positive nonsignificant outcomes, 89% negative nonsignificant outcomes). Almost three-quarters of the intervention outcomes (72%) showed positive findings supporting the review hypotheses; approximately one-quarter of the intervention outcomes (28%) showed negative findings that did not support the study hypotheses. A large proportion of the intervention outcomes (74%), however, were nonsignificant (67% positive nonsignificant outcomes, 92% negative nonsignificant outcomes).

Research question 1: Does an association exist between the availability of healthier and/or unhealthy food products in retail food stores and BMI, dietary behaviors, purchasing, and sales of these foods?

Observational studies. As shown by the effect direction plot in **Table 2**, 14 observational studies (82%) assessed food availability,^{50–55,57–66} of which over half (n = 8/14; 57%)^{50,52,59–64} found that product availability in retail food outlets was associated with outcomes that supported the review hypotheses and showed health benefits (3 positive significant [+s] outcomes, 5 positive nonsignificant [+ns] outcomes). Two studies reported

Table 2 Effect direction plot of observational studies

Author, year	Study design	Socioeconomic status	Sample size	Placement of healthy foods	Placement of unhealthy foods	Placement of healthy and unhealthy foods	Outcome type ^b	Effect direction and significance ^c	Risk of bias
Bodor et al (2008) ⁵⁹	CS	Low	102	A			Diet	△ ⁶	Low
Caldwell et al (2009) ⁵⁰	LT	Not provided	130	A			Diet	△ ₆	High
Caspi et al (2017) ⁶⁰	CS	Not provided	594	A		A	Sales	△ ₇	Low
				P			Sales	△ ₂	
							Sales	△ ₂	
Cohen et al (2015) ⁵¹	CS	Low	980	P	P		BMI	△ ₂	Moderate
							BMI	▽	
Franco et al (2009) ⁶⁵	CS	Varied	759	A			Diet	◇ ⁶	Low
Gustafson et al (2011) ⁵³	CS	Not provided	186	A			BMI	▽	Low
				A			Diet	▽	
Gustafson et al (2013) ⁵²	CS	Low	121	A			Diet	△ ₄	Low
Jani et al (2018) ⁵⁴	CS	Not provided	3817	A			BMI	◇ ₂	High
Jilcott Pitts et al (2017) ⁶¹	CS	Not provided	479	A			Diet	△ ₄	Low
Kerr et al (2012) ⁵⁵	CS	Varied	637		P		Sales	▲ ₂	Moderate
Martin et al (2012) ⁶²	CS	Low	372	A			Sales	▲ ₂	Low
Nakamura et al (2014) ⁵⁶	CS	Not provided	1 ^a	P	P		Sales	▲ ₂	Moderate
							Sales	▲	
Rose et al (2009) ⁶⁶	CS	Not provided	1243	A	A		BMI	◇ ₃	Low
							BMI	△ ₃	
Ruff et al (2016) ⁶³	CS	Varied	1904	P			Sales	▽ ₄	Low
				A			Sales	▲ ₅	
Sanchez-Flack et al (2017) ⁶⁴	CS	Low	369	A			Sales	▲ ₄	Moderate
Thornton et al (2010) ⁵⁸	CS	Varied	1082	A			Diet	▽ ₄	Moderate
Thornton et al (2011) ⁵⁷	CS	Varied	1007		A		Diet	◇ ₂	Moderate

^aNo. of stores rather than no. of participants.^bSales represents sales/purchasing.^c▲ Positive result ($P < 0.05$); △ positive result ($P > 0.05$); ▼ negative result ($P < 0.05$); ▽ negative result ($P > 0.05$); ◇ inconsistent results.

Number of outcomes within each category is 1 unless indicated in subscript beside effect direction.

Reported effect direction and significance for multiple outcomes:

- All outcomes report effect in same direction and with same level of statistical significance **OR**
- Where direction of effect varies across multiple outcomes:

Overall result direction determined if $\geq 70\%$ of outcomes report similar direction; Overall result significance level determined if $\geq 70\%$ of outcomes report similar statistical significanceInconsistent findings rated as inconsistent if $< 70\%$ of outcomes report consistent direction of effect (◇).

results that did not support the hypotheses (2 negative nonsignificant [−ns]), and 4 studies reported inconsistent results.

Of the 13 studies ($n = 13/14$; 93%) that assessed availability of healthy food products,^{50,52–54,58–66} 57% ($n = 8/14$) showed results in the expected direction for health (5 +ns, 3 +s).^{50,52,59–64} In addition, one study ($n = 1/14$; 7%) assessed the availability of healthy food items separately to unhealthy items. The results showed a nonsignificant positive relationship between unhealthy food availability and BMI but inconsistent findings for the availability of healthy foods and BMI.⁶⁶ One study showed that having a greater proportion of shelf space dedicated to fruit and vegetables, compared to unhealthy drinks and snacks, was associated with healthier purchases (+ns).⁶⁰ One study assessed the availability of chocolate and confectionery, finding an

overall inconsistent relationship with the consumption of these items – specifically, a nonsignificant positive association for confectionery exposure and confectionery consumption but no clear trend between chocolate exposure and chocolate consumption.⁵⁷

The 4 studies that considered purchasing outcomes demonstrated the most consistent support of the review hypotheses; 80% ($n = 3/4$) found significant positive associations^{62–64} and 20% ($n = 1/4$) nonsignificant positive associations.⁶⁰ Half of the studies ($n = 4/8$; 50%) with diet outcomes indicated a relationship with food availability in the expected direction for health benefit; however, none were statistically significant.^{50,52,59,61} BMI showed no clear relationship with food availability; 2 of the 3 studies showed inconsistent results,^{54,66} and one identified a nonsignificant relationship between greater healthy food availability and higher BMI.⁵³

Table 3 Effect direction plot of intervention studies

Author, year	Study design	SES status	Sample Size	Placement of healthy foods	Placement of unhealthy foods	Placement of healthy and unhealthy	Outcome type ^c	Effect direction and significance ^d	Risk of Bias
Adam et al (2017) ³⁵	QE	Not provided	10 ^a	P	P		Sales	▲	High
Adjoian et al (2017) ³⁹	RCS	Low	3 ^a	P			Sales	△ ²	High
Albert et al (2017) ⁴⁰	RCS	Low	550			P _M	Sales	△ ³	High
Ayala et al (2013) ³¹	RCT	Low	119	AP _M			Diet	△ ³	High
Dannefer et al (2012) ⁴¹	RCS	Low	294	AP _M			Sales	△ ²	High
De Wijk et al (2016) ⁴⁶	AT	Not provided	2 ^a			P	Sales	◇	High
Ejlerskov et al (2018a1) ³⁰	TS	Varied	30,000 ^b			P	Sales	▲ ²	High
Ejlerskov et al (2018a2) ³⁰	NE	Varied	30,000 ^b			P	Sales	▲	High
Ejlerskov et al (2018) ⁴²	RCS	Varied	30,000 ^b			P	Sales	◇	High
Foster et al (2014) ³²	RCT	Low	8 ^a		AP _M		Sales	△ ¹³	Moderate
Gittelsohn et al (2010) ³⁶	QE	Low	83	A _M			Diet	▽ ¹⁶	High
Holmes et al (2012) ²⁷	TS	Not provided	1 ^a	AP _M			Sales	◇ ¹⁶	High
Jilcott Pitts et al (2018) ⁴³	RCS	Low	223	A _M			Sales	▽ ³	High
				A _M			Diet	◇ ³	
				A _M			BMI	▽ ³	
Lawman et al (2015) ⁴⁴	RCS	Low	8671	A _M			Sales	△ ²	High
Sigurdsson et al (2009) ⁴⁹	AT	Not provided	2 ^a		AP		Sales	△ ²	High
Sigurdsson et al (2011) ⁴⁷	AT	Not provided	2 ^a	P		P	Sales	△	High
						P _M	Sales	◇	
						P _M	Sales	△	
Sigurdsson et al (2014) ⁴⁸	AT	Not provided	2 ^a	P		P _M	Sales	△	High
							Sales	△ ¹⁰	
Song et al (2009) ³⁷	QE	Low	13 ^a	A _M			Sales	◇ ¹⁰	High
Thorndike et al (2017) ³³	RCT	Low	575			P _M	Sales	△ ²	Moderate
Toft et al (2017) ³⁸	QE	Not provided	3 ^a			AP _M	Sales	△ ⁶	High
Wensel et al (2018) ³⁴	RCT	Low	10 ^a	P			Sales	▽ ²	High
Winkler et al (2016) ⁴⁵	RCS	Low	4 ^a			P	Sales	◇ ⁵	High

^aRelated to no. of stores.^bEstimated sample size.^cSales represents sales/purchasing.^d▲ Positive result ($P < 0.05$); △ positive result ($P > 0.05$); ▼ negative result ($P < 0.05$); ▽ negative result ($P > 0.05$); ◇ inconsistent results.

Number of outcomes within each category is 1 unless indicated in subscript beside effect direction.

Reported effect direction and significance for multiple outcomes:

- All outcomes report effect in same direction and with same level of statistical significance **OR**

- Where direction of effect varies across multiple outcomes:

Overall result direction determined if $\geq 70\%$ of outcomes report similar direction; Overall significant level determined if $\geq 70\%$ of outcomes report similar statistical significanceInconsistent findings rated as inconsistent if $< 70\%$ of outcomes report consistent direction of effect (◇).**Abbreviations:** A, availability; AP, availability and positioning; AT, alternating treatment; M, multicomponent study; NE, natural experiment; P, positioning; QE, quasi-experimental; RCS, repeated cross-sectional; RCT, randomized controlled trial; TS, time series.

Intervention studies. Table 3 shows the effect direction plot for intervention studies. Four intervention studies ($n = 4/22$; 18%) described manipulation of food availability.^{36,37,43,44} Of these, none showed results in the expected direction for health benefit. One study had results in the unexpected direction (negative significant, -ns),³⁶ and 3 showed inconsistent results.^{37,44,61} All 4 of these studies targeted the availability of healthy foods, with none reducing the availability of unhealthy food items; additionally, all 4 were implemented as part of multicomponent interventions.^{36,37,43,44}

For the studies assessing sales/purchasing ($n = 3/4$, 75%), inconsistent results were observed in 2 studies,^{37,44} and one study showed that increasing the availability of healthy food items resulted in reduced sales of these items (-ns).⁴³ In the 2 studies assessing dietary outcomes ($n = 2/4$; 50%), one found results in the unexpected direction (-ns),³⁶ and the other showed inconsistent results.⁴³ The one study ($n = 1/4$; 25%) that assessed BMI found that improving the availability of fruit, vegetables, low-fat milk, and whole-grain products in convenience stores resulted in a nonsignificant

increase in BMI among intervention customers compared with control customers.⁴³

Research question 2: Does an association exist between the prominent positioning of healthier and/or unhealthy food products in retail food stores and BMI, dietary behaviors, purchasing, and sales of these foods?

Observational studies. Of the 5 observational studies ($n = 5/17$; 29%) that assessed food positioning (Table 2), 3 (60%)^{51,55,56,60,63} showed that positioning strategies were consistently associated with outcomes beneficial to health (2 +s, 1 -ns).^{55,56,60} One of these studies assessed shelf positioning combined with store positioning and found results in the unexpected direction for shelf positioning (2 -ns) and inconsistent results for store positioning strategies (1 +ns, 1 -ns; separate results not shown).⁶³

Of the 4 studies ($n = 4/5$; 80%) that assessed the positioning of healthy food products,^{51,56,60,63} 2 showed results in the expected direction (1 +s, 1 +ns)^{56,60} and 2 showed results in the unexpected direction (2 -ns).^{51,63} Additionally, 2 of these studies also assessed the positioning of unhealthy food items, with both showing results in the expected direction: Positioning unhealthy drinks and snacks at the ends of aisles, at checkouts, and in islands was associated with greater sales of these unhealthy items and increased BMI (1 +s, 1 +ns).^{51,56} Another study assessed only unhealthy food positioning and found significant results in the expected direction (+s).⁵⁵

Sales and purchasing outcomes were reported in 4 of the studies ($n = 4/5$; 80%)^{55,56,60,63} that examined the positioning of food products; one study reported BMI,⁵¹ but no studies measured dietary outcomes. Three-quarters of studies ($n = 3/4$; 75%) reporting sales/purchasing outcomes showed that positioning healthy and unhealthy food products in prominent in-store locations was associated with greater sales of these products (2 +s, 1 +ns, 1 -ns).^{55,56,60} The single study that reported BMI revealed inconsistent results, with prominent positioning of both healthy and unhealthy foods showing associations with higher BMI.⁵¹

Intervention studies. Twelve intervention studies^{30,33–35,39,40,42,45–48} ($n = 12/22$; 55%) described the effects of manipulating the positioning of food products, of which 4 ($n = 4/12$; 33%) included additional intervention components such as signage, social media campaign, and staff training.^{33,40,47,48} Of the 8 studies^{30,34,35,39,42,45,46} ($n = 8/12$; 75%) that tested only product positioning, 4 showed results in the expected

direction for health (3 +s, 1 +ns)^{30,35,39} and 4 showed inconsistent or unexpected results.^{34,42,45,46} Two studies tested alternating treatment and control conditions. Treatment conditions included prominent positioning of healthy products alone or prominent positioning alongside point-of-purchase signage. The results were inconsistent for the positioning-alone strategies, but consistent positive results (2 +ns) were observed for the multicomponent condition.^{47,48} Of the studies describing the effects of prominent store positioning^{30,33,34,39,40,42,45–48} ($n = 11/12$; 92%), the majority ($n = 6/11$; 55%) showed these interventions have positive effects for health (3 +s, 3 +ns).^{30,33,39,40,48} The 2 studies ($n = 2/12$; 17%) that investigated the effects of shelf positioning, however, had inconsistent results (1 +ns, 1 -ns).^{34,35}

Most studies ($n = 5/9$; 56%) that concurrently positioned healthy foods in prominent locations and unhealthy foods in less prominent locations showed results in the expected direction for health (2 +s, 3 +ns).^{30,33,40,48} Positioning healthy foods in more prominent locations led to healthier dietary-related outcomes in the majority ($n = 3/5$; 60%) of studies (2 +s, 1 +ns, 1 -ns, 1 inconsistent).^{34,35,39,47,48} The single study that altered the positioning of unhealthy food found that locating high-fat dairy products in a less prominent shelf position resulted in a nonsignificant decrease in sales of these items.³⁵

Most studies ($n = 7/12$; 58%) reporting sales/purchasing outcomes showed that positioning products in prominent locations increased sales/purchases of these products (3 +s, 4 +ns).^{30,33,35,39,40,48} One study showed a decrease in eligible food sales relating to women, infants, and children after these products were positioned in prominent store and shelf locations.³⁴ The single study ($n = 1/12$; 8%) measuring dietary outcomes showed that simultaneously placing fruit and vegetables at the front of the store, and crisps at the back, resulted in a nonsignificant increase in daily fruit and vegetable intake among intervention store customers compared with control customers.⁴⁰

Availability and positioning were combined in 6 intervention studies.^{27,31,32,38,41,49} The vast majority of these studies ($n = 5/6$; 83%) showed results in the expected direction for health (5 +ns, 1 inconsistent).^{31,32,38,41,49} These results were consistent regardless of whether the intervention targeted healthy, unhealthy, or both types of products, or measured sales/purchases or dietary outcomes. Five studies reported findings from multicomponent interventions incorporating other strategies such as shelf labels, food demonstrations, and promotional events. The majority of these multicomponent intervention studies ($n = 4/5$; 80%)

showed results in the expected direction for health (4 +ns, 1 inconsistent).^{27,31,32,38,41}

Research question 3: Do these associations differ according to socioeconomic position?

Observational studies. Seven observational studies (41%) provided no description of the socioeconomic backgrounds of the study area or study participants. Of the 10 (59%) that reported socioeconomic data, 5 were conducted in study areas with varying levels of socioeconomic position (SEP)^{55,57,58,63,65} and 5 were conducted with participants of lower SEP or in areas of lower SEP.^{51,53,59,62,64} Only one study had an inclusion criterion that specifically targeted low-income participants.⁵³ No observational studies explicitly examined the interaction between SEP and food placement strategies. However, from the studies conducted amongst predominantly disadvantaged groups (ie, low income, high prevalence of government assistance, or deprived area), findings showed consistently that healthier placement strategies were associated with better diet and sales outcomes, but the association with BMI outcomes was inconsistent.

Intervention studies. Fifteen intervention studies (71%) described the socioeconomic backgrounds of the study area or study participants. Twelve of the studies (n = 12/15; 80%) reporting socioeconomic data were conducted in deprived neighborhoods, and 3 (n = 3/15; 20%) among populations of varying SEP. Only one study specifically analyzed the differential intervention effects according to household social class (occupation of highest earner) and found no clear trend across social class quintiles.⁴² In the 12 studies that focused on populations of lower SEP, half showed results indicating that the intervention was beneficial for health. The other half of the studies, however, showed inconsistent results.

Risk of bias

Tables S5 and S6 (please see the Supporting Information online) present the risk-of-bias assessment results for each article.

Observational studies. Nine observational studies (59%) were found to have a low risk of bias in relation to the research questions^{52,53,59–63,65,66}; 6 (35%) were classified as having moderate risk of bias^{51,55–58,64} and 2 (12%) as having high risk of bias.^{50,54} Of the 9 classified as having a low risk of bias, 5 showed positive results (4 +ns,^{52,59–61} 1 +s⁶²), 3 inconsistent results,^{63,65,66} and 1 negative results (–ns).⁵³

Intervention studies. Twenty (91%) intervention studies were classified as having a high risk of bias in relation to the research question,^{27,30,31,34–36,38–49} and 2 (9%) had moderate risk of bias.^{32,33} The 2 studies with moderate risk of bias both showed results indicating that health product placement interventions can be beneficial for health; however, the results from these studies did not reach statistical significance.^{32,33}

DISCUSSION

Summary of findings

This systematic review is the first to consider the overall direction of effect for food placement strategies on healthy eating behaviors. Considering the need for action on the complex public health concerns of poor diet and obesity, and the difficulties in conducting randomized controlled trials in this research field, this systematic review finds moderate evidence using a practice-based evidence perspective,⁶⁷ from both observational and intervention studies, for food placement strategies in food retail stores positively influencing healthy eating behaviors. This review indicates weaker, but still meaningful, evidence of an effect when adopting the more traditional evidence-based practice approach. Although the majority of findings showed that greater availability and more prominent positioning of healthy foods, or reduced availability and less prominent positioning of unhealthy foods, related to better dietary behaviors, many were not statistically significant. The small sample size and lack of power demonstrated in many of the studies, particularly the intervention studies, may have contributed to the high number of nonsignificant results, and likely indicate the difficulties in conducting these types of field studies with a high-quality scientific design.

Analyzing the results with greater granularity, according to placement type the literature reveals moderate observational evidence for an association between product availability and dietary-related outcomes in the expected direction for health; evidence from intervention research was more limited and equivocal. A large proportion of both observational and intervention literature focused on improving the availability of healthy foods; hence, drawing conclusions on the effectiveness of solely limiting the availability of unhealthy foods is not yet possible. Both observational and intervention literature indicated moderate evidence for product positioning strategies in food stores affecting dietary-related health outcomes; most intervention studies indicated that more prominent positioning of healthy foods, and less prominent positioning of unhealthy foods, results

in better dietary, or healthier sales, behaviors. Good evidence from the intervention studies included in this review exists to support strategies that combine the availability and positioning of both healthy and unhealthy foods to provide benefit for health. A number of interventions were multicomponent, which does somewhat weaken the conclusions we can draw about the effect of availability and positioning measures alone; however, the majority (80%) of the multicomponent interventions in this study showed findings in the expected direction for health. Sales outcomes, which were assessed in the majority of intervention studies and in almost half of the observational studies, provided the most consistent results in the expected direction for health benefit. The least abundant and least consistent evidence was found for BMI outcomes; this is perhaps not surprising given the multiple determinants of body weight and the challenges of assessing BMI in large-scale studies.

Observational studies suggested that strategies to improve the placement of healthy foods, and limit the placement of unhealthy foods, could have a positive impact on diet and sales in populations of low socioeconomic status. However, these results were not replicated among the intervention literature, which showed inconsistent findings in populations of low socioeconomic position.

Policy implications

The results from this review provide policy makers with evidence to justify the implementation of population-level policies incorporating placement strategies in food retail stores to improve dietary-related behaviors. Although more research is needed to quantify the magnitude of effect of availability and positioning strategies, this review's findings suggest that placement strategies combining both availability and positioning have the greatest potential to improve the healthfulness of sales and dietary patterns.

The evidence that is currently available – summarized in this review and the 2016 systematic review by Bucher et al,⁶⁸ which found that manipulating the order and proximity of food in eateries and food service outlets influenced food choice – supports the UK government's intention to ban the positioning of unhealthy food items in prominent locations in food retail stores and food service outlets.⁶⁹ Other governments could also consider introducing similar policies to improve dietary quality across high-income countries. Even though the current research findings do not meet the “gold-standard” level of evidence that is usually required for the scientific community to provide certainty of effect, these reviews provide a sufficient body of

evidence to recommend government action. The introduction of government policies to promote healthy food retail establishments would lead to a “level playing field” between retailers. If such placement strategies are only implemented on a voluntary basis, the high level of competition within this setting may result in some businesses not implementing such strategies, and that would likely limit the positive impact on public health.⁷⁰

Next steps for the research field

Although this review indicates moderate evidence for food placement strategies in retail food stores influencing purchasing and dietary behaviors, there are a number of ways in which the body of evidence can be strengthened. The lack of power calculations described in intervention research in particular is an issue that needs addressing to optimize external validity of the evidence. No intervention articles in this review described their power calculations or justified the study's sample size. Placement studies require power calculations that take account of clustering at the store level because the intervention is store-based. In a cluster-designed study, it is the number of clusters, rather than the number of individuals within each cluster, that is most potent in determining statistical power.⁷¹ The need for a large number of stores and the opportunistic nature of many interventions studies are key reasons why no high-quality intervention research has been conducted in this field. Considerable commitment is required from commercial collaborators to allow for the required number of stores; however, mounting societal and political pressure for food retailers to engage in healthy eating strategies could enhance future prospects of adequately powered studies being conducted.

Improving the design of future food placement research, particularly considering novel trial designs and longitudinal observational studies, would further improve the evidence base. Less than two-thirds of the intervention articles in this review included a comparison group, and only 4 were randomized controlled trials. This finding indicates that store-based placement interventions do not easily conform to scientific gold standards. Researching in real-world settings, however, provides valuable knowledge to policy makers about intervention effectiveness in complex social contexts, particularly when studies are rigorously designed. Parallel designs with control groups matched on area characteristics and store sales (plus adjustment for confounders) offer a robust design and were used in approximately one-third of the current intervention evidence, all published in the last 5 years. Alternative designs including natural experiments, stepped-wedge designs, synthetic controls, and propensity scores could be further

explored for use in future food placement intervention or policy evaluation studies.^{72–75}

There is a gap in the evidence to describe how reducing the availability of unhealthy foods in food retail stores affects diet-related outcomes as most of the literature investigating placement strategies has focused on healthy foods. Although more challenging commercially than the “win-win” of targeting healthy foods in placement interventions,⁴⁵ future research should focus on limiting the availability and prominent positioning of unhealthy foods – perhaps by replacing them with non-food items in an attempt to reduce overall food intake. Compensation to food retail chains for any loss in revenue may need to be considered. As highlighted in a recent scoping review, business outcomes of food retail strategies to improve health should be consistently reported in academic literature.⁷⁶

There is also a need for greater harmonization of in-store assessment measures that act as exposures in observational research or fidelity assessments in intervention studies. Currently, 3 categories of availability measures are used: shelf space, variety, and composite scores. Considerable within-category variation exists, and the composite scores typically measure in-store factors such as price and quality in addition to availability. Positioning measures have focused almost entirely on prominent store locations such as checkouts, ends of aisles, and front of store; only one observational article measured shelf placement in this review. An in-store assessment tool that expands the existing validated GroPromo tool⁵⁵ to include measures of availability and shelf placement would help to harmonize data in this field. Intervention research should include measures of both availability and positioning in their fidelity assessments because these two placement strategies are often intertwined. Positioning products at the checkouts or ends of aisles typically extends the availability of those products as they are located both in an aisle and in a prominent location. Only one intervention article in this review specifically considered both these aspects of placement in its evaluation.⁴⁷

Consistent with the findings of previous reviews of supermarket interventions,^{15,16} many of the studies in this review contained multiple intervention components. Food placement strategies were a core component of these interventions. It was not possible, however, to decipher the isolated effects of changing product availability or positioning because additional strategies such as signage or staff training were employed at the same time. Future research that aims to test multiple intervention components, such as the 4 Ps of marketing, should consider the study by Wensel et al,³⁴ which tested both the independent and additive effects of 4 intervention elements. This type of research,

combined with studies that test single-component placement interventions, will be scientifically advantageous and ensure efficient and cost-effective packaging of interventions.

While sales outcomes were most frequently used and showed greatest consistency of effect in this review, loyalty card data were not used in any of the observational or intervention studies. Loyalty card data are a form of “big data” that offer a potentially economical method of analyzing how in-store determinants affect household purchasing.^{16,77} Little is known from the available literature about the populations who are most affected by placement strategies in food stores. This gap could be addressed by measuring intervention effects at a household or individual level rather than at a store level. Despite existing evidence suggesting that those from disadvantaged backgrounds are more susceptible, in dietary terms, to unhealthy in-store environments than those of more affluent groups,⁷⁸ it is currently unclear whether placement strategies exacerbate or reduce dietary inequalities. Further evidence from adequately powered studies is needed to determine differential effects by SEP. Moreover, assessments of dietary outcomes, nutritional biomarkers or metabolites, and food waste are needed alongside loyalty card data to provide intelligence on the accuracy of this big data source, and the correlation between purchasing and intake patterns. It would be particularly useful if future research included dietary assessments from more than one household member to understand more clearly which household members are being affected by placement strategies. Finally, as outcome measures with frequent time points (weekly sales or purchasing data) become commonplace in this research field, more advanced statistical methods such as the time-series analyses used by Ejlerskov et al,³⁰ and appropriate adjustment for clustering and confounding, should be more consistently applied.

Strengths and limitations

This review is strengthened by the adherence to PRISMA guidelines throughout. Two reviewers independently conducted a risk-of-bias assessment and data extraction from each of the included studies to ensure consistency and rigor. In addition, the inclusion of both observational and intervention studies is a strength of this study as this allowed for a more thorough assessment of the overall relationship between placement strategies in food-store settings and diet-related outcomes. Product availability has been researched most extensively in the observational literature, while product positioning has been the focus of many intervention studies. However, including both types of literature

presents some challenges with interpreting the quality of the evidence and summarizing overall results. Separate risk-of-bias assessment criteria were used for observational and intervention studies, so the final quality scores could not be compared. Intervention research is considered a higher grade of evidence and should be treated as such when drawing conclusions. This review also only included studies that assessed physical in-store environments, excluding virtual and online settings. This approach allows for the assessment of strategies that have greater external validity and the ability to be implemented in real-life settings. The findings of this review, however, are not applicable to the growing online grocery sales market.

The search strategy for this review did not include literature published prior to 2005 or forward searching for identified articles through citations. It is therefore possible that some articles of interest may have been excluded. However, 2005 marked the year a landmark article in the field of food environment research was published.²⁴ This article, along with the Foresight obesity report,³ was among the first to highlight the importance of understanding the role of food environments on population health. Another limitation of this systematic review was the exclusion of gray literature or unpublished data in this topic area. Consequently, it is possible that the results of this review are subject to publication bias. Studies showing positive and significant effects may have an increased likelihood of publication, and our findings were potentially skewed as a result of this bias. In addition, owing to the heterogeneous nature of the study exposures, interventions, and outcomes, it is difficult to draw definitive conclusions from the available evidence. Though meta-analysis was not possible, a quantitative summary of the evidence was achieved by using a direction-based vote-counting technique or effect direction plot, as is recommended by Cochrane when meta-analysis is not feasible.²⁸ This technique, however, is limited by its lack of consideration of the magnitude of effects and differences in study size.²⁸

CONCLUSIONS

Drawing on recent evidence from observational and intervention research across high-income countries, this review suggests that more prominent placement strategies are associated with higher sales and consumption of both healthy and unhealthy foods, but not weight status. Even though further high-quality research is required in this area, the balance of evidence suggests that the introduction of government interventions may be beneficial by providing a “level playing field” between retailers and to increase the availability and prominence

of healthy foods and reduce the availability and prominent positioning of unhealthy foods. Future research priorities should focus on designing adequately powered intervention studies that test both the independent and additive effects of reducing the availability, and limiting the prominent positioning, of unhealthy foods. A greater understanding of who is most affected by placement strategies is required; this could be achieved through the use of loyalty card data as the primary outcome holds potential, alongside dietary assessments from more than one household member.

Acknowledgments

The authors would like to thank Elizabeth Payne for her assistance with the literature review search for this publication.

Author contributions. Overall integrity of the work from inception to publication: S.C.S., J.B., and C.A.V. Design, acquisition of data, or analysis and interpretation of data: S.C.S. and C.A.V. Preparation and review of the manuscript for important intellectual content: S.C.S., G.N., J.B., and C.A.V. Final approval of the version to be published: S.C.S., G.N., J.B., and C.A.V.

Funding. The authors of this paper are supported by the following funding sources: UK Medical Research Council, University of Southampton (PCTA36/2015), UK Academy of Medical Sciences (HOP001\1067), and UK National Institute of Health Research Southampton Biomedical Research Centre. The views expressed in this publication are those of the author(s) and not necessarily those of the funders or NHS, NIHR, or the UK Department of Health and Social Care.

Declaration of interest. S.C.S. and G.N. have no conflicts of interests to declare. J.B. and C.A.V. have a nonfinancial research collaboration with a UK supermarket chain. J.B. has received grant research support from Danone Early Life Nutrition. The study described in this manuscript is not related to any of these relationships.

Supporting Information

The following Supporting Information is available through the online version of this article at the publisher's website.

[Table S1 PRISMA checklist](#)

[Table S2 Search strategy](#)

Table S3 Quality assessment grading for observational studies

Table S4 Quality assessment grading for intervention studies

Table S5 Summary table of observational studies

Table S6 Summary table of intervention studies

REFERENCES

- Roberto CA, Swinburn B, Hawkes C, et al. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking. *Lancet*. 2015;385:2400–2409.
- Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med*. 1999;29:563–570.
- Foresight. *Tackling Obesity: Future Choices – Project Report*. 2nd ed. London: Government Office for Science; 2007.
- Jebb SA, Aveyard PN, Hawkes C. The evolution of policy and actions to tackle obesity in England. *Obes Rev*. 2013;14:42–59.
- Swinburn BA, Kraak VI, Allender S, et al. The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. *Lancet*. 2019;393:791–846.
- Marteau TM. Changing minds about changing behaviour. *Lancet*. 2018;391:116–117.
- Bond ME, Crammond BR, Loff B. It's not about choice: the supermarket and obesity. *Med J Aust*. 2012;197:371.
- Glanz K, Bader MD, Iyer S. Retail grocery store marketing strategies and obesity: an integrative review. *Am J Prev Med*. 2012;42:503–512.
- Garrido-Morgado A, Gonzalez-Benito O. Merchandising at the point of sale: differential effect of end of aisle and islands. *BRQ Bus Res Q*. 2015;18:57–67.
- Wilkinson JB, Mason JB, Paksoy CH. Assessing the impact of short-term supermarket strategy variables. *J Market Res*. 1982;19:72–86.
- Obesity Health Alliance. Out of place: the extent of unhealthy foods in prime locations in supermarkets. 2018. Available at: <http://obesityhealthalliance.org.uk/wp-content/uploads/2018/11/Out-of-Place-Obesity-Health-Alliance-2.pdf>. Accessed January 20, 2020.
- Department of Health and Social Care. Childhood obesity: a plan for action, chapter 2. 2018. Available at: <https://www.gov.uk/government/publications/childhood-obesity-a-plan-for-action-chapter-2>. Accessed January 20, 2020.
- Hartmann-Boyce J, Bianchi F, Piermas C, et al. Grocery store interventions to change food purchasing behaviors: a systematic review of randomized controlled trials. *Am J Clin Nutr*. 2018;107:1004–1016.
- Gittelsohn J, Trude ACB, Kim H. Pricing strategies to encourage availability, purchase, and consumption of healthy foods and beverages: a systematic review. *Prev Chronic Dis*. 2017;14:E107.
- Adam A, Jensen JD. What is the effectiveness of obesity related interventions at retail grocery stores and supermarkets? A systematic review. *BMC Public Health*. 2016;16:1247.
- Cameron AJ, Charlton E, Ngan WW, et al. A systematic review of the effectiveness of supermarket-based interventions involving product, promotion, or place on the healthiness of consumer purchases. *Curr Nutr Rep*. 2016;5:129–138.
- Liberato SC, Bailie R, Brimblecombe J. Nutrition interventions at point-of-sale to encourage healthier food purchasing: a systematic review. *BMC Public Health*. 2014;14:919.
- Escaron AL, Meinen AM, Nitzke SA, et al. Supermarket and grocery store-based interventions to promote healthful food choices and eating practices: a systematic review. *Prev Chronic Dis*. 2013;10:E50.
- Gustafson A, Hankins S, Jilcott S. Measures of the consumer food store environment: a systematic review of the evidence 2000–2011. *J Community Health*. 2012;37:897–911.
- Caspi CE, Sorensen G, Subramanian SV, et al. The local food environment and diet: a systematic review. *Health Place*. 2012;18:1172–1187.
- Hollands GJ, Bignardi G, Johnston M, et al. The TIPPME intervention typology for changing environments to change behaviour. *Nat Hum Behav*. 2017;1:0140.
- McGill R, Anwar E, Orton L, et al. Are interventions to promote healthy eating equally effective for all? Systematic review of socioeconomic inequalities in impact. *BMC Public Health*. 2015;15:457.
- Moher D, Liberati A, Tetzlaff J, et al; the PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. 2009;6:E1000097.
- Glanz K, Sallis JF, Saelens BE, et al. Healthy nutrition environments: concepts and measures. *Am J Health Promot*. 2005;19:330–333. ii.
- Centre for Reviews and Dissemination. *Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care*. 3rd ed. York: University of York; 2008.
- Department of Health and Social Care. The Eatwell Guide. Public Health England. Available at: <https://www.gov.uk/government/publications/the-eatwell-guide>. 2016. Accessed November 18, 2018.
- Holmes AS, Estabrooks PA, Davis GC, et al. Effect of a grocery store intervention on sales of nutritious foods to youth and their families. *J Acad Nutr Diet*. 2012;112:897–901.
- McKenzie J, Brennan S. Chapter 12: Synthesizing and presenting findings using other methods. In: Higgins J, Thomas J, Chandler J, et al., eds. *Cochrane Handbook for Systematic Reviews of Interventions Version 6.0*. Cochrane: Chichester, England; 2019.
- Thomson HJ, Thomas S. The effect direction plot: visual display of non-standardised effects across multiple outcome domains. *Res Syn Meth*. 2013;4:95–101.
- Ejlerskov KT, Sharp SJ, Stead M, et al. Supermarket policies on less-healthy food at checkouts: natural experimental evaluation using interrupted time series analyses of purchases. *PLoS Med*. 2018;15:e1002712.
- Ayala GX, Baquero B, Laraia BA, et al. Efficacy of a store-based environmental change intervention compared with a delayed treatment control condition on store customers' intake of fruits and vegetables. *Public Health Nutr*. 2013;16:1953–1960.
- Foster GD, Karpyn A, Wojtanowski AC, et al. Placement and promotion strategies to increase sales of healthier products in supermarkets in low-income, ethnically diverse neighborhoods: a randomized controlled trial. *Am J Clin Nutr*. 2014;99:1359–1368.
- Thornthwaite AN, Bright OM, Dimond MA, et al. Choice architecture to promote fruit and vegetable purchases by families participating in the Special Supplemental Program for Women, Infants, and Children (WIC): randomized corner store pilot study. *Public Health Nutr*. 2017;20:1297–1305.
- Wensel CR, Trude ACB, Poirier L, et al. B'more healthy corner stores for moms and kids: identifying optimal behavioral economic strategies to increase WIC redemptions in small urban corner stores. *Int J Environ Res Public Health*. 2018;16:E64.
- Adam A, Jensen JD, Sommer I, et al. Does shelf space management intervention have an effect on calorie turnover at supermarkets? *J Retail Consumer Serv*. 2017;34:311–318.
- Gittelsohn J, Song HJ, Suratkar S, et al. An urban food store intervention positively affects food-related psychosocial variables and food behaviors. *Health Educ Behav*. 2010;37:390–402.
- Song H-J, Gittelsohn J, Kim M, et al. A corner store intervention in a low-income urban community is associated with increased availability and sales of some healthy foods. *Public Health Nutr*. 2009;12:2060–2067.
- Toft U, Winkler LL, Mikkelsen BE, et al. Discounts on fruit and vegetables combined with a space management intervention increased sales in supermarkets. *Eur J Clin Nutr*. 2017;71:476–480.
- Adjoian T, Dannefer R, Willingham C, et al. Healthy checkout lines: a study in urban supermarkets. *J Nutr Educ Behav*. 2017;49:615–622.e1.
- Albert SL, Langellier BA, Sharif MZ, et al. A corner store intervention to improve access to fruits and vegetables in two Latino communities. *Public Health Nutr*. 2017;20:2249–2259.
- Dannefer R, Williams DA, Baronberg S, et al. Healthy bodegas: increasing and promoting healthy foods at corner stores in New York City. *Am J Public Health*. 2012;102:e27–e31.
- Ejlerskov K, Sharp SJ, Stead M, et al. Socio-economic and age variations in response to supermarket-led checkout food policies: a repeated measures analysis. *Int J Behav Nutr Phys Act*. 2018;15:125.
- Jilcott Pitts SB, Wu Q, Truesdale KP, et al. One-year follow-up examination of the impact of the North Carolina Healthy Food small retailer program on healthy food availability, purchases, and consumption. *Int J Environ Res Public Health*. 2018;15:2681.
- Lawman HG, Vander Veur S, Mallya G, et al. Changes in quantity, spending, and nutritional characteristics of adult, adolescent and child urban corner store purchases after an environmental intervention. *Prev Med*. 2015;74:81–85.
- Winkler LL, Christensen U, Glumer C, et al. Substituting sugar confectionery with fruit and healthy snacks at checkout – a win-win strategy for consumers and food stores? A study on consumer attitudes and sales effects of a healthy supermarket intervention. *BMC Public Health*. 2016;16:1184.
- de Wijk RA, Maaskant AJ, Polet IA, et al. An in-store experiment on the effect of accessibility on sales of wholegrain and white bread in supermarkets. *PLoS One*. 2016;11: e0151915.
- Sigurdsson V, Larsen NM, Gunnarsson D. An in-store experimental analysis of consumers' selection of fruits and vegetables. *Serv Ind J*. 2011;31:2587–2602.
- Sigurdsson V, Larsen NM, Gunnarsson D. Healthy food products at the point of purchase: an in-store experimental analysis. *J Appl Behav Anal*. 2014;47:151–154.
- Sigurdsson V, Saevarsson H, Foxall G. Brand placement and consumer choice: an in-store experiment. *J Appl Behav Anal*. 2009;42:741–745.

50. Caldwell EM, Miller Kobayashi M, DuBow WM, et al. Perceived access to fruits and vegetables associated with increased consumption. *Public Health Nutr.* 2009;12:1743–1750.
51. Cohen DA, Collins R, Hunter G, et al. Store impulse marketing strategies and body mass index. *Am J Public Health.* 2015;105:1446–1452.
52. Gustafson A, Christian JW, Lewis S, et al. Food venue choice, consumer food environment, but not food venue availability within daily travel patterns are associated with dietary intake among adults, Lexington Kentucky 2011. *Nutr J.* 2013;12:17.
53. Gustafson AA, Sharkey J, Samuel-Hodge CD, et al. Perceived and objective measures of the food store environment and the association with weight and diet among low-income women in North Carolina. *Public Health Nutr.* 2011;14:1032–1038.
54. Jani R, Rush E, Crook N, et al. Availability and price of healthier food choices and association with obesity prevalence in New Zealand Māori. *Asia Pac J Clin Nutr.* 2018;27:1357–1365.
55. Kerr J, Sallis JF, Bromley E, et al. Assessing reliability and validity of the GroPromo audit tool for evaluation of grocery store marketing and promotional environments. *J Nutr Educ Behav.* 2012;44:597–603.
56. Nakamura R, Pechey R, Suhrcke M, et al. Sales impact of displaying alcoholic and non-alcoholic beverages in end-of-aisle locations: an observational study. *Soc Sci Med.* 2014;108:68–73.
57. Thornton LE, Cameron AJ, Crawford DA, et al. Is greater variety of chocolates and confectionery in supermarkets associated with more consumption? *Aust N Z J Public Health.* 2011;35:292–293.
58. Thornton LE, Crawford DA, Ball K. Neighbourhood-socioeconomic variation in women's diet: the role of nutrition environments. *Eur J Clin Nutr.* 2010;64:1423–1432.
59. Bodor JN, Rose D, Farley TA, et al. Neighbourhood fruit and vegetable availability and consumption: the role of small food stores in an urban environment. *Public Health Nutr.* 2008;11:413–420.
60. Caspi CE, Lenk K, Pelletier JE, et al. Association between store food environment and customer purchases in small grocery stores, gas-marts, pharmacies and dollar stores. *Int J Behav Nutr Phys Act.* 2017;14:76.
61. Jilcott Pitts SB, Wu Q, Truesdale KP, et al. Baseline assessment of a healthy corner store initiative: associations between food store environments, shopping patterns, customer purchases, and dietary intake in eastern North Carolina. *Int J Environ Res Public Health.* 2017;14:1189.
62. Martin KS, Havens E, Boyle KE, et al. If you stock it, will they buy it? Healthy food availability and customer purchasing behaviour within corner stores in Hartford, CT, USA. *Public Health Nutr.* 2012;15:1973–1978.
63. Ruff RR, Akhund A, Adjoian T. Small convenience stores and the local food environment: an analysis of resident shopping behavior using multilevel modeling. *Am J Health Promot.* 2016;30:172–180.
64. Sanchez-Flack J, Pickrel JL, Belch G, et al. Examination of the relationship between in-store environmental factors and fruit and vegetable purchasing among Hispanics. *Int J Environ Res Public Health.* 2017;14:E1305.
65. Franco M, Diez-Roux AV, Nettleton JA, et al. Availability of healthy foods and dietary patterns: the Multi-Ethnic Study of Atherosclerosis. *Am J Clin Nutr.* 2009;89:897–904.
66. Rose D, Hutchinson PL, Bodor JN, et al. Neighborhood food environments and body mass index: the importance of in-store contents. *Am J Prev Med.* 2009;37:214–219.
67. Ogilvie D, Adams J, Bauman A, et al. Using natural experimental studies to guide public health action: turning the evidence-based medicine paradigm on its head. *J Epidemiol Community Health.* 2020;74:203–208.
68. Bucher T, Collins C, Rollo ME, et al. Nudging consumers towards healthier choices: a systematic review of positional influences on food choice. *Br J Nutr.* 2016;115:2252–2263.
69. Department of Health and Social Care. Consultation on restricting promotions of products high in fat, sugar and salt by location and by price. 2019. Available at: <https://www.gov.uk/government/consultations/restricting-promotions-of-food-and-drink-that-is-high-in-fat-sugar-and-salt>. Accessed January 20, 2020.
70. House of Commons Health Committee. *Childhood Obesity: Time for Action*. Eighth Report of Session 2017–19. London; 2018.
71. Hemming K, Eldridge S, Forbes G, et al. How to design efficient cluster randomised trials. *BMJ.* 2017;358:J3064.
72. Mayne SL, Auchincloss AH, Michael YL. Impact of policy and built environment changes on obesity-related outcomes: a systematic review of naturally occurring experiments. *Obes Rev.* 2015;16:362–375.
73. Hemming K, Haines TP, Chilton PJ, et al. The stepped wedge cluster randomised trial: rationale, design, analysis, and reporting. *BMJ.* 2015;350:h391.
74. Kreif N, Grieve R, Hangartner D, et al. Examination of the synthetic control method for evaluating health policies with multiple treated units. *Health Econ.* 2016;25:1514–1528.
75. Nicholas J, Gulliford MC. Commentary: what is a propensity score? *Br J Gen Pract.* 2008;58:687.
76. Blake MR, Backholer K, Lancsar E, et al. Investigating business outcomes of healthy food retail strategies: a systematic scoping review. *Obes Rev.* 2019;20:1384–1399.
77. Vogel C, Zwolinsky S, Griffiths C, et al. A Delphi study to build consensus on the definition and use of big data in obesity research. *Int J Obes.* 2019;43:2573–2586.
78. Vogel C, Ntani G, Inskip H, et al. Education and the relationship between supermarket environment and diet. *Am J Prev Med.* 2016;51:e27–e34.