

Effect of a price discount and consumer education strategy on food and beverage purchases in remote Indigenous Australia: a stepped-wedge randomised controlled trial



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Summary

Background Evidence is mounting that price discounts can be effective in improving diet. This study examined the effectiveness of a 20% price discount on food and drink purchases with and without consumer education in remote Indigenous Australia.

Methods A 20% discount on fruit, vegetables, water, and artificially sweetened soft drinks was applied for 24 weeks in 20 communities in remote Indigenous Australia where the community store was managed by the Arnhem Land Progress Aboriginal Corporation (ALPA) or Outback Stores (OBS) in a stepped-wedge randomised trial. Communities were randomly allocated to a fixed framework of five sets of four stratified by store association; ten stores (two in each set) were randomly assigned to receive consumer education. A store from each of the ALPA and OBS store groups (contained in separate opaque envelopes) was selected, and stores in turn continued to be consecutively allocated to the fixed store set framework, starting with the first store slot in the first store set, until all stores had been allocated. The effect of the discount on the weight of fruit and vegetables purchased (the primary endpoint) was assessed using weekly store sales data and mixed models per protocol. We did sensitivity analyses by repeating the analyses with the outliers included and repeating the analyses for the primary outcome measure removing each store one at a time. This trial was registered with Australian New Zealand Clinical Trials Registry, number ACTRN12613000694718.

Findings Weekly store sales data on all food and drink products sold in 20 stores were collected from July 1, 2012, to Dec 28, 2014. Price discount alone was associated with a 12·7% (95% CI 4·1–22·1) increase in purchases in grams of fruit and vegetables combined (primary outcome), and a 19·8% (6·2–35·1) increase post discount (after vs before); an effect of 12 g and 18 g per capita per day. Sensitivity analyses did not modify the results for the primary outcome measure.

Interpretation A 20% discount can only increase fruit and vegetable purchases to help protect against obesity and diet related disease to a certain extent. Large discounts might have a greater impact than small discounts. Creative merchandising approaches to consumer education could also be considered alongside fiscal interventions to achieve marked improvements in diet.

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Introduction

Poor diet has surpassed tobacco use as the leading preventable risk factor for the global burden of disease.¹ Low fruit and vegetable intake is one of the top ten risk factors contributing to mortality worldwide.² Socioeconomically disadvantaged populations tend to consume fewer fruit and vegetables and have a disproportionate burden of preventable diseases.³ Indigenous Australians are one of the most disadvantaged populations in Australia and have a burden of disease 2·3 times that of non-Indigenous Australians.⁴ Around 37% of this disease burden is preventable by reducing exposure to modifiable risk factors, such as dietary factors, which account for 10% of the total disease burden and 15% of the health gap between Indigenous and non-Indigenous Australians.⁴

Evidence is mounting that price discounts are effective in improving diet;^{5–10} the evidence for nutrition education about food purchasing is less clear, and evidence of the effectiveness of these strategies in socioeconomically disadvantaged populations is scarce.⁶ Compensatory purchasing of non-targeted food and beverages in the context of price discounts is also poorly understood, as is its effect on total dietary intake and health outcomes.¹¹ The financial effect of fiscal strategies on retail performance is also poorly understood.¹²

Price, preference, convenience, product quality, and advertising are key drivers of consumer behaviour and diet.¹³ In theory, price discounts or subsidies provide a fiscal incentive for consumers to purchase more of a target food, with the effect being an improvement in overall diet.¹⁴ A review in 2010 of studies from the USA

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Research in context

Evidence before this study

We searched PubMed, EBSCO, and Science Direct databases on May 8, 2014, with the search terms “Fast food*”, “convenience store*”, “take away*”, “restaurant*”, “dining room*”, “cafeteria*”, “café*”, “diner”, “food store*”, “food outlet*”, “corner store*”, “supermarket*”, “grocer*”, “vending machine*”, “automatic food dispenser*”, “community store*”, “diet”, “nutrition”, “food*”, “vegetable*”, or “fruit*”, “availab*”, “affordab*”, “access*”, “strateg*”, “promotion*”, “program*”, “initiative*”, “intervention*”, “practice*”, “marketing*”, “activit*”, or “food quality” for papers published in English, Portuguese, or Spanish. The results of this systematic review have been published in *BMC Public Health* in 2014. The evidence shows that there is mounting evidence that price discounts are effective in increasing healthy food purchasing. The evidence for nutrition education in modifying purchasing is less clear, and evidence of the effectiveness of these strategies in socioeconomically disadvantaged populations is scarce. To date, and to our knowledge, three randomised controlled trials (RCTs) have assessed the effectiveness of a price discount on food purchasing with and without nutrition education in socioeconomically disadvantaged populations. Results from all three studies showed an effect on fruit or vegetable purchases with the price discount, no additional benefit when combined with nutrition education, and no effect on fruit or vegetable purchases with nutrition education alone.

Added value of this study

To our knowledge, this is the first price discount trial done in a largely socioeconomically disadvantaged population, that has applied the intervention to the whole of population, and that assessed change using objective store sales data. Our data add valuable evidence to the understanding of fiscal interventions on food and drink purchasing because it examined the effect of all food and drink purchases. Our findings are consistent with previous price discount RCTs—ie, that a price discount on fruit and vegetables can increase fruit and vegetable purchases.

Implications of all the available evidence

A 20% discount can only increase fruit and vegetable purchases to levels that help protect against cardiovascular disease, cancer, diabetes, and obesity, to a certain extent. The findings of the SHOP@RIC trial suggest that incremental improvements in fruit and vegetable purchasing could potentially be achieved with sizeable price discounts applied and promoted at regular intervals on a rotating range of fruit and vegetables. A price increase (or tax) on sugar-sweetened soft drinks might need to be implemented alongside a price discount to negate the consequential increase in calories purchased and to encourage a reduction in sugar sweetened soft drink consumption. A consumer education strategy that uses retail merchandising practices to promote the purchase of healthy foods and discourages the purchase of less healthy foods, alongside fiscal interventions, might help achieve the improvements in diet needed to substantially affect health at a population level.

on price elasticity of demand showed that fruit has favourable price elasticity of 0.70 and vegetables of 0.58—ie, a 10% reduction in the price of these foods would increase purchases on average by 7.0% and 5.8%, respectively.¹⁵ However, the authors concluded that changes in prices alone were not likely to increase the consumption of fruit and vegetables to recommended levels, but when combined with public education campaigns and other regulations affecting the food environment, price changes might have a multiplicative effect that could substantially improve diets.¹⁵

Nutrition education interventions, including effective behaviour change techniques such as goal-setting and practical skill-building strategies, show some promise in promoting increased fruit and vegetable purchasing and consumption.^{16–18}

To date, three randomised controlled trials (RCTs) have assessed the effectiveness of a price discount on food purchasing with and without nutrition education including socioeconomically disadvantaged populations.^{19–21} All three RCTs showed an effect on fruit or vegetable purchases with the price discount, no additional benefit when combined with nutrition education, and no effect on fruit or vegetable purchases with nutrition education alone.

These RCTs provide high-quality evidence on the effect of food pricing strategies with and without nutrition education. However, evidence on the effects of food pricing strategies on whole populations and on compensatory purchasing, both of which are required to estimate population level cost benefits of fiscal interventions, is scarce.^{10,22,23} Despite the rapidly growing literature about food pricing strategies, there is still little high-quality evidence on healthy store retailing, in which nutrition education approaches to encourage healthy food purchasing are implemented at the point of sale in the store setting.¹²

Whole population RCTs assessing point-of-sale interventions are difficult to do because of the risk of contamination from adjacent retailers. The Northern Territory of Australia provides a unique and ideal trial location because communities are sparsely located and community stores are the main food source for most people.²⁴ In this context, store-level purchasing is a powerful proxy of community-level diet.²⁵

SHOP@RIC (Stores Healthy Options at Remote Indigenous Communities) was a trial done in partnership with two major food retail associations in the Northern Territory of Australia: the Arnhem Land Progress Aboriginal Corporation (ALPA) and Outback

Stores (OBS).²⁶ This study was done in close collaboration with the community leaders to seek solutions to counteract poor diet and its effect on health. Our aim was to measure the effect of a price discount on food and drink purchases with and without an in-store consumer education strategy applied at the population level.

Methods
Study design

This stepped-wedge randomised design protocol has been described previously.²⁶ The study comprised a 49 week baseline data-collection phase, followed by a 24 week intervention phase (price discount with or without consumer education strategy) and a 24 week post intervention follow-up (figure 1). The intervention was rolled out in five groups of four stores, at 8 week intervals. We assessed intervention effects using objective weekly sales data.

We aimed to test the hypothesis that there would be a beneficial effect of both a 20% price discount and the addition of consumer education on the primary outcome measure of per capita daily weight (g) purchases of combined fruit and vegetables, and on secondary outcome measures (purchase of food and beverages and nutrient composition).

Communities (the equivalent of small towns) were eligible if they were located in very remote regions of the Northern Territory, where access to goods and services is severely restricted²⁷ and extreme socioeconomic disadvantage is concentrated.^{28,29} Other eligibility criteria were that each community had a population more than 100 people, the community store was managed by either of the two store associations ALPA or OBS, and no other food outlet was present within 20 km. 20 communities (consisting of eight ALPA and 12 OBS stores) met the eligibility criteria, were invited to participate, and consented to participate. All stores were located 20 km or more from another food outlet with 13 stores located more than 50 km away. Estimated total population for these communities combined was 8515 people (roughly 95% Indigenous Australian; ranging in size from 125 to 1079 people per community), which represents about 21% of the very remote Indigenous population in Northern Territory and about 9% of the very remote Indigenous population in Australia.³⁰

Ethical approval was granted by the combined Northern Territory Department of Health and Menzies School of Health Research Human Research Ethics Committee (HREC-2012-1711), the Central Australian Human Research Ethics Committee (HREC-12-13

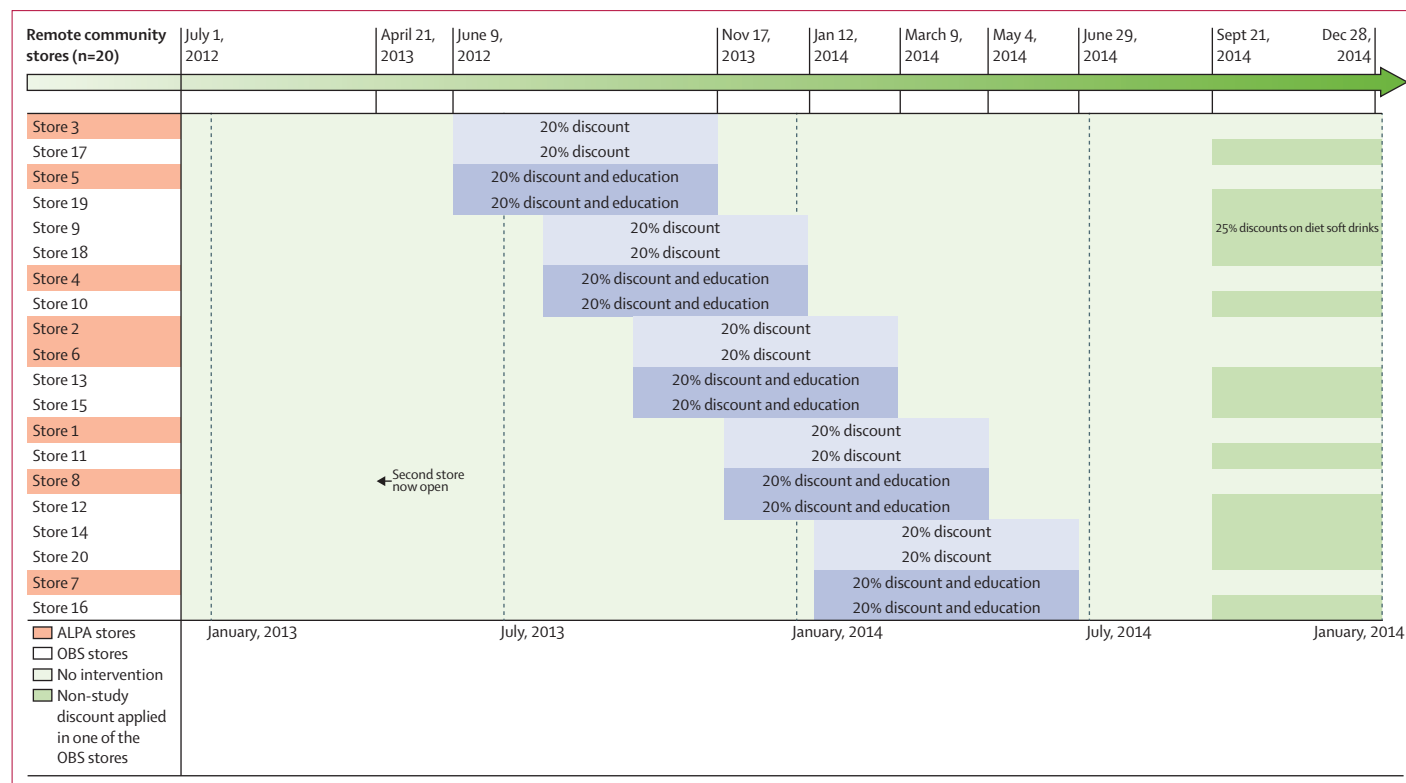


Figure 1: Study design
 Intervention phases during 131 weeks of sales data from July, 2012, to December, 2014. Four of eight ALPA stores had price discounts and consumer education. Six of 12 OBS stores had price discounts and consumer education. ALPA=Arnhem Land Progress Aboriginal Corporation. OBS=Outback Stores.

	Themes	Key messages	Activities*
Month 1	Health benefits of fruit, vegetables, and water	Fruit, vegetables, and water are important for yours and your family's health	Themed poster; themed activity sheet with prizes†; in-store sugar in drinks display; taste testing of water and diet soft drinks; receipt competition with prize‡
Month 2	How much fruit, vegetables, and water to eat and drink	Have lots of fruit, vegetables, and water everyday	Themed poster; themed activity sheet with prizes†
Month 3	Having healthy, quick, and easy meals	Healthy foods can be fast, easy, and fun.	Themed poster; themed activity sheet with prizes†; in-store cooking demonstration with vegetables and meat; receipt competition with prize‡
Month 4	Supporting family and friends to enjoy more healthy food and drinks	Children learn to eat healthy foods from their family	Themed poster; themed activity sheet with prizes†
Month 5	Trying and enjoying new healthy foods	Once is not enough; new tastes take time to like	Themed poster; themed activity sheet with prizes†; in-store taste testing of different types of fruit and vegetables
Month 6	How to buy more healthy food and drinks to make the most of your money	Save your money, spend less on soft drinks	Themed poster; themed activity sheet with prizes†; receipt competition with prize‡

*Additional activities included a school drawing competition that occurred prior to the launch of the SHOP@RIC strategy, drawings specific to each community were used in the posters, and display of fridge stickers promoting fruit, vegetables, and water over the 6 month period. †Activity sheets were given out and made available for consumers to take from a stand in the store in the first 1–2 weeks of each month; three prize winners were drawn at the end of this time each month. ‡A prize draw of receipts for every purchase of \$10 or more of discounted products.

Table 1: Themes, key messages, and activities of the nutrition education strategy, by month

	Sales, AU\$ per capita per day (%)	Weight, g per capita per day (%)	Energy, MJ per capita per day (%)
Food and beverages	11.71 (100%)	1361 (100%)	8.532* (100%)
Food and beverages, healthy	4.95 (42%)	695.4 (51%)	..
Food	8.72 (75%)	733.9 (54%)	7.541 (88%)
Beverages	2.98 (25%)	626.8 (46%)	0.991 (12%)
Food†			
Fruit and vegetables, fresh or frozen§	0.58 (7%)	90.8 (12%)	..
Fruit, fresh or frozen	0.28 (3%)	37.4 (5%)	..
Vegetables, fresh or frozen	0.30 (3%)	53.4 (7%)	..
All other food, healthy	3.44 (39%)	386.3 (53%)	..
All other food, less healthy	4.42 (51%)	247.0 (34%)	..
Fruit and vegetables, total§	0.71 (8%)	104.1 (14%)	..
Beverages‡			
Water	0.08 (3%)	43.5 (7%)	..
Soft drinks, diet	0.30 (10%)	62.8 (10%)	..
Soft drinks, regular	1.83 (61%)	364.7 (58%)	..
All other beverages	0.78 (26%)	155.7 (25%)	..

The baseline period represents 49 weeks of sales data from all 20 stores from July, 2012, with outliers included. The percentages of macronutrients in total food and beverages sales were 12% protein, 59% carbohydrate, 28% total fat (11% saturated fat), and 33% sugar. Total food and beverages sales contained 2623.5 mg of sodium per capita per day. *Weighted per capita energy requirement based on the total population age and sex distribution was 8.880. The estimated energy requirement was derived from the current Australian dietary recommendations (2006 Nutrient Reference Values) at a physical activity level of 1.6 (sedentary), and height of 1.7 m for men and 1.6 m for women. Proportion of women likely to be pregnant or breastfeeding at one time was estimated from 2010 birth data for very remote Australia and crossreferenced to the total population in the relevant age groups in very remote Australia. †Percentages of total food. ‡Percentages of total beverages. §Total fruit and vegetables includes dried and tinned fruit and vegetables, which were not discounted; only fresh or frozen fruits and vegetables were discounted.

Table 2: Baseline sales of food and beverages and energy provided

HREC-2012–1711), and Deakin University Human Research Ethics Committee (HREC-2012–243 HREC-2012–1711). Community store boards provided written consent.

Procedures

A 20% price discount on all fresh and frozen fruit and vegetables (excluding frozen potato products), all bottled water, and all artificially sweetened soft drinks was applied at the point of sale and the discount promoted in stores. The value of the price discount was reimbursed to the store associations using Australian National Health and Medical Research Council research funding. Promotional materials (large pull-up banner, price tickets [shelf talkers], shelf stripping, and fridge stickers) were developed by an expert working group and made available to stores within 2 weeks of intervention commencement.

The consumer education strategy was developed to increase intake of fruit, vegetables, and water and decrease the intake of sugar sweetened beverages with an intervention mapping approach and was informed by social cognitive theory,³¹ a working group with remote food retail and public health expertise, and interviews with public health nutritionists who worked in the ten communities. The strategy was designed to require minimal resources, and comprised six themes delivered over the 24 week intervention period with a set of supporting activities (table 1). Trained local community residents were involved where possible to maximise consumer engagement. Store managers, public health nutritionists who worked in the communities, and research staff also supported implementation.

Randomisation

Before commencement, all communities were randomly allocated by the team statistician to a fixed framework of five sets of four with at least one ALPA store and two OBS stores in each set, and with one ALPA store and one OBS store in each set to receive consumer education. A store from each of the ALPA and OBS group of stores (contained in separate opaque envelopes) was selected, and stores in

turn continued to be consecutively allocated to the fixed store set framework, starting with the first store slot in the first store set, until all stores had been allocated (figure 1).

Outcomes

The primary outcome was per capita purchases (in grams) of fruit and vegetables combined. The secondary outcomes were per capita purchases (in grams) of water, artificially sweetened soft drinks, regular soft drinks, healthy food (excluding fruit and vegetables), less healthy food, other beverages, and Australian Health Survey (AHS) food groups and nutrients; per capita purchases (in grams) of water, artificially sweetened soft drinks, regular soft drinks, and all other beverages, relative to all beverage purchases; per capita purchases (in grams) of fruit and vegetables combined, fruit, vegetables, healthy food (excluding fruit and vegetables), and less healthy food, relative to all food purchases. Weekly store sales data on all food and drink products sold were collected from July 1, 2012, to Dec 28, 2014, and uploaded to a purpose-built database³² along with product codes, quantity sold, and expenditure. We assigned the 7404 unique food and beverage items a unit weight or volume, coded each item into food categories, and expertly linked to the Food Standards Australia and New Zealand Australian Food, Supplement and Nutrient database (AUSNUT 2011–13).³³ This database provides information on 51 nutrients per 100 g of edible portion. We verified and included 99% of food and drink items. We calculated a total weight sold for each food and drink item (adjusted for edible portion and specific gravity³³). We categorised all food and beverages as healthy and less healthy using a modified health star rating system³⁴ (appendix p 1–2).

Using a purpose-built standardised electronic form, store managers reported on events or activities occurring in the store or wider community such as population movement (due to events such as funerals, ceremonies, and sporting events), pricing promotions, and delivery disruptions each week. We used these data to identify outliers in store sales data. An outlier was defined as a week in which a data point was judged as extreme for any of the outcome measures with evidence of major population movement in or out of the community, or where store provisions were severely disrupted resulting in, or close to, zero sales.

Statistical analysis

We estimated that a sample of 20 stores would have approximately 95% power to detect a common 20% change in (geometric) mean sales of the primary outcome (combined fruit and vegetables in g per person per day) due to the price discount intervention (at the 5% significance level), and approximately 97% power to detect a 20% change due to the consumer education strategy.²⁶

We did separate crude analyses for the price discount alone and combined strategies on the percentage change

	Weight, g per capita per day (%)	
	AHS food groups	AHS food groups, healthy
Beverages	612.4 (45%)	210.6 (16%)
Cereal and cereal products	266.6 (20%)	207.9 (15%)
Fats and oils	18.8 (1%)	17.8 (1%)
Fish and seafood	3.9 (<1%)	2.3 (<1%)
Fruit and fruit dishes	41.1 (3%)	40.1 (3%)
Eggs and egg products	18.8 (1%)	18.8 (1%)
Meat and meat products	118.1 (9%)	58.7 (4%)
Milk and milk products	98.7 (7%)	69.3 (5%)
Seeds and nuts	2.1 (<1%)	0.3 (<1%)
Soups and savoury sauces and condiments	8.3 (<1%)	1.2 (<1%)
Vegetables, legumes, and pulses	67.9 (5%)	67.9 (5%)
Snacks	7.6 (<1%)	0 (0)
Sugar and confectionery	92.1 (7%)	0.2 (<1%)
Miscellaneous	4.4 (<1%)	0.2 (<1%)

The baseline period represents 49 weeks of sales data from all 20 stores from July, 2012, with outliers included. AHS=Australian Health Survey. AHS food groups are based on a classification system developed for reporting food and nutrient intakes for the 2011–13 AHS, Food Standards Australia New Zealand.

Table 3: Baseline weight of food and beverage sales by AHS food group

for outcome measures during (24 weeks) and after intervention (24 weeks) compared with before intervention (24 weeks).

We log-transformed data for each of the outcomes for mixed models analyses. All models included random effects for the stores and fixed effects for store association (ALPA or OBS), the 8 week steps (to adjust for common temporal variation), the phase (before, during, and after the discount period), and the difference that the consumer education strategy (price discount alone vs combined strategy) had on sales during and after the discount period. Post protocol, a fractional effect was assumed for the education strategy for the first few weeks; specifically $\log(\text{week of combined strategy} + 1) / \log(25)$ because delivery of the combined strategy was intentionally phased. The enduring effect of the consumer education strategy was assumed to be constant over time, though it was not constrained in any way by the size of the combined strategy effect during the discount period. Within-store residuals were assumed to have an autoregressive structure of order 2. We used the mixed, reml (restricted maximum likelihood) command in Stata (version 14.2). After excluding outliers, we aggregated weekly data into fortnightly sales to overcome what appeared to be an on-pay week and off-pay week cycle in some of the stores, before calculating measures of sales and fitting models. 62 weeks, representing 2% of the total weeks for all stores combined were classified as outlier weeks and not included. Data for store 8 before April, 2013, (before the 8 week step immediately before the intervention) were also excluded because a second store opened in the community

See Online for appendix

	Price discount only*		Combined vs price discount only†	
	% change (95% CI)	p value	% change (95% CI)	p value
Sales (\$ per kg)				
Fruit and vegetables, fresh or frozen				
During	-17.6% (-20.3 to -14.7)‡	<0.0001	2.1% (-2.8 to 7.3)	0.41
After	2.1% (-3.0 to 7.4)	0.43	2.3% (-2.1 to 7.0)	0.31
Fruit, fresh or frozen				
During	-18.6% (-23.1 to -13.8)‡	<0.0001	3.5% (-4.7 to 12.4)	0.41
After	-0.7% (-9.0 to 8.2)	0.87	5.4% (-2.2 to 13.5)	0.17
Vegetables, fresh or frozen				
During	-17.5% (-19.7 to -15.1)‡	<0.0001	-0.5% (-4.4 to 3.5)	0.81
After	2.5% (-1.7 to 6.9)	0.25	0.6% (-2.9 to 4.3)	0.73
All other food, healthy				
During	-1.2% (-3.4 to 1.1)	0.30	4.8% (0.8 to 9.0)‡	0.019
After	-1.5% (-4.9 to 2.1)	0.41	2.3% (-1.5 to 6.2)	0.24
All other food, less healthy				
During	-0.3% (-3.7 to 3.2)	0.85	1.5% (-3.5 to 6.8)	0.56
After	-5.5% (-10.4 to -0.4)‡	0.033	3.0% (-1.6 to 7.9)	0.21
Water				
During	-21.2% (-25.0 to -17.1)‡	<0.0001	2.9% (-5.9 to 12.5)	0.53
After	-2.5% (-9.8 to 5.4)	0.52	3.0% (-5.5 to 12.4)	0.50
Soft drinks, diet				
During	-17.2% (-20.0 to -14.2)‡	<0.0001	1.4% (-3.5 to 6.5)	0.58
After	3.7% (-1.6 to 9.3)	0.17	-4.8% (-8.9 to -0.5)‡	0.029
Soft drinks, regular				
During	-0.8% (-2.4 to 0.7)	0.30	-0.7% (-2.9 to 1.6)	0.56
After	-0.4% (-2.7 to 2.0)	0.76	-1.0% (-2.9 to 1.0)	0.34
All other beverages				
During	0.2% (-2.8 to 3.2)	0.90	-1.3% (-6.0 to 3.7)	0.61
After	-0.7% (-5.2 to 4.0)	0.76	1.3% (-3.3 to 6.1)	0.58
Sales (\$)				
Food and beverages, total				
During	3.5% (-2.9 to 10.4)	0.29	6.5% (-3.7 to 17.6)	0.22
After	7.3% (-2.8 to 18.5)	0.16	1.7% (-7.3 to 11.6)	0.71
Food				
During	4.0% (-2.5 to 10.8)	0.23	6.5% (-3.5 to 17.5)	0.21
After	8.4% (-1.7 to 19.5)	0.11	1.7% (-7.1 to 11.3)	0.72
Beverages				
During	2.8% (-4.7 to 10.9)	0.48	7.0% (-4.9 to 20.5)	0.26
After	5.3% (-6.3 to 18.3)	0.39	2.0% (-8.6 to 13.9)	0.72
Fruit and vegetables, fresh or frozen				
During	-7.7% (-15.4 to 0.6)	0.069	10.6% (-2.2 to 25.2)	0.11
After	20.0% (5.1 to 36.9)‡	0.0069	2.4% (-8.3 to 14.4)	0.67
Fruit, fresh or frozen				
During	-2.0% (-13.6 to 11.1)	0.75	6.7% (-10.6 to 27.3)	0.47
After	27.6% (5.4 to 54.3)‡	0.012	-6.8% (-20.4 to 9.0)	0.38
Vegetables, fresh or frozen				

(Table 4 continues on next page)

at this time, after study commencement (figure 1). Additionally, post-intervention data for all stores from the end of August, 2014, onwards were excluded because of the implementation of a 25% price discount on artificially sweetened soft drinks in OBS stores (figure 1). We derived per capita daily estimates by using Australian census estimates of usual residence by Indigenous location including Indigenous and non-Indigenous status.²⁸

Analyses were done per protocol. Deviations from the protocol were the exclusion of outliers and some baseline and postintervention data as stated above, aggregation of weekly data into fortnightly sales, the fractional effect assumed for the combined strategy for the first few weeks at the start of the intervention, and use of the `reml` command for within store residuals.

We did sensitivity analyses by repeating the analyses with the outliers included and repeating the analyses for the primary outcome measure removing each store one at a time.

This trial is registered with Australian New Zealand Clinical Trials Registry, number ACTRN12613000694718.

Role of the funding source

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

Results

From July 1, 2013, to July 1, 2014, AUS\$11.71 was spent on 1361 g of food and beverages per capita per day in 20 stores in remote Indigenous Australia (table 2). Weight of food and beverages sold as categories by AHS groups are in table 3. Introduction of the price discount reduced the sales of discounted fruit and vegetables (\$/kg) by 17.6%, and when the price discount was stopped, sales returned to levels approximately the same as those before the intervention (table 4). Unit price checks of selected target products verified application of the price discount as intended except for artificially sweetened (diet) soft drinks for which the price discount was not fully applied for the entire 24 weeks for the complete range in seven stores (data not shown).

Complete implementation of the discount promotional materials and consumer education was not achieved in all stores (appendix pp 3–5). All four discount promotional materials were displayed for at least half of the intervention period in 13 stores (appendix pp 3–4). All consumer education posters in four of the ten stores and activity sheets were displayed in five of the ten stores, nine stores completed the school drawing competition, eight stores had taste testing and cooking demonstration activities, and seven stores received all three receipt competitions (appendix p 5).

Average per capita daily edible purchases were 91 g for fresh and frozen fruit and vegetables (37 g fruit, 53 g

vegetables); 386 g for other healthy food and 247 g for less healthy other food; and 44 g for bottled water, 63 g for artificially sweetened soft drink, 365 g for sugar sweetened soft drink (regular soft drink), and 156 g for other beverages (table 2). Fresh and frozen fruit and vegetables contributed 88% of total fruit and vegetable weight purchases.

The crude analysis showed that changes in outcomes during the intervention were mostly in the hypothesised direction (appendix p 6–7), and that there was a large range of differences between stores. Results after the intervention period were also compared with the period before intervention (with no adjustment for secular trends). Temporal variation other than that caused by the interventions (from mixed models) is presented in figure 2. There was considerable seasonal variation for beverages, particularly water.

Application of price discount alone, compared with before the discount was applied, was associated with a 12.7% (95% CI 4.1–22.1) increase in purchases of fruit and vegetables combined (primary outcome), and an increase of 19.8% (6.2–35.1) after the discount (after vs before); an effect of 12 g and 18 g per capita per day (table 4, figure 2A). The immediate effect was greater for fruit purchases (20.6% change, 95% CI 6.8–36.2) than for vegetable purchases (9.0%, 1.2–17.4). The additional benefit of consumer education was an increase of 7.6% (95% CI –3.6 to 20.2) for purchases of fruit and vegetables combined during the discount period, and –1% (–10.0 to 9.5) after the discount period. The benefit was greatest for vegetable purchases; 13.6% (95% CI 2.6 to 25.7) during and 9.1% (–0.2 to 19.3) after the discount period (table 4).

Other food purchases (excluding discounted fruit and vegetables) in g tended to increase with the price discount alone (table 4, figure 3A). Increases in other food purchases during the intervention were 5.8% (95% CI –0.9 to 13.0) for healthy and 5.3% (–1.9 to 13.1) for less healthy food purchases. Increases after the discount compared with before the discount were 10.8% (0.2–22.5) for healthy and 13.4% (1.7–26.4) for less healthy food purchases. No statistically significant additional effects were evident with the combined strategy. Relative to total food purchases, discounted fruit and vegetable purchases increased by 5.3% (–0.9 to 11.8) with the price discount alone and 3.6% (–5.4 to 13.5) after the discount period (table 4). This change was statistically significant for fruit purchases only and only during the discount 12.8% (1.3–25.5). With consumer education, an additional benefit in vegetable purchases (relative to total food purchases) of 7.8% (–0.5 to 16.9) was shown during the discount and 10.5% (2.9 to 18.6) after the discount (table 4).

Total weight of beverage purchases increased by 6.8% (95% CI –1.1 to 15.4) with the price discount alone. The increase in beverages purchases after the discount compared with before the discount period was 5.7%

	Price discount only*		Combined vs price discount only†	
	% change (95% CI)	p value	% change (95% CI)	p value
(Continued from previous page)				
During	–10.5% (–17.4 to –3.1)‡	0.0061	13.1% (1.2 to 26.5)	0.030‡
After	16.5% (3.3 to 31.4)‡	0.013	10.2% (–0.2 to 21.7)	0.056
All other food, healthy				
During	4.5% (–2.4 to 11.9)	0.21	6.9% (–3.8 to 18.7)	0.21
After	8.6% (–2.2 to 20.6)	0.12	0.7% (–8.6 to 11.0)	0.89
All other food, less healthy				
During	4.8% (–2.0 to 12.2)	0.17	5.9% (–4.6 to 17.7)	0.28
After	7.1% (–3.5 to 18.8)	0.20	2.1% (–7.4 to 12.6)	0.67
Water				
During	–6.3% (–19.7 to 9.3)	0.41	10.0% (–12.2 to 37.8)	0.41
After	10.9% (–12.3 to 40.3)	0.39	–4.0% (–21.8 to 17.7)	0.69
Soft drinks, diet				
During	–13.0% (–22.2 to –2.6)‡	0.015	2.6% (–14.0 to 22.4)	0.77
After	–4.2% (–19.4 to 13.8)	0.62	5.7% (–10.4 to 24.6)	0.51
Soft drinks, regular				
During	4.6% (–3.8 to 14.4)	0.29	6.3% (–6.4 to 20.6)	0.35
After	5.5% (–7.1 to 19.9)	0.41	0.6% (–10.5 to 13.0)	0.92
All other beverages				
During	4.9% (–3.9 to 14.4)	0.29	9.6% (–4.8 to 26.1)	0.20
After	5.2% (–8.1 to 20.4)	0.46	3.0% (–9.7 to 17.5)	0.66
Weight (kg)				
Food, total				
During	6.5% (0.0 to 13.4)‡	0.049	3.9% (–5.5 to 14.2)	0.43
After	13.0% (2.7 to 24.3)‡	0.013	–1.4% (–9.6 to 7.6)	0.75
Fruit and vegetables, fresh or frozen				
During	12.7% (4.1 to 22.1)‡	0.0031	7.6% (–3.6 to 20.2)	0.19
After	19.8% (6.2 to 35.1)‡	0.0033	–1% (–10.0 to 9.5)	0.88
Fruit, fresh or frozen				
During	20.6% (6.8 to 36.2)‡	0.0025	2.1% (–13.9 to 21.0)	0.81
After	29.6% (7.8 to 55.8)‡	0.0057	–12.2% (–24.6 to 2.1)	0.092
Vegetables, fresh or frozen				
During	9.0% (1.2 to 17.4)‡	0.023	13.6% (2.6 to 25.7)‡	0.014
After	15.6% (3.3 to 29.3)‡	0.012	9.1% (–0.2 to 19.3)	0.055
All other food, healthy				
During	5.8% (–0.9 to 13.0)	0.093	2.6% (–7.2 to 13.4)	0.61
After	10.8% (0.2 to 22.5)‡	0.046	–1.7% (–10.4 to 7.9)	0.72
All other food, less healthy				
During	5.3% (–1.9 to 13.1)	0.15	4.4% (–6.2 to 16.3)	0.43
After	13.4% (1.7 to 26.4)‡	0.024	–0.5% (–9.9 to 9.8)	0.92
Beverages, total				
During	6.8% (–1.1 to 15.4)	0.094	7.6% (–4.6 to 21.3)	0.23
After	5.7% (–6.1 to 19.0)	0.36	2.1% (–8.6 to 14.2)	0.71
Water				
During	17.6% (1.1 to 36.8)‡	0.036	9.8% (–11.9 to 36.8)	0.41
After	12.1% (–11.0 to 41.2)	0.33	–6.0% (–23.0 to 14.7)	0.54

(Table 4 continues on next page)

	Price discount only*		Combined vs price discount only†	
	% change (95% CI)	p value	% change (95% CI)	p value
(Continued from previous page)				
Soft drinks, diet				
During	5.0% (-6.3 to 17.6)	0.40	2.7% (-13.7 to 22.4)	0.76
After	-7.8% (-22.6 to 9.7)	0.36	11.9% (-4.8 to 31.4)	0.17
Soft drinks, regular				
During	5.5% (-3.0 to 14.8)	0.21	7.0% (-5.8 to 21.5)	0.30
After	5.9% (-6.9 to 20.5)	0.38	1.1% (-9.9 to 13.6)	0.85
All other beverages				
During	4.6% (-4.6 to 14.7)	0.33	10.4% (-4.4 to 27.6)	0.18
After	6.1% (-7.9 to 22.2)	0.41	1.0% (-11.7 to 15.5)	0.88
Weight, % total food or beverages				
Fruit and vegetables, fresh or frozen				
During	5.3% (-0.9 to 11.8)	0.097	2.6% (-5.6 to 11.4)	0.55
After	3.6% (-5.4 to 13.5)	0.44	0.8% (-6.3 to 8.3)	0.83
Fruit, fresh or frozen				
During	12.8% (1.3 to 25.5)‡	0.028	-2.3% (-15.7 to 13.2)	0.76
After	13.6% (-3.4 to 33.6)	0.12	-10.7% (-21.5 to 1.7)	0.089
Vegetables, fresh or frozen				
During	1.2% (-4.5 to 7.4)	0.68	7.8% (-0.5 to 16.9)	0.068
After	-1.4% (-9.8 to 7.7)	0.75	10.5% (2.9 to 18.6)‡	0.0063
All other food, healthy				
During	-0.5% (-2.5 to 1.5)	0.62	-1.1% (-4.0 to 1.9)	0.47
After	-1.6% (-4.6 to 1.5)	0.30	-0.1% (-2.8 to 2.7)	0.94
All other food, less healthy				
During	-1.3% (-4.1 to 1.6)	0.37	1.0% (-3.4 to 5.6)	0.67
After	0.2% (-4.1 to 4.7)	0.93	1.8% (-2.3 to 6.1)	0.40
Water				
During	10.0% (-2.5 to 24.2)	0.12	0.8% (-15.1 to 19.7)	0.93
After	5.8% (-11.9 to 27.1)	0.55	-9.0% (-21.9 to 6.1)	0.23
Soft drinks, diet				
During	-1.8% (-9.9 to 7.0)	0.68	-4.5% (-15.9 to 8.4)	0.48
After	-13.2% (-23.9 to -1.1)‡	0.034	8.5% (-3.3 to 21.7)	0.17
Soft drinks, regular				
During	-1.2% (-3.9 to 1.6)	0.40	-0.6% (-4.6 to 3.5)	0.77
After	-0.3% (-4.4 to 4.0)	0.90	-0.6% (-4.2 to 3.1)	0.76
All other beverages				
During	-2.3% (-8.4 to 4.2)	0.48	2.7% (-6.9 to 13.2)	0.60
After	0.2% (-9.2 to 10.7)	0.96	-1.2% (-9.7 to 8.1)	0.79

Models for price discount alone communities and for combined strategy (price discount and consumer education) vs price discount only. *Percentage change was calculated as during vs before and after vs before the discount period. †Percentage change was calculated during and after the discount period. ‡p<0.05.

Table 4: Modelled effects on selected outcome measures during and after discount periods

(-6.1 to 19.0). Bottled water purchases increased by 17.6% (1.1-36.8) with the price discount alone (table 4, figure 3B). Artificially sweetened (diet) soft drink purchases increased by 5.0% (-6.3 to 17.6) with the discount, as did purchases of regular soft drink 5.5%

(-3.0 to 14.8) and all other drinks (4.6%, -4.6 to 14.7). Relative to all drink purchases, water purchases increased by 10.0% (-2.5 to 24.2) with the price discount alone. No statistically significant additional effects were noted with the combined strategy.

Statistically significant increases were observed for total sodium during 8.3% (95% CI 0.5-16.6) and after the discount (13.8%, 1.8-27.3) and for total energy during (6.7%, 0.1-13.8) and after the discount period (13.8%, 3.2-25.6), but not for sodium per MJ of energy (appendix p 8-11). Total food and drink sales (\$) by 3.5% (-2.9 to 10.4) during the discount period and by 7.3% (-2.8 to 18.5) after the discount period increased with the price discount alone (table 4).

Results of sensitivity analyses are shown in the appendix (pp 12-20). These did not modify the results for the primary outcome measure.

Discussion

A price discount of 20% applied at a population level was associated with a positive shift in population level purchases of fruit and vegetables and bottled water, but not diet soft drinks. This effect seemed to persist for fruit and vegetables after removal of the discount. The effect of the price discount alone during the intervention might have been larger for fruit than for vegetables. Despite increases observed in other food purchases, proportionate purchasing on fruit increased by 13% with the price discount only. Consumer education seemed to have a small additive effect on vegetable purchases.

Indigenous Australians living in remote areas are among the most socially disadvantaged Australians and yet the effect of the price discount on purchasing we observed at the population level is consistent with the modest effect on purchasing reported in comparable RCTs that targeted individuals^{19,21} and with US estimated price elasticities of demand for fruit and vegetables.^{9,15} This finding adds to the evidence on the role of price subsidies in socioeconomically disadvantaged populations and challenges long-held views among some retailers and health practitioners that Indigenous people in remote Australia do not respond to price changes.³⁵

Increased consumption of fruit and vegetables is associated with a reduced risk of mortality from all causes, particularly from cardiovascular disease.³⁶ Findings from meta-analysis of 16 studies with 56423 deaths reported from 833234 participants (from the USA, Asia, and Europe) showed that the risk of all-cause mortality was decreased by 5% (95% CI 0.92-0.98; p=0.001) for each additional daily serving of fruit and vegetables (77 g vegetables, or 80 g fruit).³⁶ The 12 g increase in fruit and vegetable consumption per person per day we observed for the whole of the population (including infants and elderly people) is the equivalent of 15% of an additional serving per day. Interventions aimed at the whole population, as in the SHOP@RIC study, are a logical strategy for reducing disease burden because

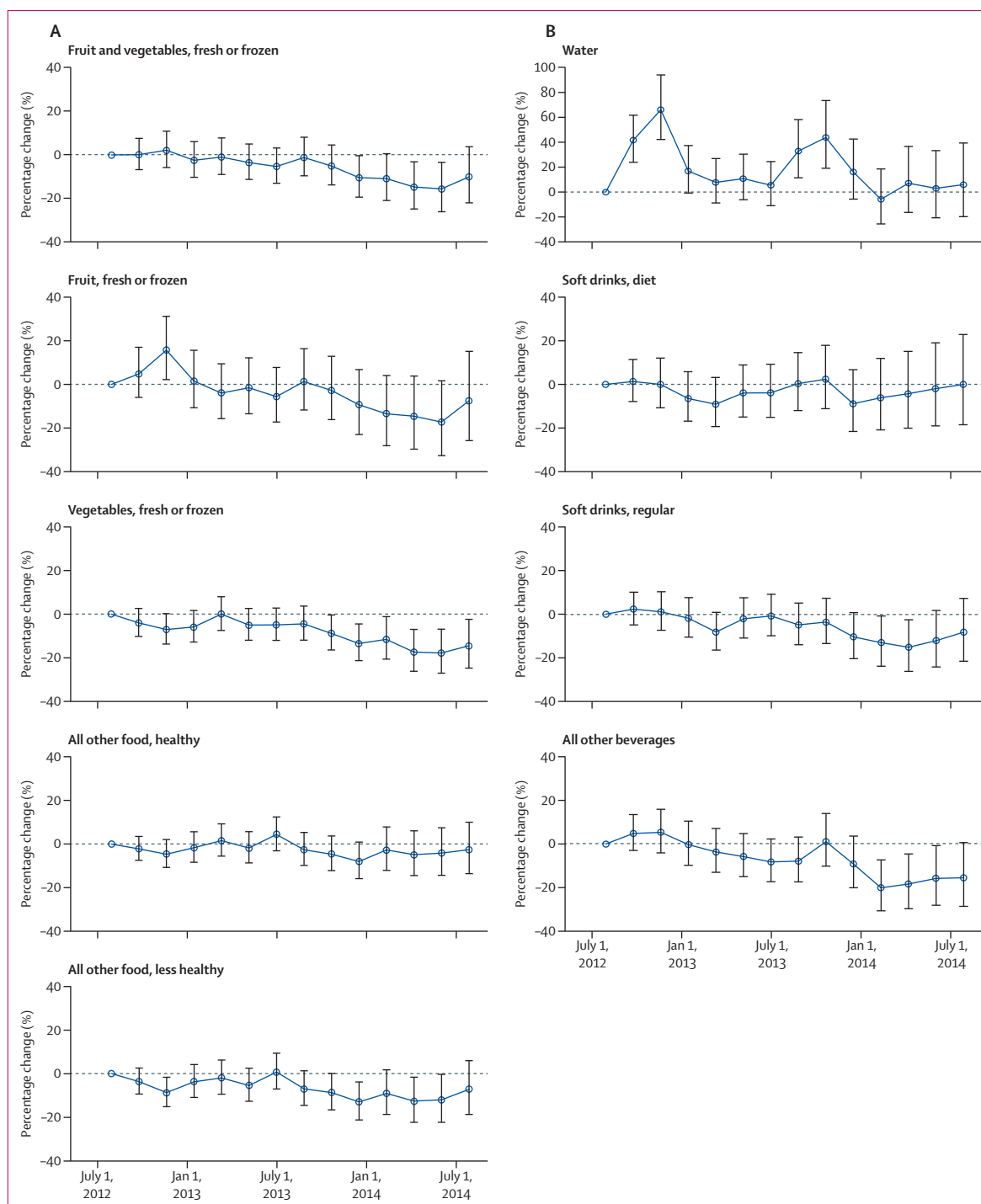


Figure 2: Modelled temporal variation on purchases of food and beverages
Percentage change from July 29, 2012. Bars are 95% CI.

this type of intervention has the potential to shift the distribution of risk factors in the whole population rather than targeting high-risk individuals only.^{23,37}

The substantial increase in fruit and vegetable purchases reported by the Dutch RCT²⁰ compared with

that reported by two other price discount RCTs^{19,21} and this study, highlights the importance of the size of a price discount. Due to weekly fluctuations in market prices, a discount of only 20% on fresh fruit and vegetables might not always be discernible to the

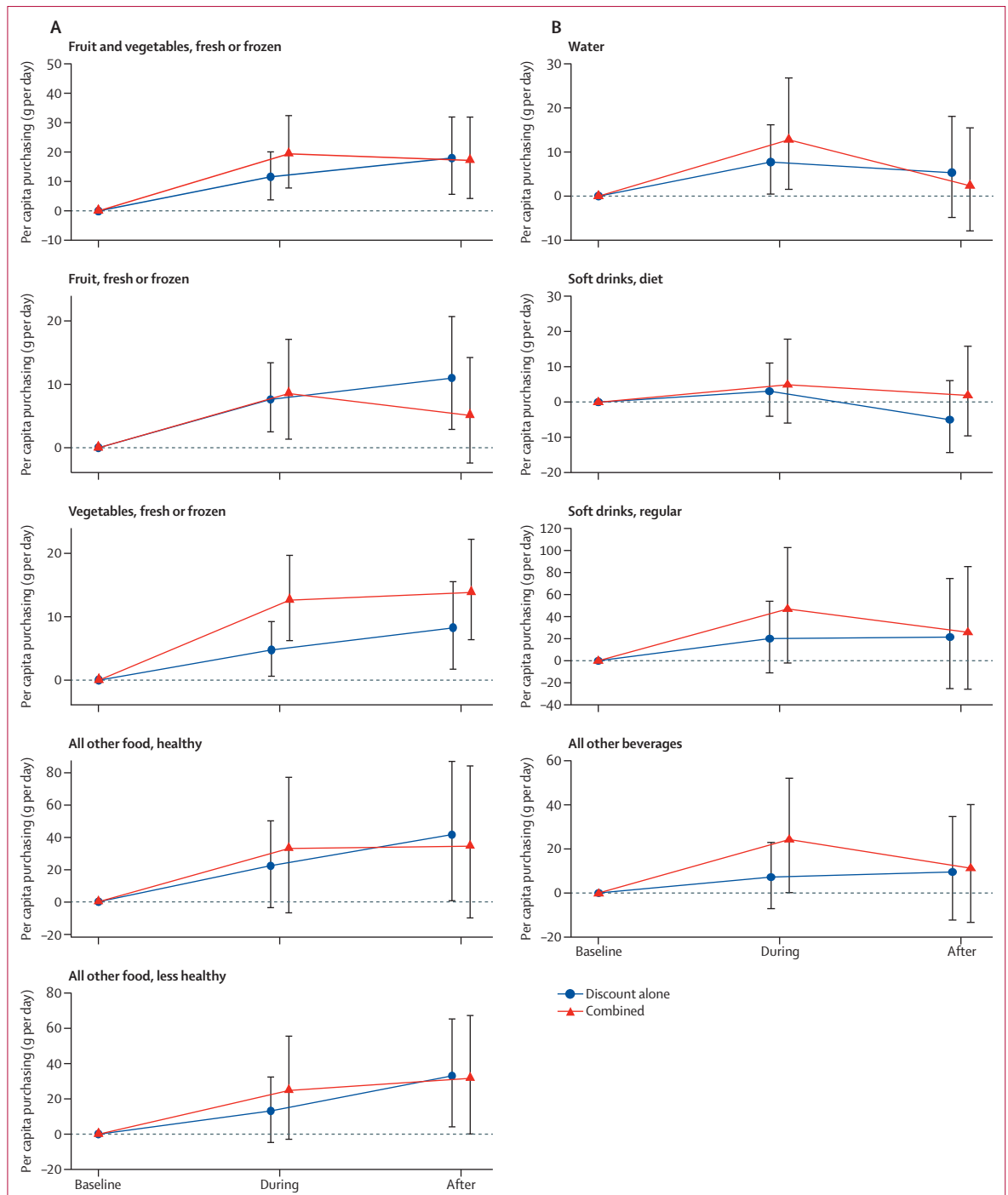


Figure 3: Modelled effect of price discount alone and combined strategy on purchases of food and beverages
 Bars are 95% CI.

consumer unless advertised. We attempted to notify customers of the dollar savings for all discounted lines as suggested by community leaders;³⁸ however, the price tickets (shelf talkers) were not consistently applied in some stores. The effect of offering a more substantial price discount on a rotating limited selection of fruit

and vegetable products on purchasing (as seen in the Dutch RCT²⁰) warrants investigation as this could potentially have a bigger impact on fruit and vegetable purchasing.

Responses to discounts might differ for different food types across populations.³⁹ Compared with vegetables,

fruit might be more amenable to increased consumption with a price discount for some populations because of its convenience, perceived affordability, and palatability. Improvement of vegetable intake might require complementary strategies. In the SHOP@RIC study context, many homes have inadequate storage and food preparation facilities and many residents cannot afford continuous electricity needed for food storage and cooking. Residents have expressed interest in enhancing their food selection and preparation skills. The SHOP@RIC consumer education strategy had a stronger focus on vegetable promotion through cooking demonstration, taste testing, and information materials provided in-store. The effect that we showed on vegetable purchases is promising. A more intensive intervention with wider reach across the community and a larger dose than used in our study might increase effectiveness. The consumer education strategy, however, was implemented primarily by using the existing resources available to remote communities. The feasibility of implementing a more intense consumer education programme without further resources in addition to the involvement and full commitment of retailers, community leaders, and public health nutritionists could, therefore, be a barrier. Further, the cost-effectiveness of such a programme relative to offering alternate interventions that have greater evidence of effect (such as a more substantial price discount on a small range of fruit and vegetable products) also needs consideration. Considering the evidence to date,^{19–21,40–42} more creative approaches to promoting fruit and vegetables in-store are likely to be needed—such as, retailer-led merchandising for health¹² together with programmes to build consumer confidence to purchase more vegetables (including cooking and food budgeting programmes), and improved household food preparation and storage infrastructure. We also suggest that future interventions should include strategies to discourage the purchase of less healthy foods, rather than just a focus on healthy foods, to have a bigger effect on total diet.¹²

The small increase shown for water purchases is in contrast to the SHELF study²¹, which reported no effect on water purchases with a 20% price discount. In the context of remote Indigenous communities, customers might be more responsive to discounts on bottled refrigerated water because many do not have access to refrigerated water and the quality of drinking water can be variable. Additionally, pricing strategies of both ALPA and OBS stores implemented before the SHOP@RIC trial resulted in bottled water being less expensive than in urban stores.⁴³ The SHOP@RIC price discount therefore further enhanced consumer demand. Conversely, artificially sweetened soft drink purchases, similar to that reported by the SHELF study,²¹ did not seem to be affected by the price discount, nor were sugar sweetened beverage purchases. The results of SHOP@RIC together with that of the SHELF study suggest that shifting sugar-sweetened

beverages in a desired direction might require approaches that target directly reducing their purchase, such as price increases or government applied soft drink taxes, rather than only encouraging replacement of beverages sweetened by sugar with bottled water or artificially sweetened soft drinks. Because young people (19–30 years) are the highest consumers of sugar sweetened soft drink, approaches that are tailored to age might also be of benefit.⁴⁴

Of the three other studies referred to previously, the RCT from New Zealand¹⁹ was the only one to report a sustained, albeit small, effect 6 months after discount on fruit and vegetable purchases. In our study, associated increases in purchases observed during the intervention were also observed after the intervention period, except for water. This finding is surprising because baseline conditions might be expected to be restored on removal of the experimental condition.^{10,45} The effect of the price discount on consumer behaviour might also be expected to continue on removal of the price discount and then decline with time. Given the involvement of retailers and public health nutritionists, and a rapidly growing interest among retailers to use merchandising strategies (using product, price, placement, and promotion) to promote the sales of healthy food, our investigation resulted in a retail environment different to that at baseline. The cost (\$/kg) of all other less healthy food was lower after the discount period than during the discount period, and might have contributed to the increase in purchasing of less healthy food observed after the discount period.

There is political interest in the use of fiscal measures to improve population diet and health. Uncertainties remain, however, on the effect of subsidies on total food and drink expenditure. There have been concerns that total calories purchased might increase with price subsidies on healthy foods thereby potentially negating health gains.^{10,14,46} Our findings add to this evidence because we observed increases (albeit non-significant) in the volume of other food purchases and increases in energy and sodium (due to its ubiquity in the food supply) during and after the price discount. Similar increases in purchases were observed for both healthy and less healthy food groups. The RCTs^{19,20} from the Netherlands and New Zealand found no indication that participants spent the money saved from the discounts on other supermarket items. These studies, however, unlike the SHOP@RIC study, did not promote the price discount in-store because participants either received discount coupons to redeem at purchase or received the discount through use of a rewards type card. No change in total spending was observed in the SHELF study; however, mean weekly household expenditure increased slightly for bakery items and dairy.⁴⁷ The effect of the price discount and combined strategy on total diet, including the changes observed for energy and sodium in the context of increased fruit and vegetables, and the associated cost-effectiveness are currently being investigated by our team.

Researchers have shown through modelling studies that adoption of a revenue-neutral tax on less healthy foods to subsidise fruits and vegetables presents the greatest opportunity in terms of health benefit.⁴⁸ Evidence of attempts by remote retailers in Australia to use such a strategy exists; however, flaws in implementation and small percentage subsidies have jeopardised the potential for an effect.³⁸ We did not have the data to establish the effect of the discount on overall retail performance. There was, however, no evidence of a negative effect on overall food and drink store dollar sales. Whether or not the non-significant increase in total food and drink dollar sales observed could offset the cost of the discount on fruit and vegetables to the retailer would depend on the mix of additional food purchased and the respective profit margins. This possibility warrants further investigation to contribute to understanding on the sustainability of price discounts.

To the best of our knowledge, this is the first price discount trial that has applied the intervention at a population level and assessed change using objective sales data from stores that together provided 96% (range 55–119%) of the population's energy requirements. Our study adds valuable empirical evidence to the understanding of the effect of fiscal interventions. There are a number of strengths of this study. Sales data is objective. The price discount was automatically applied at the store level, and therefore was not reliant on study participants redeeming the discount at point of purchase. The sophisticated stepped-wedge design, in which each cluster contributes both exposed and unexposed observations,⁴⁹ produced an estimate of effect while allowing all consenting communities to benefit from the intervention. The study design allowed for temporal variation to be accounted for such as seasonal effect, which was particularly strong for water purchases in our study. Random assignment of communities helped to ensure that potential confounders were spread across study groups and strategies and the lag in intervention initiation between groups also allowed for temporal variation across the groups at the start and end of intervention to be accounted for. Finally, within-store comparisons, an important part of the mixed models, meant that unchanging store level factors were accounted for. The main limitation is the wide variation in the fortnightly store sales within stores and, for this reason, with the small number of participating stores, precision in the estimate of effects was limited as indicated by the wide CIs. Multiple statistical comparisons were also made, thereby increasing the chance of statistically significant results.

The generalisability of these study findings to other extremely disadvantaged populations needs consideration. With regards to generalisation to remote Indigenous Australia, the communities were spread across the Northern Territory. 44% of Indigenous Australians who live in very remote parts of Australia are located in the Northern Territory³⁰ and the population

distribution by age and gender of the 20 study communities matched that of the broader remote Indigenous population. There are communities and small rural and remote non-Indigenous townships in Australia and internationally that experience similar degrees of social disadvantage and issues of food affordability for whom these findings are relevant.

This study contributes empirical evidence on the effect of a price discount with and without consumer education applied at the population level in an extremely socioeconomically disadvantaged population. A bigger discount might lead to greater impact. Other strategies might be needed alongside a price discount to negate potential increase in calories purchased and to encourage a reduction in sugar-sweetened soft drink consumption. Creative merchandising approaches to consumer education could also be considered alongside fiscal interventions to achieve marked improvements in diet.

Contributors

JB and MF conceived of the study. JB led all aspects of the study including development of the strategies and interpretation of the results and wrote the manuscript. JB planned the analytical approach with MDC who did the analysis and prepared the figures and data to populate tables. SCL coordinated the development of the consumer education strategy and collated the information on its implementation. KB provided expert input into the study design. AG was project manager and coordinated strategy implementation and data collection. EM provided cultural and community engagement expert advice. AG, MM, and AM contributed to development of the price discount promotional materials and tool to consider outliers. All authors contributed to study design, data interpretation, contributed to the manuscript, and approved the final version.

Declaration of interests

We declare no competing interests.

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