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Synopsis

Evaluation of a supermarket placement strategy to nudge healthier dietary habits: synopsis of the WRAPPED study

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Abstract

Background: Poor diet is a leading risk factor of non-communicable diseases. Product placement strategies in retail outlets can influence customers' food preferences. The United Kingdom government introduced legislation in October 2022 restricting chain retailers from using location promotions on unhealthy food and drinks. High-quality scientific evidence is needed to inform the inclusion of healthier product placement approaches into these regulations. In the context of Brexit, COVID-19 and the cost-of-living crisis, this study assessed whether positioning an expanded fresh fruit and vegetable section near store entrances in discount supermarkets, which do not routinely market produce this way, improved store sales, household purchasing and diet.

Methods and limitations: This natural experiment had a prospective matched controlled cluster design, involving 36 stores (18 intervention and 18 control) across England. The intervention was implemented continuously for 6 months. Control stores were matched on store sales, customer profiles and neighbourhood deprivation. Participants were women, aged 18–60 years, with loyalty cards and were assigned to their primary store (n = 280 intervention and n = 300 control). Weekly store sales and household data from loyalty cards were provided by the collaborating supermarket chain. Dietary quality, household food waste and demographic characteristics were collected through questionnaires. A process evaluation and economic evaluation were completed.

Results: Store-level sales of fruit and vegetables were greater in intervention stores than predicted at intervention implementation and 3 and 6 months' follow-up, equivalent to ≈ 2525, ≈ 1940 and ≈ 1450 extra portions per store per week, respectively. Effect sizes were somewhat stronger in stores where the produce section moved forwards more than 14 m. The proportion of households purchasing fruit and vegetables were somewhat protected among intervention compared to control participants after 3 and 6 months. Changes in dietary quality were small but generally in the expected direction for health benefit. Changes in frequency of household fruit and vegetable waste were negligible at 3 months' follow-up but increased at 6 months.

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The intervention was implemented according to the study protocol, with marked differences in the positioning of fresh fruit and vegetables between intervention and control stores post-intervention implementation. Fresh fruit and vegetable availability increased post intervention in intervention compared with control stores. Interviews with store staff demonstrated that changes in staff attitudes had a positive reinforcing effect on intervention implementation. Assessment of the policy context showed that stakeholders across the food system largely support the United Kingdom government's unhealthy placement ban; some felt it does not go far enough.

Future work: This study shows that positioning produce sections near supermarket entrances can improve the nutrition profile of store sales and may improve household purchasing and diet. The United Kingdom Food (Promotion and Placement) Regulations could be refined to require a produce section near supermarket entrances to increase its health impact. Future research should continue to build the evidence for which healthy eating interventions are effective in retail outlets. Further evaluations of real-world supermarket intervention studies using robust scientific study designs are required, alongside process and economic evaluations, to provide evidence for policy intervention to improve retail food environments in the United Kingdom and internationally.

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Study overview

Rationale for research and background

Unhealthy diet is a key modifiable risk factor for non-communicable diseases,[3] and the cost of diet-related ill health to the NHS is £5.8B annually.[4] The greatest burden of poor diet and diet-related ill health falls upon those experiencing greatest socioeconomic disadvantage, with the gap between socioeconomically vulnerable and affluent families widening over the past decade.[5,6]

There is clear evidence from systematic reviews that interventions providing information about healthy dietary behaviours alone are mostly ineffective among disadvantaged groups and that educational campaigns such as '5 A Day' can even increase inequalities.[7,8] The evidence suggests that interventions addressing broader environmental determinants of diet hold most promise for equitably enhancing population diet.[9] There is increasing recognition that unhealthy food environments play a key role in driving dietary inequalities.[10]

Supermarkets are a major source of food for many families, and the subtle use of marketing techniques influences the food choices of an almost captive market.[11] Healthy food is more than twice as expensive per calorie than unhealthy foods high in fat, sugar and salt (HFSS),[12] price promotions are mostly offered on HFSS products[13] and < 1% of placement promotions are for fruit and vegetables.[12,14] Discount and small supermarkets have been shown to have less-healthy in-store environments than other supermarkets, including less-prominent placement of fresh fruit and vegetables.[15] This situation is concerning because these types of stores are used more regularly by families experiencing disadvantage and younger adults who have poorer dietary behaviours.[16,17]

Systematic reviews of supermarket interventions targeting the in-store environment, such as product placement strategies that alter the availability and positioning of healthy or unhealthy foods, show promising effects.[18–20] The evidence base is sufficient for governments to take action to improve the healthfulness of supermarkets' in-store environments.[21] Our own pilot study, involving three intervention and three control stores, showed that removing food items from checkouts and aisle ends opposite, in addition to placing an expanded fruit and vegetable section near store entrances, improve the healthfulness of store sales, household purchasing and dietary quality.[22]

The majority of supermarket studies assessing the effects of healthier product placement strategies, however, have poor methodological quality. Our own systematic review of the literature in this field identified that many studies have not included a control group nor reported sample size calculations, and none included an adequate number of stores for a cluster design study.[21] Additionally, very few studies assessed the effect of product placement changes on outcomes at the household or individual level (i.e. customers' purchasing and dietary patterns), with most

assessing change at the store level. Not a single study reported on cost-effectiveness.[19,21] Further high-quality, adequately powered studies are needed to quantify the effect of placement interventions in supermarkets and inform future food policy action. Studies that measure cost-effectiveness and examine differential effects by socioeconomic status are particularly important for policy-makers.

In October 2022, the UK government implemented the first component of the Food (Promotion and Placement) Regulations in England.[23] This regulation prohibits the positioning of HFSS products at store entrances, aisle ends and checkouts in chain retail outlets. Our pre-implementation assessment of this regulation indicated widespread support for these new rules; however, a number of stakeholders felt the restrictions could go further in supporting everyone to make healthier food choices.[24,25]

This study addresses several evidence gaps regarding the use of placement strategies to improve population diet. It draws upon the collaboration with a UK discount supermarket chain established for our pilot study to assess the effectiveness and cost-effectiveness of creating a healthier store layout in supermarkets frequently used by disadvantaged families. This study is unique in its analysis of individual loyalty card data, in addition to store sales data, as well as collecting dietary data from more than one family member.[26,27] The study also assessed household fruit and vegetable waste patterns; estimated the costs of the intervention at the individual, retailer and societal levels; and undertook a detailed process evaluation alongside the outcome evaluation to provide a comprehensive picture of the evidence.

Study objectives

Primary objective

To assess whether increasing availability of fresh fruit and vegetables and positioning them at the front of the store in discount supermarkets improves fresh fruit and vegetable purchasing patterns after 6 months among women customers aged 18–60 years compared to control customers.

Secondary objectives

1. To assess effect modification by educational attainment on women's change in fruit and vegetable purchasing.
2. To assess how the intervention affects women's dietary quality and daily fruit and vegetable intake, and the dietary quality of their young children.
3. To assess how the intervention influences weekly store sales of fruit and vegetables.
4. To conduct an economic evaluation from individual, retailer and societal perspectives.
5. To conduct a detailed process evaluation to examine: (1) intervention implementation in each store and the exposure and reach to participants, (2) mechanisms of intervention impact by exploring the experiences of participants and staff and, (3) how contextual factors, such as social influences, spatial access to supermarkets and government policy, influence intervention effects.

Methods

Study design

The Women's Responses to Adjusted Product Placement and its Effects on Diet (WRAPPED) study is a natural experiment with prospective matched controlled cluster design. It had a 6 months' intervention period, alongside a 3-month baseline period and 0–3 and 3–6 months' follow-up assessments. Full details of the study protocol were published in 2020.[11]

Study setting

The WRAPPED study focused on households experiencing socioeconomic disadvantage and therefore sampled from customers who shopped at stores of the collaborating discount supermarket chain. This supermarket has over 1000 stores nationwide and holds approximately 2% of the grocery market share in the UK.[28]

Intervention and control conditions

The WRAPPED intervention incorporated both placement intervention types from the typology of interventions in proximal physical microenvironments: availability and position.[29] The intervention created a healthier store layout by expanding the produce section to increase the availability of fresh fruit and vegetables, and positioning the section near the store entrance. The supermarket chain implemented the intervention. The logic model (*Figure 1*) specifies the intervention components and routes of impact for the short, medium and long terms. The model specifies that exposure to the product placement changes increases store sales and household purchasing of fresh fruit and vegetables (short-term outcome) that in turn will improve dietary quality (medium-term outcomes) and subsequently reduce inequalities in diet and obesity (long-term outcomes). This study assessed short- and medium-term outcomes.

The control condition was the previous layout of stores, with a limited range of fresh fruit and vegetables, placed

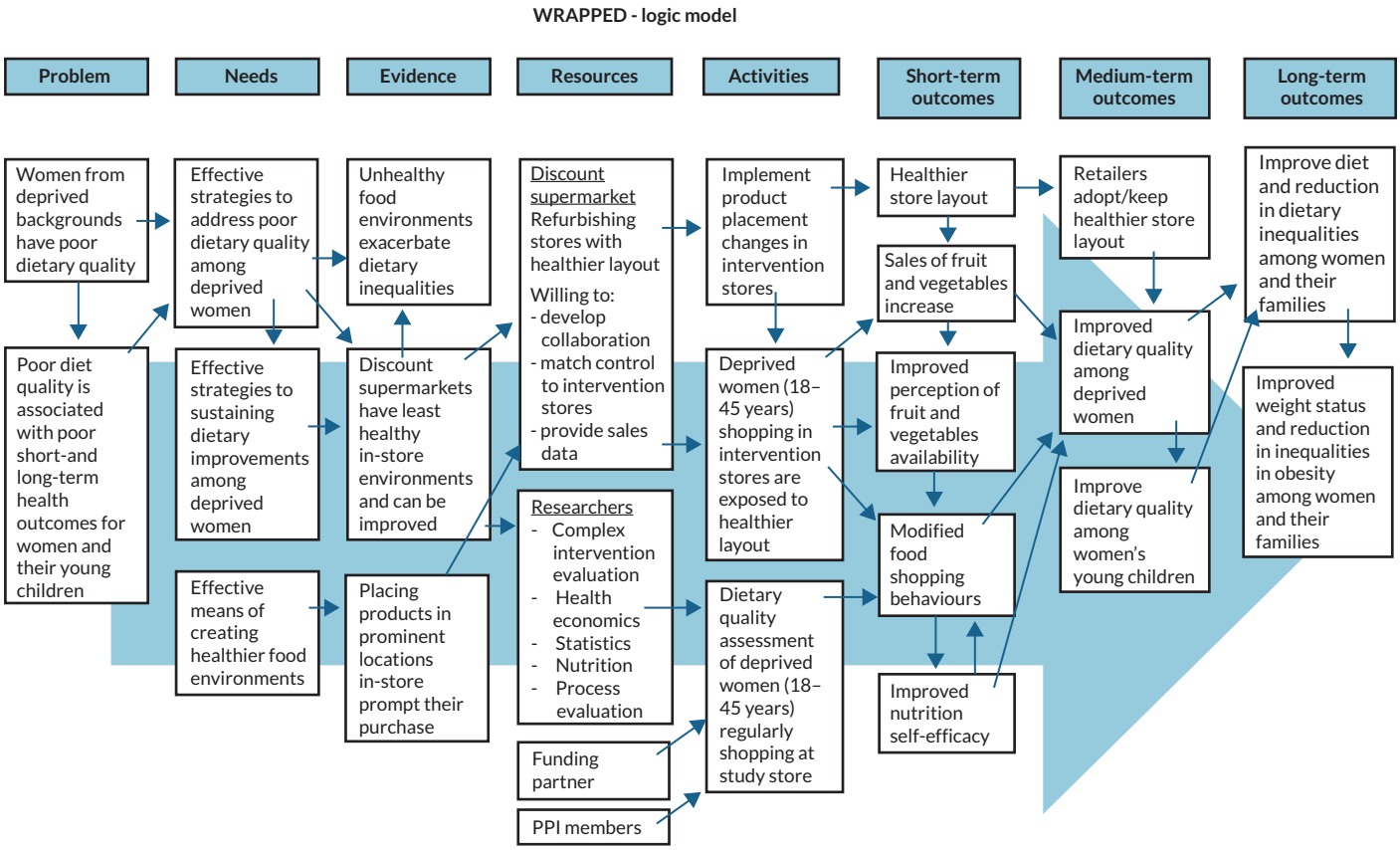

FIGURE 1 Logic model describing the WRAPPED study. PPI, patient and public involvement.

near the back of the store. Both control and intervention stores were sampled from locations across England to improve generalisability (*Figure 2*).

Eligibility criteria

The store sample was 36 stores, 18 intervention and 18 control stores, with allocation to the intervention condition at the store level. Intervention stores were selected, in a phased approach, from the collaborating supermarket's ongoing refurbishment programme. Randomisation was not possible, because it is recognised that in real world, supermarket research randomised controlled trial designs are problematic in this highly competitive, commercial setting.[30] Consequently, control stores were matched to an intervention store based on: (1) sales profile, (2) customer profile and (3) neighbourhood deprivation [Index of Multiple Deprivation (IMD)].[31] Matching on these factors increased the similarity of intervention and control stores, reducing effects of confounding.

Participants were women, aged 18–60 years, who held a loyalty card with the study supermarket chain and shopped in a study store in the 12 weeks before recruitment (according to loyalty card data). Shoppers who chose items in-store but opted for home delivery were eligible, but online only shoppers were not eligible to participate. Women aged 18–60 years were the target population, because improving the diets of women in this age group will improve their own health and the short- and long-term health of their children.[32,33] Women within this age group are also primarily responsible for domestic food-related tasks that influence their partners' and families' diets.[34,35]

Participant recruitment

Women from matched intervention and control stores were recruited concurrently prior to the intervention implementation stores' refurbishment from May 2018 to October 2021. Eligible women, identified from the loyalty card register, were sent an invitation and information letter by the collaborating supermarket. Participants were not informed of the intervention. Interested women contacted the study team via Freephone number, text or e-mail and were screened for eligibility and consented. In-store recruitment was also used, whereby members of the research team approached women customers while shopping and provided them with a study information sheet. Interested women registered with the researcher in-store and were subsequently phoned and consented. This method proved effective at enhancing the diversity of customers in a previous supermarket pricing trial[36] and

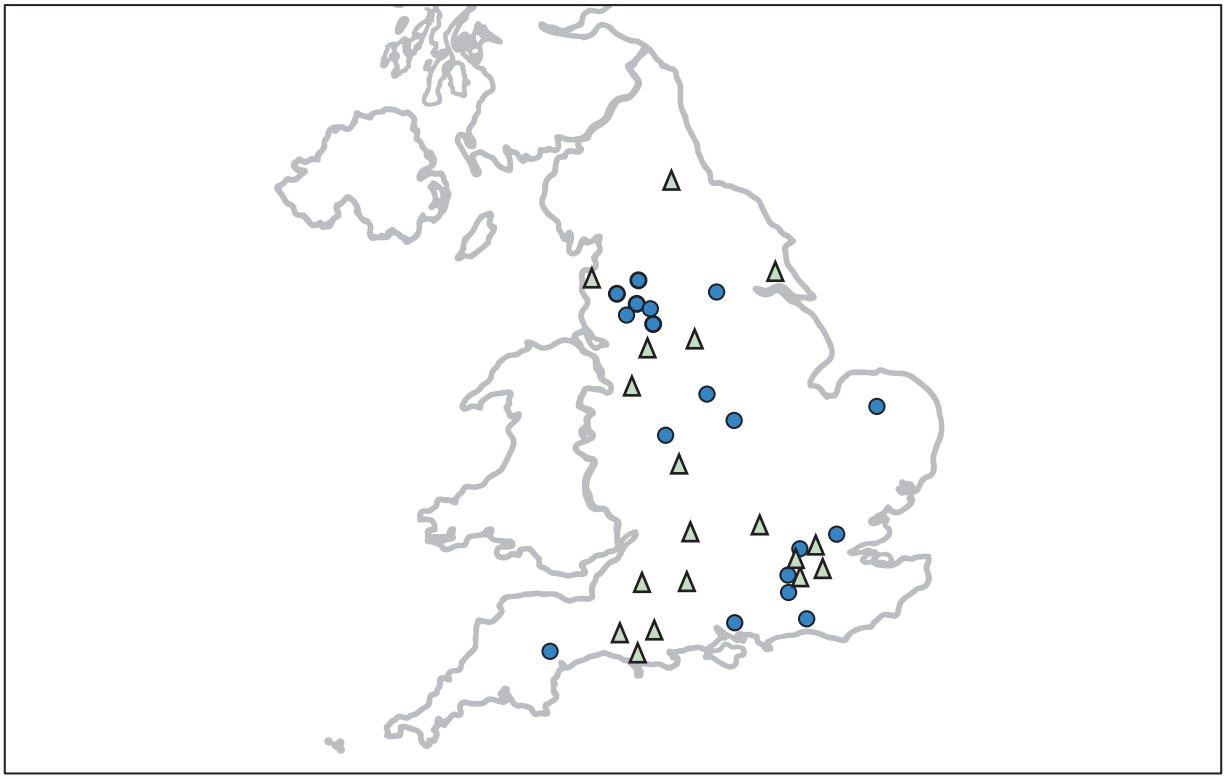

FIGURE 2 Location of study stores participating in the WRAPPED study. Circle, intervention store; triangle, control store. This figure has been reproduced from Baird *et al.*[2] This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) licence which permits others to distribute, remix, adapt and build upon this work for commercial use, provided the original work is properly cited. See: https://creativecommons.org/licenses/by/4.0/. The figure above includes minor additions and formatting changes to the original text.

was used in all 36 stores. All participants were offered up to 3 × £10 Love2Shop (Liverpool, UK) or Amazon (Amazon.com, Inc., Bellevue, WA, USA) vouchers for taking part.

Due to recruitment challenges over the COVID-19 pandemic, an additional wave of recruitment was undertaken between September 2022 and February 2023 to boost participant numbers providing purchasing data. A letter was sent by the collaborating supermarket offering participants 1 × £15 vouchers for completing one telephone interview and providing their retrospective loyalty card data.

All participants provided demographic information about their age, ethnicity, marital status, highest educational qualification, employment status, number of children in the home, amount of money spent on groceries each week and whether the study supermarket chain was where they bought most of their household's food. Participants also provided their home postcode to enable IMD to be identified.

Outcome measures

Store weekly sales and household purchasing data were provided by the collaborating supermarket and covered three time periods: (1) baseline, 3 months before refurbishment, (2) 0–3 months post intervention and (3) 3–6 months post intervention. Store sales and participant purchasing of fresh fruit and vegetables were aggregated to numbers of items sold in each week of the study period. Store sales and participant purchasing data sets consisted of 11–14 weeks prior to the intervention and 24–28 weeks afterwards.

Secondary outcome data about women's diets,[37] their young child's diet (2–6 years),[38] frequency of household fruit waste and vegetable waste, food shopping habits, perceptions of supermarket environment and demographic characteristics were collected by telephone survey before refurbishment (baseline) and 1, 3 and 6 months after. Details describing these variables can be found in the published study protocol.[11]

Economic evaluation was conducted from individual, retailer and societal perspectives. Individual perspective evaluation used participant survey data for food expenditure, time spent food shopping, as well as travel costs to and from supermarkets. Retailer perspective evaluation assessed factors likely to influence supermarket decisions about investments in food product and placement

strategies. Societal perspective costs were estimated for resources associated with the capital investment and ongoing costs of the store refurbishment, changes in food expenditure, time and travel costs for individuals and health and social care costs for related health conditions.

Process evaluation

Process evaluation assessed intervention implementation, mechanisms of impact and context, following Medical Research Council (MRC) guidance.[39] Intervention implementation was assessed in intervention and control stores through: (1) in-store surveys to measure product positioning in prominent in-store locations, (2) analysis of store planograms (visual representation of stores and product placement) to determine fresh fruit and vegetable section positioning and distance moved post intervention and (3) change in fresh fruit and vegetable availability according to study store stock-keeping units (SKUs). Intervention dose was determined through changes in positioning and availability pre and post intervention, and participants' reporting of whether the study store was used for most grocery shopping.

Mechanisms of impact were assessed by conducting qualitative semistructured interviews with senior staff of (n = 30) study stores.

The local food retail environment surrounding each study store was assessed to confirm that study results were not caused by local retail environments. Ordnance Survey Points of Interest data identified supermarkets, convenience stores and takeaways at each of the study time points within 1 km activity spaces defined as road network buffers around the respondent's home and their main food store, and a 50 m buffer around the shortest travel road linking these two points. Participants' scores for each study store were combined to provide a store-level outlet density indicator for each of the three alternative opportunities at each study time point. The broader policy context was determined via semistructured interviews with a purposive sample (n = 108) of consumers, businesses, local authority officers and health group representatives.

Data analysis

Analyses were performed using intention-to-treat multilevel models, including three-level models with women's weekly purchasing data clustered within women, who are clustered within stores. Store sales data were analysed using an interrupted time series analyses.[40] Random effects meta-analysis[41] was used to synthesise the differences between pairs of stores at the time of intervention, 3 and 6 months' post-intervention time points. This method enabled: (1) retention of the store pairing in the study design, (2) comparisons between pairs and (3) overall statements of effect size and precision.[42] The collaborating supermarket chain sells only packaged fruit/vegetables (not singly), with each item averaging five portions (≈ 400 g). This information informed conversions from items to portions.

Participant purchasing data were dichotomised to indicate whether each week resulted in any purchases of the food category under consideration. A difference-in-differences approach was used so that each logistic regression model included fixed effects for intervention group, time period and the interaction between intervention group and time period. Planned subgroup analyses focused on differing effects for level of educational attainment (marker of disadvantage) and intervention dose.

The effects of the intervention on changes in dietary quality from baseline to 3 and 6 months post intervention were explored using linear regression models with diet as the outcome and intervention group and diet at baseline as predictors. Linear regression models were fitted in each pair of stores separately, and random effects meta-analysis[41] synthesised the differences between pairs. Other quantitative data were analysed using descriptive statistics and linear regression analyses for continuously distributed outcomes.[43] Adjusted regression models included confounding variables determined using directed acyclic graphs (DAGs).[44] All analyses were performed in Stata 14 (StataCorp LP, College Station, TX, USA).

Individual and retailer economic evaluation results are presented as simple cost–consequence analysis tables, with estimates of monetary costs or savings shown in a 'balance sheet' alongside summary statistics.[11] For the societal perspective, cost–utility analysis was conducted, to assess the efficiency of the investment in store refurbishment in relation to future costs and savings to public and private bodies and health effects for the women, as well as the impact on health inequalities. Health effects [quality-adjusted life-years (QALYs)] and related treatment and care costs were estimated using a Markov model.

Qualitative data were analysed using inductive reflexive thematic analysis and rapid qualitative analysis following Braun and Clarke's guidelines and Vindrola-Padros's approach, respectively to ensure that themes and subthemes were derived from the raw data.[45,46] Themes and subthemes were compiled together with verbatim quotes, following an iterative processing of coding frame development. The analysis was conducted in a manner that considered differences between intervention and control stores.

Additional research activities

Two literature reviews were also completed; one was a systematic review of the evidence of the effectiveness of placement interventions to improve healthy eating in retail outlets,[21] and the second was a synthesis of evidence from systematic reviews of interventions conducted in supermarkets to improve healthy eating published as a book chapter.[20]

A case study synthesis of the opportunities, challenges and lessons of partnering with national supermarket chains to conduct public health research and build high-quality evidence for future food policy was conducted with colleagues in the Netherlands and Australia.[30]

Results

Sample characteristics

A total of 580 women aged 18–60 years who regularly shopped at one of the 36 study stores were recruited; 300 participants were from control stores and 280 from intervention stores (*Figure 3*). A total of 475 women provided purchasing data [248 from control stores and 227 from intervention stores which provides 85% power at 5% significance level (two-sided)], and 360 women provided information about their dietary and household fruit and vegetable waste patterns (190 from control stores and 170 from intervention stores). Out of these 360 women, 250 reported living with children (aged < 18 years) and 127

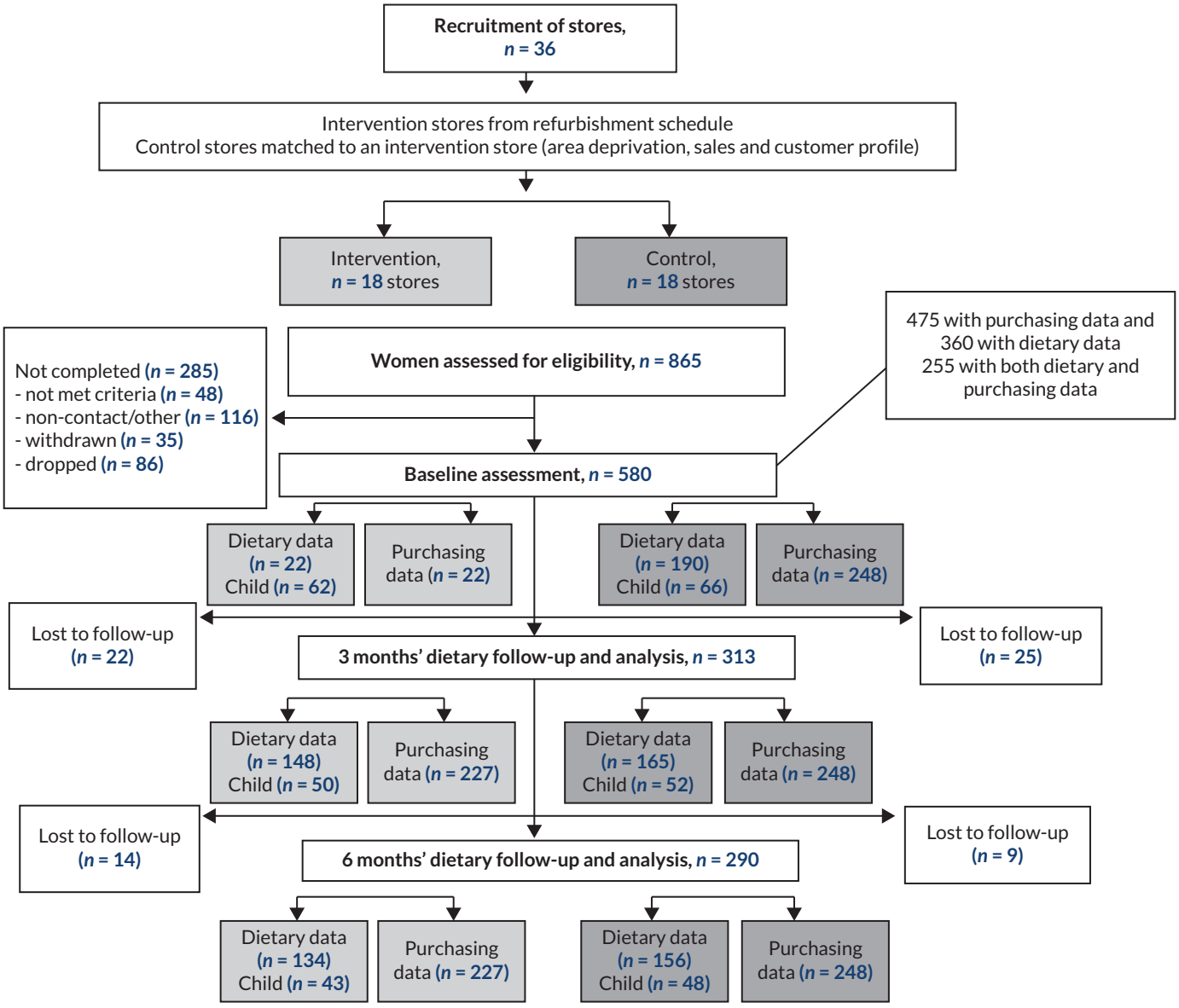

FIGURE 3 Flow diagram of the WRAPPED study participants.

provided data about their child aged 2–6 years. Attrition rates for diet and waste data were 13% at 3 months' and 19% at 6 months' follow-ups.

There were slight differences in participant characteristics at baseline between intervention and control participants, with intervention women less likely to identify as being of White ethnicity and more likely to live in more deprived neighbourhoods (*Table 1*). More than half of the sample were aged 31–45 years, 72% identified as being White British, 40% had low educational attainment (no qualifications beyond age 16 years) and 63% were in paid employment. Almost a third reported that the collaborating supermarket chain was where they purchased most of their groceries (31%).

Primary outcome results

There were 5077 store visits made by the 475 participants with purchasing data, 2704 from control store participants and 2373 from intervention store participants. Modelled proportions of fruit and vegetable purchasing show an overall decline over time (*Figure 4*). The proportion of control participants purchasing fruit and vegetables decreased from baseline to 3 months {−1.4% [95% confidence interval (CI) −5.4% to 2.5%]} and from baseline to 6 months [−4.9% (95% CI −8.7% to −1.0%)]; among intervention participants, the reduction was less marked than among control participants at 3 months [−0.8% (95% CI −5.1% to 3.6%)] and at 6 months [−1.4% (95% CI −5.7% to −2.3%)] (*Table 2*).

When stratifying by intervention dose using distance produce section moved, the reduction in proportion purchasing fruit and vegetables among intervention participants compared to control participants was less marked (though not statistically significant) (*Table 2*). Among participants whose main supermarket was the study store, those shopping at intervention stores showed somewhat less-marked reductions in fruit and vegetable purchasing at 3 and 6 months' follow-ups compared to those who shopped at control stores.

Results for stratification by educational qualification showed that the proportion purchasing fruit and vegetables among intervention participants increased somewhat from baseline among those with fewer educational qualifications compared to those with more educational qualifications, with the greatest difference at 6 months (*Table 2*). The same contrast was not observed among control participants.

Secondary outcome results

Results from the meta-analysis of store sales are shown in *Figure 5*, illustrating results at baseline and 3 and

TABLE 1 Baseline characteristics of all participants (n = 580)

Characteristic	Total (n = 580)	Control (n = 300)	Intervention (n = 280)	p-value
Age group, % (n)				0.45
18–30 years	16% (90)	17% (51)	14% (39)	
31–45 years	51% (298)	50% (151)	53% (147)	
46–60 years	33% (192)	33% (98)	34% (94)	
White ethnicity, % (n)	72% (417)	80% (239)	64% (178)	< 0.001
Married/civil partnership/cohabiting, % (n)	61% (354)	66% (197)	56% (157)	0.05
Low education (no qualifications beyond age 16), % (n)	40% (224)	40% (117)	39% (107)	0.36
Most deprived half of neighbourhood deprivation (IMD), % (n)	69% (400)	61% (183)	78% (217)	< 0.001
Paid employment, % (n)	63% (361)	66% (193)	60% (168)	0.16
Main supermarket used is study supermarket, % (n)	31% (177)	29% (85)	33% (92)	0.25
Pounds (£) spent on food per week, median (IQR)	70 (50–100)	70 (50–100)	70 (50–100)	0.74
Number of children in the house, median (IQR)	1 (0–2)	1 (0–2)	1 (0–2)	0.30

IQR, interquartile range.

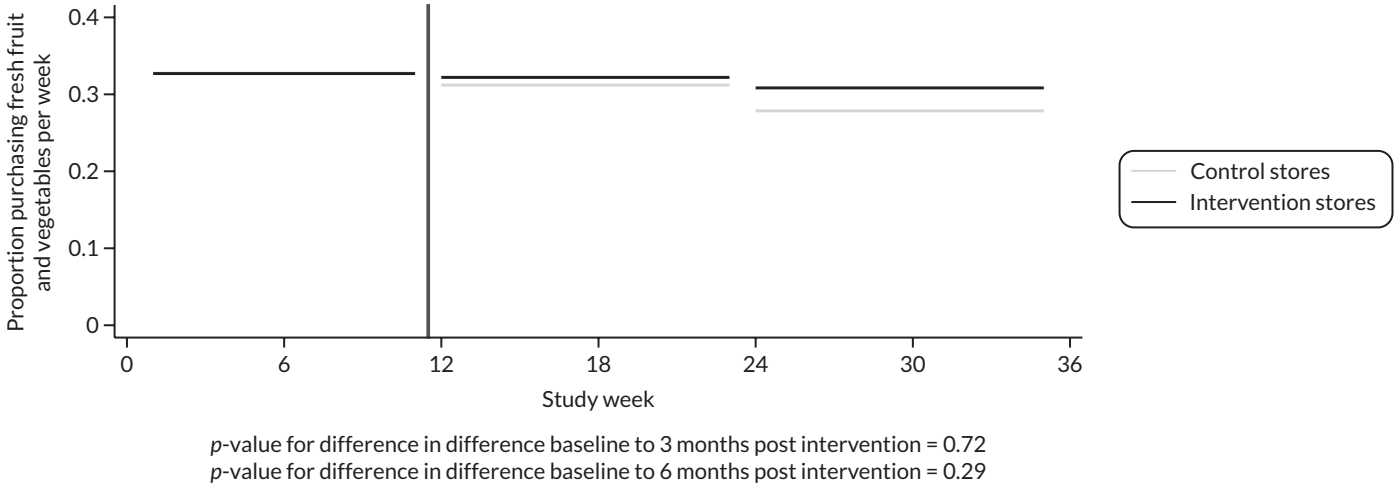

FIGURE 4 Modelled proportion of women purchasing food items in intervention and control stores. This figure has been reproduced from Vogel *et al.*[1] This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) licence which permits others to distribute, remix, adapt and build upon this work, for commercial use, provided the original work is properly cited. See: https://creativecommons.org/licenses/by/4.0/. The figure above includes minor additions and formatting changes to the original text.

TABLE 2 Effect of intervention on change in proportion of fresh fruit and vegetable purchasing from baseline to 3 and 6 months' follow-up

	Control		Intervention		Number of stores	Number of women	Number of visits	*p*-value for control vs. intervention	*p*-value for interaction
	Change	(95% CI)	Change	(95% CI)					
All participants[a]									
Baseline to 3 months	−1.4%	(−5.4% to 2.5%)	−0.8%	(−5.1% to 3.6%)	36	475	4793	0.83	
Baseline to 6 months	−4.8%	(−8.7% to −1.0%)	−1.4%	(−5.7% to 2.9%)				0.23	
Moved ≥ 14 m forwards[b]									
Baseline to 3 months	−3.7%	(−8.9% to 1.6%)	−1.6%	(−7.8% to 4.7%)	18	242	2462	0.61	
Baseline to 6 months	−6.1%	(−11.2% to −0.9%)	−1.0%	(−7.2% to 5.2%)				0.20	
Moved < 14 m forwards									
Baseline to 3 months	1.2%	(−4.8% to 7.2%)	0.0%	(−6.0% to 6.2%)	18	233	2331	0.80	0.44
Baseline to 6 months	−3.5%	(−9.2% to 2.2%)	−1.8%	(−7.8% to 4.2%)				0.69	0.50
Study store is main store[b]									
Baseline to 3 months	−3.5%	(−10.5% to 3.4%)	0.0%	(−7.5% to 7.6%)	33	138	1755	0.49	
Baseline to 6 months	−10.3%	(−16.9% to −3.7%)	−1.0%	(−8.5% to 6.3%)				0.07	
Study store is not main store									
Baseline to 3 months	−0.4%	(−5.2% to 4.4%)	−1.3%	(−6.6% to 4.1%)	36	337	3038	0.82	0.49
Baseline to 6 months	−2.0%	(−6.8% to 2.7%)	−1.7%	(−7.0% to 3.6%)				0.91	0.18

continued

TABLE 2 Effect of intervention on change in proportion of fresh fruit and vegetable purchasing from baseline to 3 and 6 months' follow-up (*continued*)

	Control		Intervention		Number of stores	Number of women	Number of visits	*p*-value for control vs. intervention	*p*-value for interaction
	Change	(95% CI)	Change	(95% CI)					
Educated up to age 16 years[a]									
Baseline to 3 months	3.4%	(−2.9% to 9.8%)	2.8%	(−4.0% to 9.8%)	36	180	1863	0.94	
Baseline to 6 months	−2.7%	(−8.8% to 3.3%)	5.0%	(−1.8% to 11.8%)				0.09	
Educated over 16 years of age									
Baseline to 3 months	−3.3%	(−8.6% to 1.9%)	−2.5%	(−8.2% to 3.3%)	35	283	2812	0.79	0.32
Baseline to 6 months	−5.0%	(−10.3% to −0.9%)	−4.7%	(−10.3% to 1.0%)				0.66	0.19

a These analyses were pre-defined in the study protocol.[11]
b These analyses were defined from the process evaluation findings of intervention implementation[2] and offer potentially important policy-relevant information

6 months post intervention implementation. Increases in sales of fresh fruit and vegetables were greater in the intervention stores than would be predicted by the model counterfactuals at the time of intervention [difference = 0.32 standard deviations (SDs) (95% CI 0.10 to 0.53); p = 0.002], with a reduction in effect at 3 months post intervention [difference = 0.23 SDs (95% CI −0.05 to 0.52), p = 0.10] and 6 months post intervention [difference = 0.18 SDs (95% CI −0.16 to 0.52); p = 0.29]. These changes are approximately equivalent to 2525 (95% CI 775 to 4115), 1940 (95% CI 380 to 3950) and 1450 (95% CI −945 to 3950) extra fruit and vegetable portions per store per week at intervention and 3 and 6 months post intervention implementation, respectively.

As shown in *Table 3*, there were somewhat greater increases in sales of fresh fruit and vegetables in the intervention stores which received a greater intervention dose, where the produce section moved forwards more than 14 m compared to stores where the fruit and vegetables moved less far forwards. The changes in stores where fruit and vegetables moved forwards more than 14 m are approximately equivalent to 3645 (95% CI 2350 to 5305), 3115 (95% CI 960 to 5350) and 2350 (95% CI 720 to 6045) greater fruit and vegetable portions per store per week at intervention and 3 and 6 months' follow-up, respectively. More mixed findings were observed when intervention dose was defined as being in the first, compared to the last half of the first aisle.

The intervention showed a positive effect on women's dietary quality at 6 months post intervention [0.25 SDs (95% CI 0.10 to 0.40)]. The effect was small, however, at 1 month's follow-up [0.07 SDs (95% CI −0.09 to 0.23)] and in the opposite direction at 3 months' follow-up [−0.15 SDs (95% CI −0.33 to 0.03)]. Analyses of children's dietary quality demonstrated positive effects of the intervention on dietary quality at 1 and 3 months' follow-up [0.34 SDs (95% CI −0.30 to 0.98) and 0.43 SDs (95% CI −0.39 to 1.25), respectively], although uncertainty is indicated by wide conference intervals. There were no effects at 6 months post intervention [0.06 SD (95% CI −0.13 to 0.24)].

The intervention effect on reported household fruit and vegetable waste revealed little change in frequency of fresh fruit and vegetables being thrown away at 1 [−0.01 times per week (95% CI −0.24 to 0.22) and −0.02 times per week (95% CI −0.20 to 0.17), respectively] and 3 months' follow-up [0.07 times per week (95% CI −0.18 to 0.32) and −0.02 times per week (95% CI −0.25 to 0.20), respectively]. After 6 months, however, frequency of vegetable waste was more evident among women from intervention than control stores [0.20 times per week (95% CI 0.07 to 0.32)] and fruit waste was also somewhat greater among intervention participants [0.12 times per week (95% CI −0.12 to 0.35)].

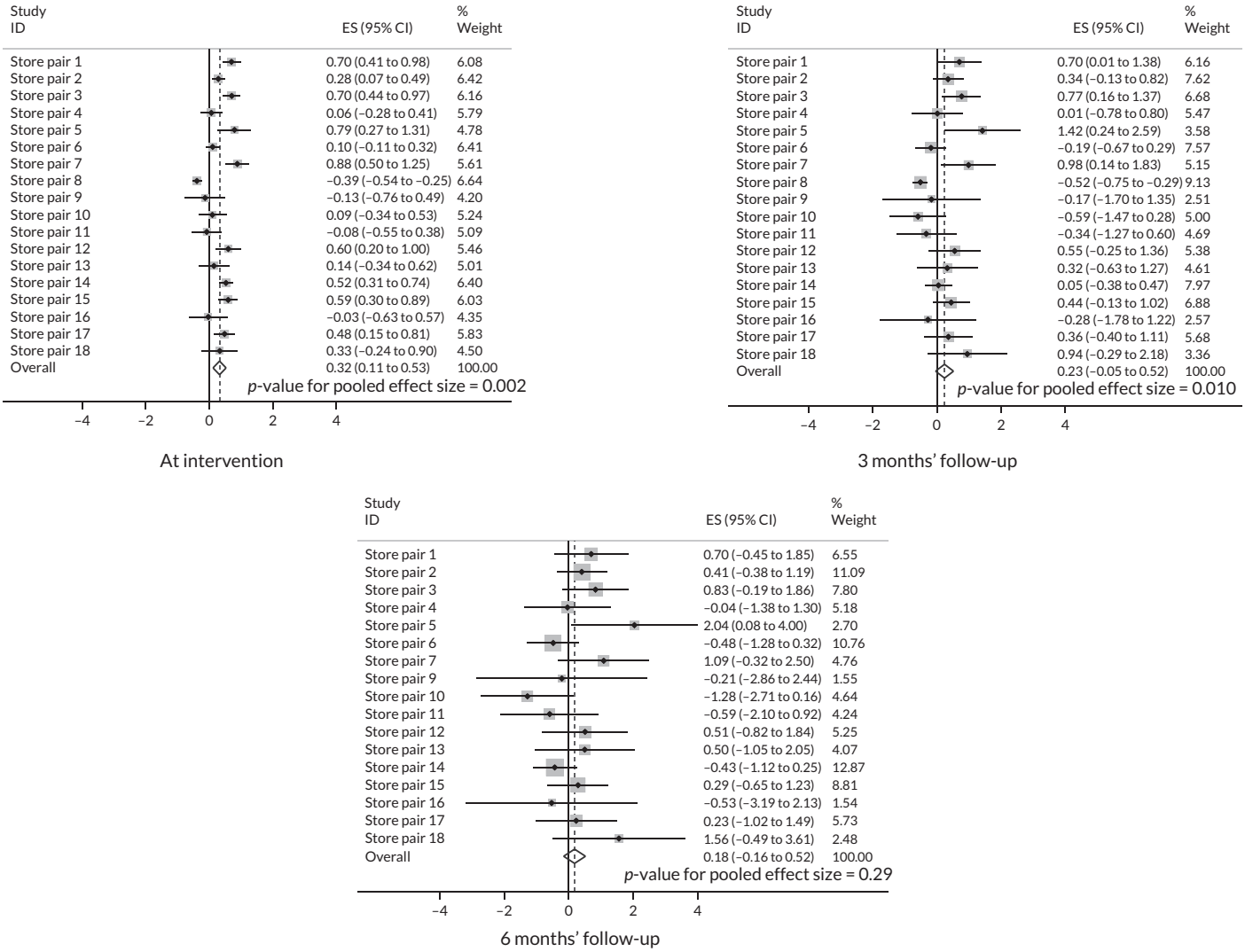

FIGURE 5 Meta-analysis of total sales of fresh fruit and vegetables at three time points. This figure has been reproduced from Vogel *et al.*[1] This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) licence which permits others to distribute, remix, adapt and build upon this work, for commercial use, provided the original work is properly cited. See: https://creativecommons.org/licenses/by/4.0/. The figure above includes minor additions and formatting changes to the original text.

Economic evaluation results

A summary of the economic and health impacts of the intervention is shown in *Table 4*. From a household perspective, the purchasing data indicates a positive effect on the quantity of fresh fruit and vegetables bought over 6 months, which was not associated with an increase in reported spending on supermarket foods. Effects on the reported time spent on food shopping or travel distance to the main food shop, and wastage of fruit and vegetables were not substantial. Extrapolating the mean effect on fruit and vegetable purchasing in the health economic model, we estimated small reductions in the incidence of cardiovascular disease and cancer for individuals, which would translate to a meaningful health gain at the population level (1.2 QALYs gained per 1000 population).

From a retailer perspective, there is an initial capital cost to relocate the fresh fruit and vegetables, and additional costs for maintaining a larger volume and range of produce. The financial net impact of effects on sales is difficult to quantify. There was no evidence that increased spending on fresh fruit and vegetables was offset by reduced spending on frozen or tinned fruit and vegetables or other items in the intervention stores.

The overall economic and health effects of the intervention at a societal level are difficult to estimate, due to uncertainty over some key model parameters. For our illustrative base case analysis, we assumed an intervention effect of 0.11 portions of fruit and vegetables per day (0.15 items per week), waning of the effect to zero between 4 and 8 years after the intervention, a one-off refit cost of £185

TABLE 3 Increase in-store sales of fresh fruit and vegetables (SDs) in intervention stores compared to that predicted by model counterfactuals at intervention, and 3 and 6 months' follow-up post intervention by dose (positioning)

Store location	Overall effect size SD (95% CI)	*p*-value	Number of stores
All stores[a]			
At intervention	0.32 (0.11 to 0.53)	0.002	36
12 weeks post intervention	0.23 (−0.05 to 0.52)	0.10	36
24 weeks post intervention	0.18 (−0.16 to 0.52)	0.29	36
Fruit and vegetables moved ≥ 14 m forwards[b]			
At intervention	0.48 (0.30 to 0.67)	< 0.001	18
12 weeks post intervention	0.40 (0.12 to 0.68)	0.005	18
24 weeks post intervention	0.30 (−0.13 to 0.74)	0.17	18
Fruit and vegetables moved < 14 m forwards			
At intervention	0.15 (−0.16 to 0.45)	0.35	18
12 weeks post intervention	0.01 (−0.38 to 0.40)	0.97	18
24 weeks post intervention	−0.01 (−0.57 to 0.56)	0.98	18
Fruit and vegetables to first half of first aisle[b]			
At intervention	0.41 (0.25 to 0.57)	< 0.001	26
12 weeks post intervention	0.27 (0.02 to 0.53)	0.04	26
24 weeks post intervention	0.12 (−0.27 to 0.52)	0.53	26
Fruit and vegetables to last half of first aisle			
At intervention	0.09 (−0.37 to 0.56)	0.69	10
12 weeks post intervention	0.15 (−0.52 to 0.81)	0.67	10
24 weeks post intervention	0.61 (−0.24 to 1.47)	0.16	10

a These analyses were pre-defined in the study protocol.[11]
b These analyses were defined from the process evaluation findings of intervention implementation[2] and offer potentially important policy-relevant information.

per customer and annual discount rates of 1.5% for QALYs and 3.5% for costs. Overall analyses showed an incremental cost-effectiveness ratio of £156,574 per QALY gained, which is higher than the usual threshold applied for public sector health investments. However, this result was highly sensitive to assumptions about the cost of the refit, and the waning of the intervention effect over time.

Process evaluation results

Staff survey data assessing intervention implementation showed that 41% of intervention stores positioned the fresh produce section in the front half of the first aisle compared to 27% of control stores before intervention implementation ($p = 0.39$).[2] At 1 month post intervention implementation, fresh fruit and vegetables were positioned in the front half of the first aisle in all intervention stores (100%) compared with less than a quarter (23%) of control stores ($p < 0.001$). At 6 months post implementation, 94% of intervention stores reported fresh produce in the front half of the first aisle compared to 39% of control stores ($p = 0.001$). There were no significant differences between intervention and control stores in the positioning of other products frequently placed in the front half of the first aisle (all $p > 0.10$).[2]

TABLE 4 Economic balance sheet: summary effects of intervention on change

	Units	Time period	Estimated effect (95% CI) Intervention vs. control	Source
Household perspective				
Fruit and veg purchased	Items per week[a]	Change 0–6 months	+ 0.15 (−0.04 vs. −0.19)	Purchasing data[b]
Supermarket food spend	£ per person per week	Change 0–6 months	− 1.07 (−3.26 to 1.12)	Survey
Main food shop time	Minutes per week	Change 0–6 months	+ 9.4 (−11.2 to 29.9)	Survey
Main store distance	Mean km	Change 0–6 months	+ 1.3 (−6.47 to 8.98)	Postcode analysis
Estimated QALY gain	QALYs per woman	Lifetime projection	0.0012	Economic model[c]
Retailer perspective				
Refit cost	Reports of £211,000 per store for a mini refit to £362,00 for a full refit			Trade press
Running costs	Additional costs for stocking and wastage for fresh fruit and vegetables			Store staff interviews
Sales impact	Approximately 1450 extra fruit and vegetable portions per store per week			Purchasing data
Satisfaction: choice	Very good or good	Change 0–6 months	OR 1.17 (0.70 to 1.94)	Survey
Satisfaction: service	Very good or good	Change 0–6 months	OR 0.92 (0.55 to 1.55)	Survey
Satisfaction: value	Very good or good	Change 0–6 months	OR 0.80 (0.48 to 1.33)	Survey
Societal perspective	*Base case estimates*			
Net cost of intervention	£ per woman	Lifetime projection	£187	Economic model[c]
Health effect	QALYs per woman	Lifetime projection	0.0012	Economic model[c]
Incremental ratio	£ per QALY gained	Lifetime projection	£156,574	Economic model[c]

OR, odds ratio.
a Fresh fruit and vegetables, approximately 5 portions per item.
b Negative binomial model, reduction of 0.04 items (−0.23, 0.16) in intervention vs. reduction of 0.19 (−0.35, −0.02) items in control stores.
c Base case estimate, assumes waning of effect between 4 and 8 years after intervention; discounting at 3.5% for costs, 1.5% for QALYs.

Planogram data from all 36 study stores (18 intervention and 18 control) showed that the distance of fresh fruit and vegetables from the store entrance was markedly shorter in intervention compared to control stores after intervention implementation.[2] The median distance for intervention stores was 8.0 m [interquartile range (IQR) 5.0–10.0] compared with 23.8 m (IQR 21.0–30.0) for control stores ($p < 0.0001$). The mean distance that the fresh fruit and vegetable section moved forwards in intervention stores from baseline to post implementation was 14 m (SD 9.7) ($p < 0.0001$).

Analysis of SKU data showed that the mean number of different fruit and vegetable products available was higher in intervention compared with control stores post intervention implementation.[2] The mean value among intervention stores was 69.8 (SD 16.1) compared with 57.9 (SD 13.0) among control stores ($p = 0.02$). The mean change from baseline to post-intervention implementation in number of different fruit and vegetables available in intervention stores was 15.3 (SD 16.7) ($p = 0.01$).

Semistructured interviews with senior staff working in study stores described three themes related to intervention implementation.[2] The first outlined the processes by which the company supported intervention implementation. In particular, the provision of detailed floor plans (planograms) which guide product positioning and supply chains matching the additional demand for fresh fruit and vegetables with regular deliveries. The second described the autonomy that store managers and staff had for the positioning of product displays that were not fixed. They described drawing upon their knowledge of their customers' preferences to make decisions about the types

of products placed in these moveable display units, which were often less healthy and prominently positioned. The third, highlighted staff support for prominent positioning of the fresh produce section near the store entrance because it boosted sales and supported customers in making healthier choices.

To assess the possibility that results might be affected by changes in the wider food retail environment, Ordnance Survey Points of Interest data were used to identify supermarkets, convenience stores and takeaways at each of the study time points within participant's local food retail activity spaces or within 1 km radius around study stores. Activity spaces were defined as 1 km road distance buffers around the participant's home and their main food store together with a 500 m buffer around the shortest travel road linking these two points. These data provided an indication of alternative food retail opportunities. Scores for each study store were combined to provide a store-level outlet density indicator for each of the three food retail outlets at each time point. Paired *t*-tests found no significant difference between control and intervention sites at baseline in terms of each of the three alternative food retail outlets. One-way analysis of variance confirmed by non-parametric testing found no significant change in any of the three aspects of the wider food retail environment for either control or intervention sites across the study time points. These results suggest that the WRAPPED study findings are unlikely to have been impacted by changes in the wider food retail environment.

Data from semistructured interviews with 108 stakeholders across the food system about the Food (Promotion and Placement) Regulations 2021 identified that there was widespread support for the regulations but concerns about prioritisation and capacity which could hinder implementation and enforcement activities.[24] As shown in *Figure 6*, six policy recommendations were identified by participants. Three key recommendations included the need for resources to identify in-scope products, ring-fenced funding for enforcement activities and greater support for smaller businesses to enable them to offer more healthy foods to customers.

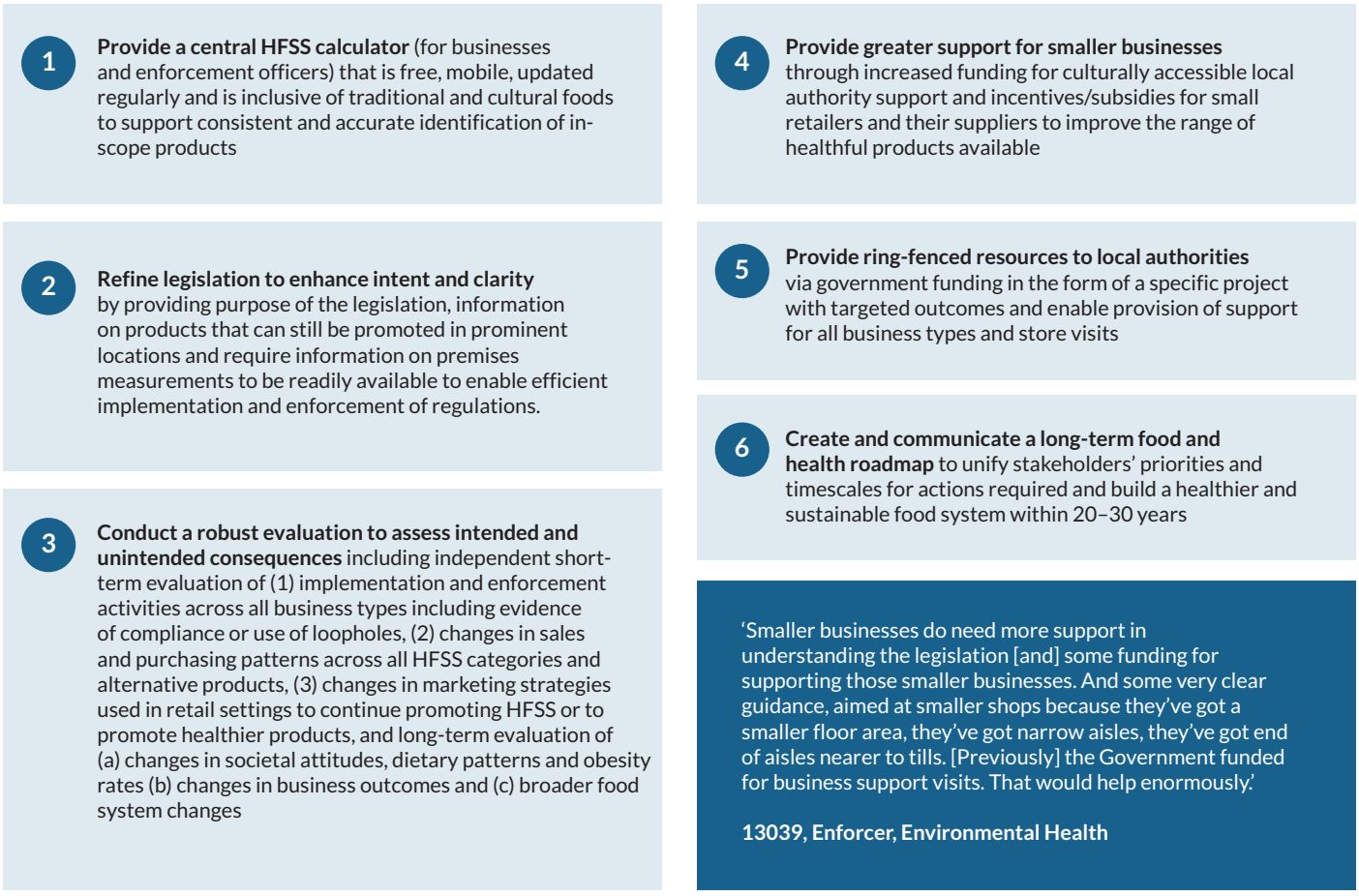

FIGURE 6 Six policy recommendations identified from stakeholders to optimise effectiveness of the Food (Promotion and Placement) Regulations.

Discussion

Principle findings and achievements

This study took place in a UK discount supermarket chain and showed that enhancing the placement (positioning and availability) of fresh fruit and vegetables resulted in promising results across a range of outcome variables. At the household level, the intervention showed a somewhat protective effect on declining fresh fruit and vegetable purchasing patterns, particularly after 6 months of intervention implementation. There was a less-marked reduction in fruit and vegetable purchasing among intervention compared to control families at a time when fruit and vegetable purchasing was declining across the overall UK population. Among families using the study store for most of their groceries, and those experiencing low socioeconomic position (measured by educational attainment), the intervention showed a marginally more beneficial effect with a greater proportion of intervention families purchasing fresh fruit and vegetables compared to control families; these differences became stronger over time.

At the population (store) level, fresh fruit and vegetable sales increased, particularly when fruit and vegetables moved further forwards from their baseline position. Among stores with the higher intervention dose, approximately 3645, 3115 and 2350 additional portions of fruit and vegetables were sold in each intervention store, per week at the time of intervention implementation and 3 and 6 months later, respectively. Women's dietary quality improved after 6 months of exposure to the intervention, compared to women not exposed to the intervention, although beneficial effects of the intervention were not seen on diet at earlier time points. Children's dietary quality improved somewhat after the intervention, but the effect size declined at 6 months. Self-reported household waste of fruit and vegetables was not different between intervention and control families immediately and shortly after intervention exposure; however, intervention families reported higher vegetable waste after 6 months compared to baseline.

The economic balance sheet suggests that the net effect of the intervention after 6 months is positive from an individual or household perspective. The improvement in reported diet quality for study participants would be expected to have health and well-being benefits if maintained. Importantly, the intervention was not accompanied by an increase in reported spending on supermarket foods, or significant increases in shopping time, distance travelled or food waste. The net economic effect of the intervention from a retailer perspective is more difficult to evaluate, because of limited information about the impact on commercial costs, revenue and profit. The effects on customer satisfaction and reputational benefit are not clear. Our economic analysis also indicates uncertainty over the cost-effectiveness of the intervention from a societal perspective because of uncertainties over the cost of the intervention, and likelihood of persistence of dietary improvements, and subsequent health improvements.

The process evaluation revealed that implementation of the placement intervention adhered closely to the protocol. Both intervention components showed high fidelity, with more prominent positioning and increased availability of fresh fruit and vegetables. Differences in intervention dose across study stores were observed both for distance the produce section moved forwards towards the store entrance and the number of fresh fruit and vegetable items available. No differences in local retail food environments were observed between intervention and control groups across the 9-month study period.

Semistructured interviews with store staff showed leadership on implementation of the intervention from the supermarket chain's head office. This leadership was achieved through provision of store planograms to enhance protocol adherence and robust supply chain management ensuring regular deliveries of fresh produce. Staff also acknowledged the autonomy of store managers and senior staff in positioning mobile product display units to increase sales. This activity may have increased the availability and prominent positioning of unhealthy foods in intervention stores and/or promotion of fruit and vegetables near store entrances in control stores. Staff also described several store-level factors which positively reinforced intervention implementation, including: (1) the increased sales of fresh fruit and vegetables observed following intervention implementation, (2) heightened staff awareness of the powerful role positioning items in prominent locations has on prompting customers' choices and (3) staff recognition that supermarkets play an important role in supporting healthier diets when implemented collectively.

Our study provides robust and contextually relevant contributions to food policy, particularly in relation to the Food (Promotion and Placement) Regulations in England. The two literature reviews associated with this study[20,21] provided evidence in support of the introduction of this government regulation to restrict prominent positioning of unhealthy foods in retail outlets, namely at checkouts, aisle ends and store entrances. The process evaluation activities for this study included assessment of the policy context within which our intervention trial was set. The views of over 100 stakeholders across the system affected by these new regulations on product placement

were collected before the policy was introduced across England.[24] Results showed widespread support across stakeholder groups which included women citizens, businesses, enforcement officer and health representatives. Concerns were raised about the prospects of inconsistent implementation due to resource constraints among smaller businesses and lack of ring-fenced funding for enforcement activities. Many stakeholders felt the regulations did not go far enough in supporting citizens to make more healthy choices while shopping. The results of our intervention trial provide some novel evidence to support future refinement of the UK Food (Promotion and Placement) Regulations to require a produce section near supermarket entrances. Our results suggest that such a change to the existing regulations may be particularly effective among families relying on discount supermarket stores or smaller supermarkets for most of their groceries and among families experiencing greater socioeconomic disadvantage because these stores do not routinely place fresh produce near their entrances.[15]

Contribution to existing knowledge

This study makes a meaningful contribution to existing knowledge on the topic of using product placement interventions in food retail outlets to promote healthy dietary choices. The literature syntheses undertaken as part of this study[20,21] have aided understanding of the positioning of placement strategies within the context of other retail interventions.

A synthesis of evidence from previous systematic reviews of healthy eating interventions within retail settings was published as a book chapter 'Food Retail Environments' within the book 'Transforming Food Environments' edited by Charlotte Evans.[20] Key findings from this review are illustrated in *Figure 7*. In brief, the literature identified that signage interventions have been widely studied but show little benefit when used alone. There is robust evidence of price interventions improving diet and moderate evidence of effectiveness for availability and positioning interventions, particularly when used in combination. Limited evidence exists for price promotion interventions because of the small the body of literature.

Our systematic review assessing the body of evidence from product placement interventions aimed at supporting healthy food choices conducted in high-income countries revealed a number of methodological difficulties for this research field.[21] These challenges were likely reflected in the volume of studies which had results that were not statistically significant, despite being in the expected direction for health benefit. An important recommendation

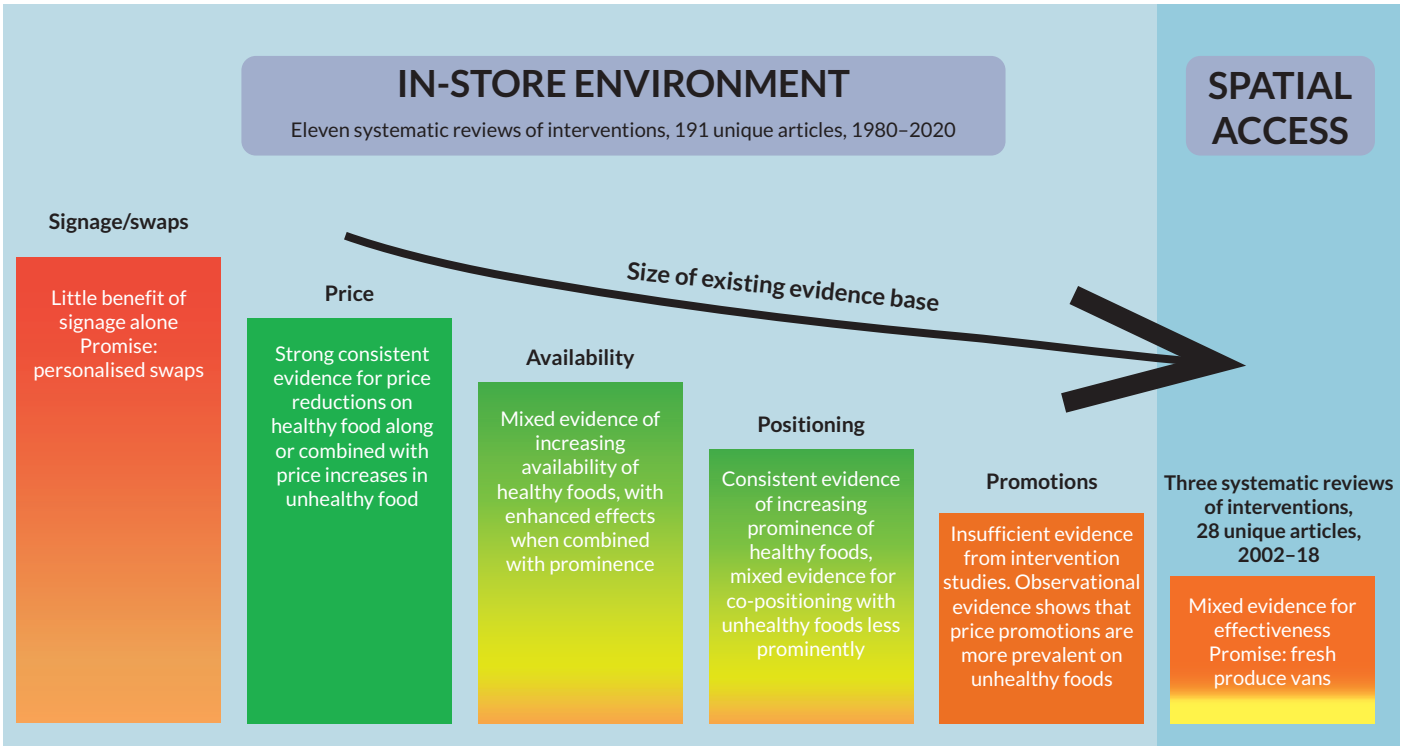

FIGURE 7 Synthesis of evidence of effectiveness across different food retail interventions.[47] Larger bar, larger evidence base; Colour coding: Red, little evidence of effectiveness; Amber, moderate evidence of effectiveness or small evidence base; Green, strong evidence of effectiveness.

from the review was the need for larger cluster intervention studies that test both the independent and additive effects of availability and positioning strategies.

To support other research groups achieve better study design in this field, we collaborated with researchers across the world who have undertaken large trials with national supermarket chains to develop best practice guidance.[30] This guidance applied a collective case study approach to collate experiences of engaging and sustaining research collaborations with large food retailers from Australia, the Netherlands and the UK. Six recommendations were identified to support the conduct of high-quality research (*Figure 8*). These include: (1) using personal contacts, knowledge of supermarket activities and engaging executive management to establish a partnership and allowing time to build trust; (2) formalising data exchange arrangements and allocate adequate resource for data extraction and recategorisation; (3) assessing effects at individual/households level where possible; (4) designing a mixed-methods process evaluation to measure intervention fidelity, dose and unintended consequences; and (5) ensuring scientific independence through formal contract agreements. Our full-scale WRAPPED study applied these recommendations to contribute policy-relevant and robust findings to this field of research.

The outcome findings from our WRAPPED trial are similar to previous intervention studies which repositioned fresh fruit and vegetables to store entrances or other prominent locations in food stores.[47–49] The additional contribution of our study lies in the assessment of intervention dose (i.e. distance produce section moved and study store being main source of groceries) which have been rarely undertaken in healthy product placement research.[20,30] This nuanced assessment has extended methods used in previous literature through the use of store planograms for positioning calculations and SKU counts for availability calculations. Such measures of intervention dose are important to provide a deeper understanding of

FIGURE 8 Six recommendations for conducting high-quality public health research with national supermarket chains.

intervention effects. In particular, we found that greater intervention dose boosted additional sales of fruit and vegetables at a population level, as well as protecting against declining fruit and vegetable purchasing at the household level. Previous studies which implemented a lower-intensity fruit and vegetable positioning intervention, such as co-locating produce alongside unhealthy foods or having smaller displays, have shown no intervention effect or only very small intervention effects.[47,49,50] Assessment of intervention dose is likely to be particularly important for interpreting the effects of natural experiments on outcomes of interest.

Our study illustrates a worrying decline in fresh fruit and vegetable sales from retail outlets in the UK. Over the timing of this study, 2018–22, British families have experienced disruptions to produce availability and price rises caused by the COVID-19 pandemic, Brexit, climatic events and the war in Europe. UK household purchasing of fruit dropped by 7.2% and vegetable purchasing dropped by 5.3%[51] over this time period. While the findings from our study show a slight reduction in intervention effect size on store-level sales over the 6 months' intervention period, which mirrors population trends, it is important to acknowledge that even small increases in fruit and vegetable consumption (0.3–1.0 portion/day) can reduce an individual's risk of coronary heart disease by 4% and stroke by 5%.[52,53] Our intervention results therefore suggest a potentially meaningful effect size at the population level despite contextual disruptions.

Our study results also indicated that the intervention somewhat protected against these national trends, with the difference in the proportion of fruit and vegetable purchasing between intervention and control families increasing over time. Our findings for household purchasing of fresh produce and for women's dietary quality show that intervention effects were strongest after 6 months of continued intervention exposure. This finding was particularly evident for families relying on the study store for most of their groceries and those experiencing lower socioeconomic position. Among these groups, the proportion of families buying fruit and vegetables increased for those who shopped at intervention stores compared to those who shopped at control stores, especially after 6 months. Evidence from the US found similar effects among families receiving governmental financial support to buy nutritious foods for their young children, with higher voucher use after 5 months of exposure to produce sections near their store's entrance.[48] This evidence is consistent with the broader literature about changing health-related practices which suggests that new habits may take more than 12 weeks to form and can strengthen with time,[54] particularly if contexts or environments support those new practices.[55,56] Observational evidence from the UK indicates that discount and small supermarkets who attract families living with lower incomes do not provide this contextual support, frequently not positioning fruit and vegetable sections near store entrances.[14,15] Thus, positioning the produce section near store entrances routinely could have protective benefits, particularly for those most at risk of low fruit and vegetable intake.

Our assessment of fruit and vegetable waste within participants' households, economic evaluation at the individual, retailer and societal levels, and detailed process evaluation provide a comprehensive analysis of the interventions' impact beyond the outcome variables of sales, purchasing and dietary quality. These measures of potential unintended consequences enable policy-makers to make more informed decisions and provide significant contributions to the literature in this field.

Our findings that household waste of fruit and vegetables increased among intervention households after 6 months suggest that policy-makers should consider encouraging retailers to promote the sale of loose produce to enable greater choice in quantities of fruit and vegetables purchased alongside more prominent positioning of the fresh produce section. Our economic and process evaluation results additionally suggest that the cost-effectiveness of regulations supporting healthier in-store layouts could be enhanced by a more detailed framework for policy implementation and enforcement.

Our process evaluation results indicate that head office support for intervention implementation plays an important role in store staff compliance and overcoming logistical implications for intervention implementation, which is consistent with previous literature.[57,58] Our process evaluation, however, also identified that store staff have autonomy over the positioning of mobile product display units and this freedom is used to boost sales, usually of unhealthy foods, based on their knowledge of their store's customers. These findings bring new insights for the implementation of the Food (Promotion and Placement) Regulations in England, indicating that store staff activity may vary from a supermarket chain's commitment to policy implementation and subsequently undermine policy effectiveness. Further research of this understudied area is needed to ensure effective and implementation of healthy food retail policies.[24]

Strengths and weakness of the study design

To our knowledge, this is the first fresh fruit and vegetable placement trial in supermarkets to provide 85% power (*Box 1*) to detect an effect of household purchasing patterns using loyalty card data. This study is also unique in its collection and analyses of outcome data at multiple levels, including store sales data, to measure population-level effects, purchasing data from loyalty cards to measure household effects, dietary data from more than one household member to aid understanding of who has been affected by the intervention, and household waste as a measure of sustainable food practices.

BOX 1 Revised sample size calculation based on numbers in analysis file ($n \approx 475$)

The study sample size calculations were based on the primary outcome being differences in fresh fruit and vegetable purchasing between women in the intervention and control groups during the 3–6 months post intervention. Average fruit and vegetable purchases per week are not normally distributed, thus the sample size calculation is based on changes in average fresh fruit and vegetable purchases per week from the baseline period to the post-intervention period, which are approximately normally distributed. It was not practical to calculate a rho from the pilot study due to the small number of clusters. We used data from our previous research on women in Hampshire who were the same age range as the proposed participants of this study and considered the supermarkets at which the women shopped as clusters to estimate a rho of 0.1 as our intraclass correlation coefficient. We aimed to detect a difference of 0.3 items (1.5 portions) per week. Assuming a SD of 0.7 items (3.5 portions) per week as seen in the pilot data, 18 stores in each arm and 13 women per store (totalling 468 women) provides 85% power at a 5% significance level (two-sided).

This study has a number of other advantages over existing supermarket placement research,[27] including: (1) use of a matched comparison group; (2) use of robust statistical analysis methods, particularly the interrupted time series approach to assess intervention effects on store sales; (3) the participant sample, including good representation of families from lower socioeconomic backgrounds thus providing important information about differential interventions effects; (4) assessment of the effect intervention dose on outcomes; and assessment of economic impact at individual, retailer and societal levels. The fact that it was not possible to randomise stores to intervention or control groups is a limitation because the study may be biased by unmeasured confounding effects. Parallel designs, like the one used in our study, offer a robust design in real-world settings. Our findings provide valuable knowledge of intervention effectiveness in complex social contexts, particularly with data collected at store, household and individual levels that can be useful for policy-makers. Store selection and intervention implementation was not within the control of the research team, and some deviations from the protocol were identified. It was also beyond the scope of the study to assess the contribution of other sources of food shopping beyond assessing whether the study supermarket chain was the source of most of the household's food. Under- or overestimation of intervention effects observed may, therefore, be possible; however, stratified analyses aimed to account for these variations. Due to interpretation of data protection regulations, each participant was required to specify their consent to sharing their purchasing data from the supermarket chain to the research team. A reasonable proportion of participants did not check this consent; therefore, fewer than anticipated participants provided primary outcome data limiting the certainty in the stratified and interaction analyses and increasing the ability to detect statistically.[59] The study's sample size was based on household purchasing and not the secondary outcomes. Individual dietary and household waste results should be viewed with some caution due to difficulties recruiting during the COVID-19 pandemic, resulting in smaller than predicted sample sizes for these variables. Additionally, while confounders identified by DAGs were adjusted for in the dietary and household waste analyses, the potential for residual confounding remains. Nevertheless, the study's effect sizes demonstrated meaningful improvements in the healthiness of store sales and indicate a somewhat protective effect on household purchases of fresh produce. This study considered only female adults, thus results for male shoppers may differ from the findings of this study.

The process evaluation methods used in this study were consistent with guidance on best practice. These methods provide novel insights in relation to assessment of intervention dose and factors affecting the fidelity. The use of a convergent mixed-methods approach[60] optimised understanding of intervention fidelity, intervention dose and contextual drivers of intervention implementation. The different sources of data collected and collated during the process evaluation helped to minimise bias that may have arisen from reliance on a single data source and provided a detailed picture of the influencing factors. The process evaluation survey data, however, were not complete due to the effects of the pandemic on staff workloads in 2020 and 2021. Nevertheless, all but two intervention stores provided data at baseline, and all but one took part in the final survey at 6 months; figures were equivalent for control stores.

The self-report nature of the survey measures may introduce some bias to the results; however, methods were applied consistently across intervention and control samples to minimise impacts on final analyses. There may be some bias in participants who agreed to participate in the

semistructured interviews that formed part of the process evaluation activities. The rapid qualitative approach used to assess stakeholder views of the broader policy context for this study enabled inclusion of views from 108 participants and adoption of a complex systems approach, covering views from sectors across food systems and different regions in England. The original sample size targets for the qualitative interviews with store staff and stakeholders affected by the Food (Promotion and Placement) Regulations were extended because new findings continued to emerge, indicating the breath of views covered in these data sets.

Reflections on the study and protocol changes

This study is the result of a non-financial research collaboration with a UK discount supermarket chain which commenced in 2015 and developed through a pilot study into a full-scale study. This collaboration required a close working relationship between the retailer and the research team to achieve the robust scientific design, develop data exchange arrangements that align with General Data Protection Regulation (GDPR) requirements and ensure independence of our scientific analyses through formal contract agreements.

The WRAPPED full-scale study recruitment commenced in May 2018 and ended in October 2021. Over the course of the study, a number of major events, including Brexit, COVID-19 pandemic lockdowns, climatic events and the war in Ukraine impacted on the food retail sector, which had consequences for our study. The collaborating supermarket responded to these events by pausing and altering their scheduled refit programme, which required pauses to study recruitment. For example, no stores were recruited between December 2021 and March 2022 due to the Christmas retail period, plus end-of-financial year budget/pandemic constraints for the collaborating supermarket. Additionally, the COVID-19 pandemic national lockdowns led to lower-than-anticipated participant recruitment numbers because in-store recruitment was not possible and the study team were reliant on postal letters over a time when families were experiencing extended uncertainty. The restriction on in-store visits also impacted process evaluation data collection, particularly the surveys with senior study store staff. The introduction of GDPR in January 2019 had implications for the research team's access to the primary outcome (loyalty card data) because the retailer required an additional stage of consent, directly between the retailer and participants. This additional consent requirement caused lower than anticipated numbers of participants providing outcome data.

The study team worked closely with the retailer to develop strategies to boost recruitment of study stores and participants. These changes were agreed with our independent Study Steering Committee and NIHR project manager to increase the sample size for the study. The changes required minor alterations to the original study protocol and an extension of the duration of the study. All protocol changes were approved through the study's governance structures, were documented through protocol amendments and shared in advance of changes being made.

The specific protocol changes required throughout this study included:

- Recruiting intervention stores located within neighbourhoods of any deprivation; the original protocol aimed for store recruitment from the most deprived neighbourhoods (IMD ≤ 5).
- Expanding the age range of eligible women participants from 18–45 years to 18–60 years.
- Offering participant incentives as both paper and online Love2shop vouchers and Amazon vouchers as a result of the COVID-19 pandemic when many families chose to shop online.
- Implementing a revised recruitment strategy to boost numbers of participants with primary outcome data to increase the sample size; invitation letters and e-mails were sent reinviting eligible bonus card holders to take part in the study by sharing their purchasing data retrospectively.

Some additional protocol changes were required for the statistical analysis of dietary quality data and the economic modelling of the intervention's potential societal impact. These changes were proposed to, and agreed by, the independent Study Steering Committee prior to analyses being undertaken.

The dietary quality data analysis to detect differences between intervention and control groups at the follow-up phases was due to be undertaken using three-level (women clustered within stores within pairs) multilevel models. These models, however, did not fit because of sparse data (small numbers of women per store). Alternative analyses involving linear regression models among each pair of stores and combining the results using meta-analysis were agreed and completed for these data. Previous research suggests that this meta-analysis approach usually produces equivalent results to multilevel models.[61]

The main economic evaluation analysis was the cost–utility analysis conducted from a societal perspective, using

Treasury recommended discount rates for costs and health effects.[62] The team had intended to use the published IMPACTNCD model for this analysis,[63] but this model could not run on the University of Southampton High Performance Computing system. We therefore developed our own model, based on similar data sources, but with a simplified structure. This new Markov model enabled estimates of the health effects and costs for the intervention to be calculated.

This economic model is driven by an effect on fruit and vegetable consumption estimated from study purchasing data, which impacts on the incidence of four diseases (cardiovascular disease, type 2 diabetes, colorectal cancer and breast cancer) and death from other causes.[64] Relative risks for the four diseases and mortality per unit increase in fruit and vegetable consumption are taken from the literature.[65] Data from the Health Survey for England 2016 and established risk calculators[66–69] were used to characterise baseline fruit and vegetable consumption and risks for the four diseases and other mortality, in a cohort of women similar to the WRAPPED participants, stratified by age group (decades between 20 and 70 years of age) and by IMD quintiles. Health-related quality of life is based on general population EuroQol-5 Dimensions data from the Health Survey for England, with disutilities for the four diseases from the literature.[70,71] Health and social care costs are also based on published sources.[72–75] The results were reported as an incremental cost per QALY gained, with exploration of uncertainty in sensitivity analysis, including deterministic, probabilistic and scenario analysis.

Capacity-strengthening activities and outcomes

This study provided several capacity building and stakeholder engagement opportunities, including developing the research team's confidence in patient and public involvement (PPI) (see *Patient and public involvement and engagement*), career development, knowledge exchange and engagement with business representatives and policy-makers.

Members of the research team have benefited from career development as a direct result of this study. Principal investigator (PI) (Vogel) has been promoted twice over the course of this study, once to associate professor in 2019 and then to Professor of Food Policy in 2022 and Director of the Centre for Food Policy, City, University of London in 2024. Project manager (Dhuria) was awarded a doctoral scholarship from the University of Southampton while working part-time on the WRAPPED study. Muir (postdoctoral team member) and Crozier [coinvestigator (coI)] have both received promotions, to senior research fellow and associate professor, respectively. The study also supported the career development of three early career researchers in their roles as research assistant supporting participant recruitment and data collection.

Patient and public involvement and engagement

The entire WRAPPED research team have developed their skills and competence in PPI activities over the course of this study. Two members of the public new to the role of public contributor have supported the activities of this study from its inception through to dissemination of study findings. Both researchers and public contributors have attended and benefited from PPI training, delivered by the NIHR Southampton Biomedical Research Centre, and have developed productive relationships that have been mutually beneficial. The strength of these partnerships is evident from the recent inclusion of one public contributor being named as a public coI on a recent NIHR submission on pester power (arranged by the PI of this study who is a coI on the recent stage 1 grant submission).

Our study's two public contributors were women with similar demographic profiles to our study's participants. The PPI activities undertaken as part of this study have ensured that all study materials, data collection methods and study processes were conducted in ways that were acceptable to participants. Our public contributors also raised creative ideas and methods that enabled the research team to sustain participant involvement in the study.

A dedicated member of the team worked closely with our public contributors. Meetings in person initially and maintaining regular contact throughout the study in the form of e-mails, text messages, telephone calls and virtual meetings have been effective methods for sustaining our public contributors' involvement since early 2019. Having a dedicated member of the research team maintain regular contact and foster these relationships has been critical for the success of our PPI activities. Both our public contributors were paid for their time in accordance with NIHR's guidance throughout the duration of the study.

The level of engagement of our two public contributors changed throughout the study depending on their other work and family commitments. One of the members had her second baby midway through the study, thus her involvement became more dependent on e-mail and text rather than meetings or calls. Offering this flexibility to our public contributors maintained the strong relationships

throughout the study while continuing to benefit from public contributor input.

One of our public contributors was nominated to be part of our Study Steering Committee. She participated in meetings; however, there were occasions when the research discussions became very academic. The research team have reflected on this situation. In future studies, the research team will actively engage with public contributors on Study Steering Committees or Advisory Groups in advance of these meetings to prepare the public contributor and aid their confidence in actively participating during meetings. Follow-up meetings with public contributors will also be offered to ensure appropriate opportunities for input are provided.

Our study's public contributors' skills have been acknowledged beyond this study, with them having been invited to contribute to the development stage of other studies relevant to their lived experiences. One of our public contributors has also been acknowledged for her contribution to the study receiving an award through the University of Southampton's PPI recognition scheme.

Patient and public involvement evaluation activities are ongoing but involved asking for written feedback and verbal feedback to an academic outside of the research team to maximise honest feedback.

Equality, diversity and inclusion

This study intentionally sought a research collaboration with a discount supermarket chain because they have less-healthy in-store environments than other types of supermarkets, and they attract customers with over-representation of individuals experiencing disadvantage. This intervention study has therefore targeted dietary inequalities and enabled investigation of differential intervention effects according to socioeconomic status using the proxy of educational attainment. The study included stores and participants from across England. When comparing our study participants to the general population of women in England, we identified a number of similarities (*Table 5*). Our study participants were of comparable marital status to national data of the same age, with 44% single, the same as the national figure, and 46% married or in a civil partnership, compared to 43% nationally. WRAPPED participants were slightly more ethnically diverse than the general population, with 72% reporting being of White ethnicity compared to 79% nationally.

Our participants over-represented individuals experiencing lower socioeconomic position than the total national population, whereby only 25% of our participants held a degree qualification, compared to 43% in the national population. Similarly, 69% of our WRAPPED cohort lived in the most deprived neighbourhoods (IMD 1–5)

TABLE 5 Representativeness of WRAPPED participants compared to national population of England

Characteristic	WRAPPED participants (*n* = 580)	National data	National data reference population	National data source
White ethnicity, % (*n*)	72%[a]	79%	English women aged 20–59	2021 census[77]
Overweight or obese, % (*n*)	67%[b]	56%	English women aged 16–64	HSE 2021[78]
Current smoker, % (*n*)	18%[b]	12%	English women aged 18–64	2022 ONS APS[79]
Marital status, % (*n*)	[a]		English women aged 20–59	2021 census[80]
Single	44%	44%		
Married/civil partnership	46%	43%		
Separated	2%	3%		
Divorced or civil partnership dissolved	7%	9%		
Widowed or surviving civil partnership partner	1%	1%		
Degree level qualification or above, % (*n*)	25%[a]	43%	English women aged 20–59	2021 census[81]
Most deprived half of neighbourhood deprivation (IMD), % (*n*)	69%[a]	52%	English residents aged 16–59	gov.uk[82]
Paid employment, % (*n*)	63%[a]	73%	English women aged 20–59	2021 census[83]

a Main and purchasing only (demographics) cohorts combined.
b For main cohort only.

compared to 52% nationally. The proportion of women living with overweight or obesity (67%) and smoking (18%) were higher in the WRAPPED cohort compared to national data (56% overweight or obese and 12% current smokers). Furthermore, the proportion of our participants in paid employment (63%) was less that observed nationally (73%).

The research team had representation from both male and female researchers at early career stages as well as senior researchers, spanning an age bracket from early twenties to retirement age. Our WRAPPED study manager is a postgraduate researcher from an ethnic minority background; all other members of the research team are of White ethnicity. Our two public contributors also identify as being of White ethnicity. As a research team we have reflected on our approach to equality, diversity and inclusion (EDI). We recognise that, while our study has been inclusive in terms of actively seeking methods that would enhance representation of individuals experiencing socioeconomic disadvantage, our methods have not actively sought inclusion in terms of ethnicity. We did not offer translation services to facilitate participation or take other proactive steps towards EDI. PI (Vogel) is now actively seeking approaches to maximise diversity in development of subsequent research projects she leads (NIHR203438; NIHR156535).

Impact and learning

Findings from this study, and the pilot study that preceded it, have been presented by the PI Vogel during evidence sessions for House of Lords Select Committees (i.e. Select Committee Food, Poverty, Health and Environment in November 2019 and Select Committee on Food, Diet and Obesity in March 2024) and shared with colleagues at the Department for Health and Social Care (DHSC). Written submissions were made by the team to a number of UK and Scottish government consultations. Presentations about the study findings by team members have also been delivered at numerous national and international conferences. The PI Vogel was also invited in 2020 to join the expert group advising development of Access to Nutrition initiative's (ATNi) UK retailer index. She is now an invited member of ATNi international expert group. Press coverage about a number of WRAPPED outputs has also been achieved, including in *The Times*, *The Conversation* and *BBC Radio Solent*, among other national and international media outlets.

The process evaluation semistructured interviews showed an immediate impact on the attitudes of staff working in study stores and among study participants. Participants expressed that taking part in the study helped them reflect on the consumption patterns and made them more aware of the food choices they make. Staff from intervention stores noted that taking part in the study had a positive effect on their attitudes and practice. Many welcomed the positive effect the intervention showed on store sales, and several highlighted a change in awareness about the importance of offering healthy foods in prominent locations to support customers to make healthy choices. Several store managers also recognised the powerful role of supermarkets in influencing customers' food choices and supported changes across all stores to create a level playing field in a sector fierce with commercial competition.

In May 2022, the WRAPPED team hosted a conference with 458 registrants including businesses, local authorities and policy-makers with the aim of supporting effective implementation and enforcement of the Food (Promotion and Placement) Regulations. The team arranged for speakers from the Consumer Goods Forum, British Retail Consortium, Association for Convenience Stores, Food Foundation and Chartered Trading Standards Institute to speak about product placement marketing and the incoming regulations. Members of the team also presented preliminary findings from the rapid qualitative analysis and delegates validated and prioritised the policy recommendations in the form of an online poll. A recording of the online conference can be found on YouTube (YouTube, LLC, San Bruno, CA, USA).[83]

This study has resulted in a number of subsequent research and policy-related activities. Findings from the policy context assessment and pre-implementation of the UK government Food (Promotion and Placement) Regulations identified an evidence gap of research with the convenience store sector in the UK. The research team, led by Vogel, developed a research application which was successfully awarded by NIHR PHR (NIHR156535) to address this evidence gap. The project runs from January 2024 to July 2026. This new project involves a number of collaborations with the commercial sector, including Asian Media, Newtrade Media and Federation of Wholesale Distributors, as well as six local authorities across England (Southampton, Surrey, Greenwich, Southwark, Nottingham County, Gateshead). Vogel is also coI and lead of the 'Food systems and food policy' workstream in the newly formed NIHR Policy Research Programme (PRP) Healthy Weight Policy Research Unit (led by Professor Viner at University College London). One of the first projects this policy research unit is undertaking is investigating convenience store food systems from January 2024 to December 2025. Additionally, a stage 2 application for a NIHR

PRP commissioned call on the evaluation of the Food (Promotion and Placement) Regulations, led by Vogel, has been funded and commenced in January 2025. This study involves collaborations with the same six local authorities and industry leaders such as the British Retail Consortium. Vogel is also an invited member of Public Health Scotland's evaluation advisory group for the Scottish government's restrictions on promotions of HFSS food and drinks.

Our synthesis of experiences and lessons learnt from scientific trials with national supermarket chains in Australia, the Netherlands and UK provides unique insight into the challenges and opportunities of conducting research partnerships with commercial supermarket chains who have nationwide reach into the shopping trolleys of millions of families. We identified six recommendations that can help guide the development of future intervention studies that will generate more evidence from scientifically robust studies in this field. Additional evidence from real-life supermarket interventions is needed to aid identification of sustainable strategies that can improve population diet and maintain necessary commercial outcomes. Scientifically robust study designs are appropriate for partnerships with commercial supermarket chains because of the routine data that are collected at store and household levels, and because of the large number of stores available to achieve adequately powered trials. Due to the nature of working with large supermarket chains, research teams need to ensure independence in analysis and transparent contractual negotiations because these contracts are of great importance to both commercial and academic institutions. While our experiences are drawn from studies conducted in high-income countries, the recommendations also apply to working with large supermarket chains in low- and middle-income countries, thus having widespread applicability.

Vogel moderated a webinar hosted by the Food and Agricultural Organisation in July 2024, entitled 'Aligning policies for healthy food environments: Exploring the role of food retail environments for improved diets'. More than 100 participants attended, including numerous member states from the Global South. This moderation has led to an opportunity to work with the Pakistani and Canadian governments in their development of food policies to improve the environments of retail outlets. A number of other international collaborations have also developed from this study including: (1) the WRAPPED team sharing learnings in May 2024 with state and territory governments in Australia and Julie Brimblecombe's research team at Monash University, Melbourne, about interventions and regulations to improve the healthfulness of retail food outlets; (2) Vogel and Muir contributing to the development of an International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support (INFORMAS) research project developing and testing a tool to benchmark and monitor online retail environments in 2023–4; (3) Vogel and Crozier contributing to an international research study in 2023–4 that pooled data from real-world supermarket trials to increase power to assess the modifying role of socioeconomic and demographic characteristics on the effectiveness of healthy eating interventions led by colleagues at Amsterdam UMC and (4) Vogel joining and presenting in May 2024 to the United States Nutrition and Obesity Policy Research and Evaluation Network's working group on Healthy Food Retail.

Implications for decision-makers

The findings from our large-scale intervention trial offer evidence to support expansion of the Food (Promotion and Placement) Regulations to include the positioning of fresh produce sections near store entrances in all large food stores (> 2000 square feet) to boost fruit and vegetable sales and improve diet at the population level. Evidence from our systematic review showed that concurrently positioning healthy foods in prominent locations and moving unhealthy foods from these locations to less-prominent locations is more beneficial for diet-related outcomes than colocating unhealthy and healthy items in prominent locations or implementing only one positioning strategy.[21] Refining the legislation to also require the positioning of certain healthy foods, like fruit and vegetables, at the prominent position of store entrance would likely help maximise the regulation's population impact. By illustration, findings from the pilot phase of our study, which concurrently increased the placement (availability and positioning) of produce and removed unhealthy items from checkouts and aisle ends opposite (replaced with non-food items), showed an increase of approximately 9820 additional fruit and vegetable portions per store per week after 6 months.[22] Comparatively, the current full-scale study, which only improved the placement of produce, revealed an increase of approximately 1450 additional portions per store per week after 6 months. These collective findings demonstrate the added benefit from combining placement strategies for both healthy and unhealthy products and align with stakeholders calls for UK food policy to go further in curbing unhealthy food promotions.

The WRAPPED research team is working with Public Policy Southampton to organise a roundtable that will bring together interested stakeholders from DHSC, businesses and other organisations to discuss further policy

and research priorities to improve the healthfulness of retail environments. The research team plan to share key WRAPPED findings, early insights about the impact of the Food (Placement and Promotions) Regulations on commercial and health-related outcomes in the convenience store sector, and insights about enforcement needs of businesses and local authorities.

It is clear from our WRAPPED study findings, our evidence synthesis results and the broader literature that commitment from food retailers is vital to effective implementation of healthy food retail interventions and policies both in terms of leadership and resource provision. The pivotal role of store managers in overseeing implementation of in-store interventions remains an understudied area but one which has important implications for the introduction of food retail policies and interventions. The positive changes to the attitudes of store managers resulting from participation in the intervention study are an encouraging finding and may go some way to overcome some of the barriers to policy change; however, greater evidence of the commercial impacts and opportunities is required.

Research recommendations

Future research would benefit from building the evidence in the following areas:

- Undertaking large, adequately powered real-world supermarket intervention studies using robust scientific study designs.
- Conducting studies that pool data from previous real-world supermarket studies to provide important information about the differential effects of healthy retail interventions on subgroups (e.g. socioeconomic, ethnicity, gender, age and so on).
- Using robustly designed online/virtual supermarket intervention studies and/or modelling approaches (e.g. agent-based modelling) to test interventions which are not possible or acceptable in real-world supermarkets due to commercial risk/palatability (e.g. testing removal of all ultra-processed foods from prominent positions, testing removal of price promotions from HFSS or ultra-processed products, testing limited availability of HFSS or ultra-processed products and so on).
- Conducting robust process and outcome evaluations of food policies aiming to improve the healthfulness of retail environments [e.g. Food (Promotion and Placement) Regulations and so on].
- Undertaking through process and economic evaluations, alongside outcome evaluations, of large adequately powered real-world supermarket intervention studies.

Conclusions

This study provides a comprehensive assessment of a fruit and vegetable placement intervention whereby both positioning and availability were enhanced in discount supermarkets across England. The results of this study reveal that fresh fruit and vegetable sales increased at the population level, although this effect reduced over time. Among stores where the intervention dose was higher, approximately 3645, 3115 and 2350 additional portions of fruit and vegetables were sold in each intervention store, per week at the time of intervention implementation and 3 and 6 months later, respectively. The findings from our study show a reduction in intervention effect size at the population level over the 6-month intervention period. The pattern mirrors reductions in population trends in fruit and vegetable purchasing over recent years, caused by the COVID-19 pandemic, Brexit and cost-of-living crisis. It is important to note, however, that even small increases in fruit and vegetable consumption (0.3–1.0 portion/day) can reduce an individual's risk of coronary heart disease or stroke by up to 5%. Thus, these results suggest a potentially meaningful effect size at the population level despite contextual disruptions.

Small protective intervention effects were also indicated for household fruit and vegetable purchasing and household member's dietary quality whereby the fruit and vegetable placement intervention buffered against widescale reductions in fruit and vegetable purchasing. This effect was somewhat more successful among families using the study store for most of their groceries and among families experiencing greater socioeconomic disadvantage. One unintended consequence was observed: self-reported household waste of fruit and vegetables was higher among intervention families after 6 months of intervention exposure.

The economic balance sheet suggests that the net effect of the intervention after 6 months is positive from an individual or household perspective, with health and well-being benefits and no increases in money spent or shopping time. The cost-effectiveness of the intervention from retailer and societal perspectives are generally positive; however, there are uncertainties over the cost

This synopsis should be referenced as follows:
Vogel C, Crozier S, Dhuria P, Lawrence W, Moon G, Muir S, *et al.* Evaluation of a supermarket placement strategy to nudge healthier dietary habits: synopsis of the WRAPPED study. *Public Health Res* 2026;**14**(14). https://doi.org/10.3310/KSDT8756

of the intervention and the likelihood of persistence of dietary improvements.

Assessment of intervention implementation and the policy context within which this intervention study was implemented showed that across the food system, stakeholders largely support supermarkets' efforts to make healthier choices easier for citizens. Many stakeholders also support the UK government's ban on placing unhealthy products in prominent locations, such as checkouts, aisle ends and store entrances, in large retail chains across England. Concerns were raised, however, that the ban does not go far enough in making the layouts of retail outlets healthier. There were concerns that loopholes would be exploited by businesses to sell unhealthy products, and insufficient resources for enforcement would lead to inconsistencies in regulations' implementation.

Collectively, the results of this study provide novel evidence to support refinement of the UK Food (Promotion and Placement) Regulations to require a produce section near supermarket entrances. Policy strategies to reduce household waste of fresh produce could also be considered to avoid unintended consequences of such a policy change. For example, promoting the sale of loose produce to enable greater choice in quantities purchased is a recommended strategy for reducing household waste of fruit and vegetables.

Future research should continue to build the evidence on which healthy eating interventions are effective in retail outlets. Undertaking large, adequately powered real-world supermarket intervention studies using robust scientific study designs is required, alongside process and economic evaluations, to provide sufficient evidence on effective food policy recommendations to address poor diet and inequalities in the UK and internationally.

Additional information

CRediT contribution statement

Christina Vogel (https://orcid.org/0000-0002-3897-3786): Conceptualisation (equal), Methodology (lead), Data curation (equal), Formal analysis (lead), Validation (support), Writing – original draft (lead), Writing – editing and reviewing (lead).

Sarah Crozier (https://orcid.org/0000-0002-9524-1127): Formal analysis (lead), Data curation (equal), Validation (lead), Writing – editing and reviewing (support).

Preeti Dhuria (https://orcid.org/0000-0003-2803-4424): Project management (lead), Methodology (support), Data curation (equal), Formal analysis (support), Writing – editing and reviewing (support).

Wendy Lawrence (https://orcid.org/0000-0003-1264-0438): Methodology (support), Writing – editing and reviewing (support).

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Joanne Lord (https://orcid.org/0000-0003-1086-1624): Methodology (support), Formal analysis (lead), Validation (lead), Writing – editing and reviewing (support).

Janet Cade (https://orcid.org/0000-0003-3421-0121): Methodology (support), Writing – editing and reviewing (support).

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Cyrus Cooper (https://orcid.org/0000-0003-3510-0709): Conceptualisation (equal), Methodology (support), Writing – editing and reviewing (support).

Janis Baird (https://orcid.org/0000-0002-4039-4361): Conceptualisation (equal), Methodology (support), Formal analysis (support), Writing – editing and reviewing (support).

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Data-sharing statement

Data described in this synopsis that have been collected by the research team during this study and, which can be anonymised, will be made available upon reasonable request to the corresponding author, pending their approval. Purchasing and sales data are confidential and will not be made available because of the conditions of the agreement with the commercial collaborator.

Ethics statement

Ethical approval for this study was obtained from the University of Southampton, Faculty of Medicine Ethics Committee (ID 20986.A9), 4 June 2019.

Information governance statement

The University of Southampton is committed to handling all personal information in line with the UK Data Protection Act (2018) and the General Data Protection Regulation (EU GDPR) 2016/679. Under the Data Protection legislation, the University of Southampton is the Data Controller for the data collected by the research team during this study. For purchasing and sales data, the University of Southampton is the Data Processor and Iceland Foods is the Data Controller. You can find out more about how we handle personal data, including how to exercise your individual rights and the contact details for University of Southampton Data Protection Officer here: https://www.southampton.ac.uk/about/governance/information-publications/data-protection-information-breach and for Iceland Foods Ltd here: https://about.iceland.co.uk/?_gl=1*1aqffab*_up*MQ..*_gs*MQ..&gclid=Cj0KCQiAhaHMBhD2ARIsAPAU_D5NJ5JBv5rG-Dol6hUyhUz64zuDOMrQUWFswKBuhVJ5r-QvOGsLKoaAp0-EALw_wcB&gclsrc=aw.ds

Disclosure of interests

Full disclosure of interests: Completed ICMJE forms for all authors, including all related interests, are available in the toolkit on the NIHR Journals Library report publication page at https://doi.org/10.3310/KSDT8756.

Primary conflicts of interest: No funding was received from the supermarket involved in this study, and all analyses were conducted independently, without involvement of supermarket staff. Christina Vogel, Sarah Crozier, Preeti Dhuria, Graham Moon, Wendy Lawrence, Kylie Ball, Sarah Muir, Marcia Takahashi and Keith Cooper have no conflicts of interest to declare. Janis Baird was on NIHR PHR programme funding board (May 2019–23). She was a core member (2016–22) and vice chairperson (2018–22) of a National Institute for Health and Care Excellence (NICE) Public Health Advisory Committee. Joanne Lord has been on HTA Commissioning Sub-Board (2016–7), HTA National Stakeholder Advisory Group (2015–23), HTA Funding Committee Policy Group (2014–6) HTA Commissioning Committee: (2011–6) and Evidence Synthesis Programme Grants Committee/Evidence Synthesis Programme Advisory Group (2017–20). Janet Cade is Director of a spin-out company Dietary Assessment Ltd and holds founder shares. She is the chair of advisory board for British Nutrition Foundation and leads a collaborating centre in nutritional epidemiology for WHO. Cyrus Cooper has received consultancy, lecture fees and honoraria from AMGEN, GKS, Alliance for Better Bone Health, MSD, Eli Lilly, Pfizer, Novartis, Servier, Medtronic and Roche. The study described in this synopsis is not related to these conflicted relationships.

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This synopsis was published based on current knowledge at the time and date of publication. NIHR is committed to being inclusive and will continually monitor best practice and guidance in relation to terminology and language to ensure that we remain relevant to our stakeholders.

Trial registration

This trial is registered as ClinicalTrials.gov NCT03573973.

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Award publications

This synopsis provided an overview of the research award *Nudging healthier dietary habits: evaluation of a supermarket placement strategy in the* WRAPPED *study*.

Other articles published as part of this thread are:

Vogel C, Crozier S, Dhuria P, Lord J, Moon G, Lawrence W, *et al.* Impact of supermarket fruit and vegetable placement on store sales, customer purchasing, diet and household waste: A prospective matched-controlled cluster trial. *PLOS Med* 2026 Mar 31;**23**:e1004575. https://doi.org/10.1371/journal.pmed.1004575

Baird J, Dhuria P, Payne H, Crozier S, Lawrence W, Vogel C. Implementation of a UK supermarket intervention to increase purchasing of fresh fruit and vegetables: process evaluation of the WRAPPED natural experiment. *Int J Behav Nutr Phys Act* 2024;**21**:128. https://doi.org/10.1186/s12966-024-01679-3

Vogel C, Dijkstra C, Huitink M, Dhuria P, Poelman M, Mackenbach J, *et al*. Real-life experiments in supermarkets to encourage healthy dietary-related behaviours: opportunities, challenges and lessons learned. *Int J of Behav Nutr Phys Act* 2023;**20**:73. https://doi.org/10.1186/s12966-023-01448-8

For more information about this research, please view the award page (www.fundingawards.nihr.ac.uk/award/17/44/46).

Additional outputs

Vogel C, Crozier S, Dhuria P, Shand C, Lawrence W, Cade J, *et al*. Protocol of a natural experiment to evaluate a supermarket intervention to improve food purchasing and dietary behaviours of women (WRAPPED study) in England: a prospective matched controlled cluster design. *BMJ Open* 2020;**10**:e036758. https://doi.org/10.1136/bmjopen-2020-036758

Shaw S, Ntani G, Baird J, Vogel C. A systematic review of the influences of food store product placement on dietary related outcomes. *Nutr Rev* 2020;**78**:1030–45. https://doi.org/10.1093/nutrit/nuaa024

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Muir S, Dhuria P, Vogel C. Government must proceed with landmark anti-obesity regulations in England. *BMJ* 2022;**378**:o2358. https://doi.org/10.1136/bmj.o2358

Muir S, Dhuria P, Roe E, Lawrence W, Baird J, Vogel C. UK Government's new placement legislation offers a solid start to creating healthy retail outlets: a rapid qualitative analysis of consumer, business, enforcement and health stakeholder perspectives. *BMC Med* 2023;**21**:33. https://doi.org/10.1186/s12916-023-02726-9

Dhuria P, Muir S, Lawrence W, Roe E, Crozier S, Cooper C, et al. Women consumers' views on legislation to restrict prominent placement and multibuy promotions of high fat, sugar and salt products in England: a qualitative perspective. *Int J Health Policy Manag* 2023;**12**:7597. https://doi.org/10.34172/ijhpm.2023.7597

Dhuria P, Muir S, Jenner S, Roe E, Lawrence W, Baird J, Vogel C. 'If government is saying the regulations are important, they should be putting in funding to back it up' In-depth analysis of enforcement officers' perspectives of landmark The Food (Promotions and Placement) (England) regulations 2021. *BMC Med* 2024;**22**:514. https://doi.org/10.1186/s12916-024-03720-5

Dhuria P, Muir S, Shaw S, Lawrence W, Roe E, Baird J, Vogel C. 'It will sort of drive us to rethink our approach to high fat salt and sugar product' – a qualitative analysis of businesses' reactions to the landmark Food (Promotions and Placement) regulations in England. *BMC Med* 2025;**23**:576. https://doi.org/10.1186/s12916-025-04384-5

Cooper K, Takahashi MT, Vogel C, Baird J, Dhuria P, Crozier S, Lord J. Cost effectiveness of an intervention to increase fruit and vegetable consumption for women customers of discount supermarkets. Under review.

Dhuria P, Muir S, Bird A, Lawrence W, Roe E, Baird J, Vogel C. The Food (Promotions and Placement) regulations begin to shift the onus for healthier choices from individuals to businesses: in-depth perspectives from health experts. *BMC Med* 2025;**23**:686. https://doi.org/10.1186/s12916-025-04484-2

Policy-relevant outputs to date

Christina Vogel was invited to give oral evidence to the House of Lords Select Committee on Food, Poverty, Health and Environment in November 2019. Among other evidence, she described the pilot study results and full-scale trial design that was underway.

The WRAPPED study team submitted a response to the DHSC consultation on the proposal to restrict promotions of products HFSS by location and multibuy promotions in April 2019.

The WRAPPED study team submitted a response to the DHSC consultation on the proposed regulations to restrict promotions of products HFSS by location and multibuy price promotions, including enforcement activities, in February 2021.

Members of the study team published an article in *The Conversation* outlining the importance of the UK government Food (Promotions and Placement) regulations which were implemented in October 2022, amid fears implementation would be delayed alongside the promotions component.

Policy brief developed to summarise policy-relevant findings from the WRAPPED process evaluation on the policy context and pre-implementation evaluation of the Food (Promotions and Placement) regulations, February 2023.

Janis Baird participated in the working group of the Science Advice to Policy by European Academies (SAPEA) on the Scientific Opinion on sustainable food consumption, June 2023.

Christina Vogel was invited to give oral evidence to the House of Lords Select Committee on Food, Diet and Obesity in March 2024. Among other evidence, she described a range of findings from the WRAPPED study outcome and process evaluation.

The WRAPPED study team submitted a response to the House of Lords Select Committee on Food, Diet and Obesity consultation on food and health policy options in April 2024.

The WRAPPED team submitted a response to the Scottish consultation to restrict promotions of food and drink high in fat, sugar or salt – consultation on the detail of proposed regulations in May 2024.

The WRAPPED study team submitted written evidence to the House of Commons Select Committee on Food and Weight Management consultation in September 2025.

Christina Vogel was invited to give oral evidence to the House of Commons Health Select Committee on Food and Weight Management in November 2025. Among other evidence, she described a range of findings from the WRAPPED study outcome and process evaluation.

About this synopsis

The contractual start date for this research was in March 2019. This synopsis began editorial review in March 2025 and was accepted for publication in October 2025. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The Public Health Research editors and publisher have tried to ensure the accuracy of the authors' synopsis and would like to thank the reviewers for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this synopsis.

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List of abbreviations

ATNi	Access to Nutrition initiative
coI	coinvestigator
DHSC	Department of Health and Social Care
DAG	directed acyclic graph
GDPR	General Data Protection Regulation
HFSS	high in fat, sugar and salt
IMD	Index of Multiple Deprivation
MRC	Medical Research Council
PI	principal investigator
PPI	patient and public involvement
QALY	quality-adjusted life-year
SKU	stock-keeping unit
WRAPPED	Women's Responses to Adjusted Product Placement and its Effects on Diet

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