The economic feasibility of price discounts to improve diet in Australian Aboriginal remote communities

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Abstract

Objective: To estimate the cost-effectiveness of fiscal measures applied in remote community food stores for Aboriginal Australians.

Methods: Six price discount strategies on fruit, vegetables, diet drinks and water were modelled. Baseline diet was measured as 12 months' actual food sales data in three remote Aboriginal communities. Discount-induced changes in food purchases were based on published price elasticity data while the weight of the daily diet was assumed constant. Dietary change was converted to change in sodium and energy intake, and body mass index (BMI) over a 12-month period. Improved lifetime health outcomes, modelled for the remote population of Aboriginal and Torres Strait Islanders, were converted to disability adjusted life years (DALYs) saved using a proportional multistate lifetable model populated with diet-related disease risks and Aboriginal and Torres Strait Islander rates of disease.

Results: While dietary change was small, five of the six price discount strategies were estimated as cost-effective, below a $50,000/DALY threshold.

Conclusion: Stakeholders are committed to finding ways to reduce important inequalities in health status between Aboriginal and Torres Strait Islanders and non-Indigenous Australians. Price discounts offer potential to improve Aboriginal and Torres Strait Islander health. Verification of these results by trial-based research coupled with consideration of factors important to all stakeholders is needed.

Key words: cost-effectiveness, fiscal strategies, price elasticity, nutrition, Aboriginal and Torres Strait Islanders

In Australia, Aboriginal and Torres Strait Islanders have an adult life expectancy 10-11 years lower than that of the non-Indigenous population, with about 80% of the mortality gap attributable to non-communicable diseases.[1] Within the Aboriginal and Torres Strait Islander population living remotely, the gap in adult life expectancy is larger: 19 years lower for males and 17 years for females.[2] Diseases related to poor nutrition are prominent among causes of excess mortality for Aboriginal and Torres Strait Islander Australians. Coronary heart disease (22%) and type 2 diabetes (14%) are major non-communicable diseases contributing to the health gap and the higher mortality among these populations is most striking among the younger age groups and remote communities.[3] Elevated body mass and blood pressure and low fruit and vegetable consumption are modifiable risk factors that contribute 11%, 5% and 3% to the Aboriginal and Torres Strait Islander population disease burden, respectively, following tobacco use (12.1%).[2]

Increased body mass index (BMI) in children and adults is associated with an energy-dense diet, characteristically low in fruit and vegetables (F&V) and high in sodium, foods containing added fats, sugars and refined cereals.[4] In contrast, a healthy diet high in F&V can protect against obesity, cardiovascular disease (CVD) and certain cancers.[5]

Gains in health outcomes for the Aboriginal and Torres Strait Islander population living remotely could result from a shift in current consumption patterns, particularly in F&V and sodium or sugar-containing foods and beverages.[6,7] However, the cost of food and the socioeconomic position of the Aboriginal and Torres Strait Islander population in remote locations are key determinants of their poor quality diet.[8,9] While there is growing evidence that fiscal measures applied to food and beverages can potentially influence consumption patterns and improve health outcomes,[10,11] most preventive interventions in Australia use nutrition information and education approaches alone where the evidence is less clear.

A number of Australian studies suggest that price incentives and health education can be cost-effective strategies for improving health in Australia,[12-14] but we have little understanding of their potential health benefit or cost-effectiveness when delivered to Aboriginal and Torres Strait Islander remote communities.

Preventing diet-related disease could result in significant savings to Australian governments. With health expenditure in Australia predicted to increase to 12.4% of Gross Domestic Product by 2033, from 9.3%

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Submitted: July 2014; Revision requested: December 2014; Accepted: February 2015
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The authors have stated they have no conflict of interest.

Aust NZ J Public Health. 2016; 40 (Suppl. 1) S36-S41; doi: 10.1111/1753-6405.12391

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in 2003,[15] evidence is urgently needed on the cost-effectiveness of interventions to prevent disease.

Objective

This modelled economic evaluation aims to inform fiscal-related policy to address nutrition improvement in the Aboriginal and Torres Strait Islander population living in remote Australia. This study explores the health benefits and cost of combining fiscal policy with and without nutrition education in a multi-level strategy to improve dietary quality.

Methods

We modelled the potential impact of discounted prices designed to increase consumption of F&V, diet drinks and water– with and without nutrition education – on final health outcomes measured as Disability Adjusted Life Years (DALYs), via the mechanism of improved intermediate outcomes of diet quality. We used empirical Aboriginal population-level food purchasing data (baseline data), published price-elasticity data, published baseline Aboriginal and Torres Strait Islander population health status indicators and modelled evidence of health outcome changes following modelled improvement in intermediate diet quality outcomes. The target population of the model was the 2011 Aboriginal and Torres Strait Islander population living in remote Australia.[16] The target population represents about 26% of this population which, in turn, makes up 2.5% of the entire Australian population.[17]

The costs and benefits of each fiscal strategy were identified from a society-wide perspective (including impacts on individuals, businesses and health sector) and were compared to current practice, reflecting no nutrition-based price discounts, Aboriginal diet and health status in 2011. The time period used for measurement of benefits and cost-offsets was the remaining lifetime of the target population. Future costs and benefits were discounted at 3%.[18] Further details of each modelling element follow.

Fiscal Strategies

Six fiscal strategies applied for 12 months were evaluated independently. They were a 20% discount in the price of: 1) all fruit (fresh, dried, frozen and tinned); 2) fresh vegetables only; 3) all vegetables (fresh, dried, frozen and tinned); 4) all F&V; 5) diet drinks and water; and 6) all F&V, plus diet drinks and water.

Nutrition education

The nutrition education strategy modelled was a low-cost, population-level, in-store program, based on an unpublished case study conducted in one remote community.[19] It aimed to guide customer food selection by highlighting healthy food and beverage choices including F&V, diet drinks and water. Healthy food and drinks were identified according to a pre-determined set of nutrient criteria and shelf labels, developed locally by community members, were positioned near these items.

Baseline population

Since the actual combined population of the three Aboriginal communities in 2010/11 was unavailable, we estimated the population from the known 2% of the total Australian Aboriginal and Torres Strait Islander population in the 2006 census living remotely,[20] projecting forward to 2011 using the ABS projection series B.[17] The combined population estimate of 2,638 was found to be consistent with the total energy available from the actual community food purchases (2010/11) and energy requirements for each age and gender group, assuming a physical activity factor of 1.6 (National Health and Medical Research Council [NHMRC] – light activity).[21]

Baseline anthropometry

No measured anthropometric data (BMI, height, weight or blood pressure) or published estimates were available for the three communities under consideration. The adult estimates of Wang et al. (2000),[22] based on three Tiwi Island communities in the Northern Territory (NT), and Daniel et al. (2002),[23] based on 15 remote communities across northern Australia, were selected as most appropriate to the remote Aboriginal population.

Current practice – baseline diet

Actual community-level food purchasing data (in dollars and kilograms) were collected for 12 months to June 2011 for three remote Aboriginal communities in the NT. Food items were categorised according to the 1995 National Nutrition Survey (NNS)[24] and mapped to the food groups within the reported price elasticity tables of Ulubasoglu et al. (2010).[25] Beverage data (in dollars and litres) were mapped to the published beverage categories of Smith et al. (2010).[26] Sweet drink intake was based on soft drinks, other drinks (fruit and vegetable drinks and juices) and cordial. Liquid volumes (in litres) were converted to standard weight (kilograms) using the Food Standards Australia and New Zealand's nutrient database AUSNUT 2007[27] and AUSNUT 1999 specific gravity conversion factor (see Supplementary File 1, available online). The energy density and nutrient contents for food and beverages (mean and standard deviation) were derived from the energy and nutrient contents data sourced from the Australian Food and Nutrient Databases[27] (see Supplementary File 2).

Current practice – Baseline diet per adult

It was important to isolate baseline adult diet, since the modelling of improved final health outcomes related to intermediate dietary change, and was based on adult populations by gender. Rather than underestimating the total adult diet by using average dietary kg per person (including both adults and children), total foods and each food group were converted to kilograms consumed per person by gender and age group (<15 years and ≥15 years), assuming that the proportions of each food group reported consumed in the Australian general population 1995 NNS[24] by boys and girls <15 years and male and female adults were applicable to Aboriginal and Torres Strait Islander populations (summing to 100% across the four age and gender groups within each food group). The resultant total daily intake estimates (1.8 kg/boy, 1.4 kg/girl, 2.5 kg/adult male and 1.6 kg/adult female) were consistent with both sustainment of life and total actual food purchases data in the three remote Aboriginal communities (see Supplementary File 3).

Estimated impact on the intermediate outcome – consumption

Price elasticity measures the responsiveness of the quantity demanded of a good to a change in its price. There are no published food price elasticity data for Australian Aboriginal and Torres Strait Islander populations. An Australian study by Ulubasoglu et al.[25] and an American study by Smith et al.[26] were used because the time periods – 1998 to 2007 and 1998/9 to 2003/04, respectively – were sufficiently similar, and Smith et al. captured the targeted beverages while Ulubasoglu et al. covered the targeted foods.

The price elasticity values applied in the modelling (Table 1) represent the response to a 1% increase in price for each food or beverage group. The highlighted cells refer

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to the 'own-price' elasticity of demand (a 1% increase in the price of fresh fruit would lead to a fall of 1.049% in the quantity of fresh fruit demanded and vice versa). Both statistically significant and non-significant food and beverage price elasticities were modelled for their effect on diet. Since no standard errors were reported for foods, uncertainty of demand change within food price elasticity data was not incorporated. The non-bolded cells in Table 1 refer to 'cross-price elasticity' of demand, reflecting the impact that a percentage change in price of one item may have on demand for complementary or substitute items. The cross-price elasticity of juices and caloric sweetened beverages were summed and applied to the sweet drinks category. The reported standard errors for beverages were incorporated to reflect uncertainty of demand change, assuming a normal distribution around the mean.

Assuming that body weight at the population level was in equilibrium,[28] (i.e. neither increasing nor decreasing in the short term), the weight of the daily diet was held constant during each fiscal strategy and a balancing adjustment was made to the weight of other foods without price elasticity data. The modelled change in diet composition in response to price discounts led to reductions in sodium intake and energy value. The percentage change in energy value was converted to a percentage change in baseline weight and BMI by applying age group specific conversion factors derived from Swinburn et al. (2009).[29] No change in physical activity was assumed to occur.

Sensitivity threshold analysis

The addition of a nutrition education strategy to the fiscal strategies was modelled. Since the augmentation of behaviour change in addition to price elasticity impact alone is unknown, we report the effect of an arbitrary but illustrative threshold of 20% (i.e. the total impact on purchases of discounts plus nutrition education becomes 24%).

Benefits, DALYs and final health outcomes

The changes in adult dietary sodium intake and BMI by gender were next entered into a multi-healthstate lifetable (previously reported)[30] to determine adult population level changes in mortality and morbidity (DALYs) applicable to the 2011 Aboriginal and Torres Strait Islander population living remotely. The effect of each strategy on the incidence of a specific disease was quantified by the potential impact fraction, which is a function of relative risk of disease and risk factor prevalence. The resulting change in prevalence and mortality of each disease (ischaemic heart disease, stroke, hypertensive heart disease, type 2 diabetes and its sequelae, breast and colon cancer) was modelled over the remaining lifetime of the adult Aboriginal and Torres Strait Islander population living remotely, taking all other causes of mortality into account. Years of life lived by the population were adjusted for disability associated with each disease specific health-state as well as disability related to other causes as a function of age. Given strong evidence[31] that dietary behaviour change is difficult to maintain, the effects on behaviour were assumed to exponentially decay at a rate of 50% per annum, meaning little effect was sustained beyond 5.5 years.

Table 1: Published price elasticities (Ulubasoglu et al)[18] and (Smith et al).[19]

Food item	Fresh fruit	Standard error	Fresh vegetable	Standard error	Preserved fruit	Standard error	Preserved vegetables	Standard error
Fresh fruit	**-1.049**	na	-0.215	na	-0.21	na	0.045	na
Fresh vegetable	-0.202	na	**-0.526**	na	0.012	na	-0.11	na
Preserved fruit	-0.197	na	0.944	na	**-0.439**	na	-0.116	na
Preserved vegetables	0.49	na	0.201	na	-0.094	na	**-1.383**	na
Beverage Item	**Caloric sweetened beverages**	**Standard error**	**Diet beverages**	**Standard error**	**Juices**	**Standard error**	**Bottled Water**	**Standard error**
Caloric sweetened beverages	**-1.264**	-0.089	-0.457	-0.103	0.557	-0.095	0.749	-0.196
Diet beverages	-0.192	-0.048	**-0.753**	-0.106	0.159	-0.071	-0.088	-0.153
Juices	0.233	-0.045	0.096	-0.071	**-1.012**	-0.09	-0.255	-0.135
Bottled Water	0.131	-0.035	-0.044	-0.057	-0.087	-0.051	**-0.969**	-0.157

Note: The rows refer to the price of the item and the columns represent the quantity demanded of the respective product.

Costs and cost-offsets of the fiscal strategies

Modelled costs of the fiscal strategies included reimbursement of the price discount to store management, and time costs associated with advertising and ticketing the price changes (Table 2). The major costs of the nutrition education strategy were participant time, travel and printing of materials.

Cost-offsets comprised future cost savings to the health sector from cases averted of risk-factor-related diseases nominated above as a result of modelled dietary changes from each fiscal strategy (see Supplementary File 4). The cost-offset estimates included an adjustment of 119% to cover the additional health costs of treating the Aboriginal and Torres Strait Islander population[32] and were multiplied by the appropriate health price index to derive 2011 estimates. The net cost of each fiscal strategy was calculated by subtracting cost-offsets from the strategy's delivery cost (with and without the nutrition education program) for a period of 12 months.

Cost-effectiveness

The present value of net costs was divided by discounted lifetime DALYs to determine the Incremental cost-effectiveness ratio (ICER) expressed as dollars per DALY averted.

Uncertainty analysis

Probabilistic uncertainty analysis was undertaken using the @RISK software[33] using Monte Carlo simulations[34] (2000 iterations of change in dietary consumption behaviour and 1000 iterations of DALYs). Results are reported in 2011 Australian dollars as median ICERs together with 95% uncertainty intervals.

On the cost-effectiveness plane (Figure 1), values associated with positive DALYs averted and cost saving (south-east quadrant) are termed 'dominant', and values associated with a loss in DALYs and an increase in costs (northwest quadrant) are termed 'dominated'. The interpretation of all other values (north-east quadrant) depends on the value relative to (above or below) the cost-effectiveness threshold (the dotted line). A cost-effectiveness ratio of less than $50,000 / DALY is widely accepted in Australia as cost-effective or providing 'value-for money'.[35]

Results

Intermediate dietary outcomes

All fiscal strategies had a positive impact on diet quality resulting in a net reduction in sodium intake and energy density per person. The largest reduction in sodium intake and energy density occurred following combination discounting of F&V, diet drinks and water, while the smallest reduction resulted from the discounting of fresh vegetables alone. The addition of the nutrition education program slightly enhanced the positive effect of each fiscal strategy, without altering their relative

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ranking, but the change was not statistically significant. Supplementary tables showing percentage change in energy (kJ), weight (kg), BMI and sodium (mg/day), with and without the education program, are provided in Supplementary File 5.

Health outcomes – DALYs

While all fiscal strategies were beneficial, the total DALYs averted were modest (Table 3) ranging from 38 to 250.The most DALYs (250) were averted by a combination of discounting F&V, diet drinks and water, coupled with the nutrition education program, while the least (38) were averted by discounting of diet drinks and water without the nutrition education program.

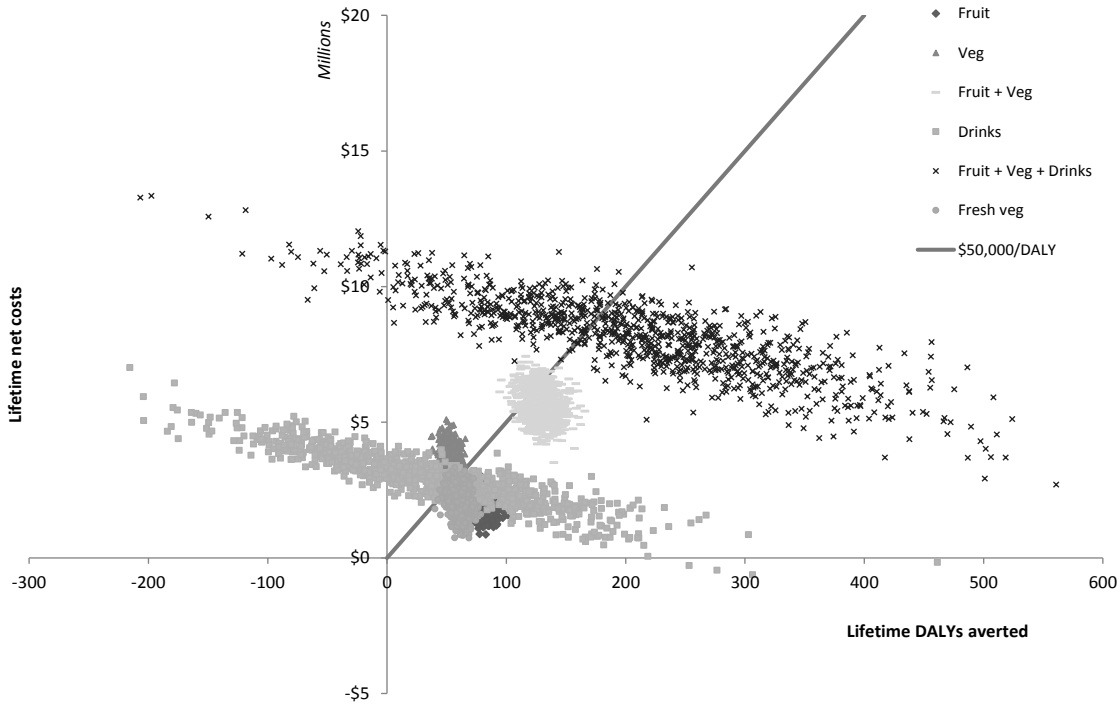
Cost-effectiveness

Compared to current practice of no fiscal strategies, five of the six price discount strategies (without the nutrition education program) were estimated to be cost-effective, providing 'value-for-money', with ICERs less than the $50,000/DALY threshold (Table 3). The ICER of discounting all vegetables was higher than the threshold at $69,000/DALY averted and does not represent a cost-effective strategy. The addition of the nutrition education program to each of the discount strategies had the effect of averting additional DALYs while increasing net costs. Compared to current practice of no fiscal strategies in remote communities, and applying the same threshold, three of the six discount strategies were estimated to be cost-effective, if the nutrition education program was delivered concurrently. However, the incremental DALYs averted by the addition of the nutrition education program were maximised (250–210=40) and offered further 'value-for-money', only when it was added to the combination discounting of F&V, diet drinks and water. This was because the cost of the nutrition education program was constant regardless of the range of food and drink items discounted and consequent dietary and health benefits achieved.

Table 2: Fiscal strategy and nutrition education strategy costs (AUD), sources and uncertainty distributions.

Parameter	Point estimate (uncertainty range)	Uncertainty Distribution	Source
Reimbursement of 20% discount on food and beverage items			
Based on monthly store sales data of the three remote communities			
Fruit (not fresh)	$ 4,052 (SD $1,172)	Normal	Monthly food purchases data
Fruit fresh	$ 18,629 (SD $2,248)	Normal	Monthly food purchases data
Vegetables (not fresh)	$ 12,017 (SD $1,225)	Normal	Monthly food purchases data
Vegetables fresh	$ 20,957 (SD $3,267)	Normal	Monthly food purchases data
Water	$ 5,694 (SD $2,000)	Normal	Monthly food purchases
Diet drinks	$ 20,553 (SD $2,162)	Normal	Monthly food purchases data
Promotion of store based discounts using shelf tickets (weekly cost)			
Applied for the three remote communities in total			
Fruit	$ 24 (+/- 10%)	Uniform	Assumed 40 tickets/week and 0.5 hours staff time
Vegetables	$ 28 (+/- 10%)	Uniform	Assumed 80 tickets/week and 0.5 hours staff time
Fruit and Vegetables	$ 52 (+/- 10%)	Uniform	Assumed 120 tickets/week and 1.0 hours staff time
Drinks	$ 22 (+/- 10%)	Uniform	Assumed 20 tickets/week and 0.5 hours staff time
Fruit, vegetables and drinks	$ 74 (+/- 10%)	Uniform	Assumed 140 tickets/week and 1.5 hours staff time
Nutrition Education strategy (planning, implementing and evaluating)			
Human resources, including volunteer time	$12,185	Uniform (+/-10%)	Menzies, Department of Health, personal communication
Travel	$1790	Uniform (+/-10%)	Menzies
Material resources	$238	Uniform (+/-10%)	Menzies
Total cost per store	$14,213	Uniform (+/-10%)	Derived
Number of remote community stores	175		Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA)

Figure 1: Cost-effectiveness plane of fiscal strategies without nutrition education program.



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There was considerable uncertainty surrounding each strategy that included discounting of diet drinks and water (largely due to incorporation of standard errors around price elasticity of beverages), leading to a small (4%) chance of health reduction at a cost (i.e. strategy dominated), see Figure 1.

Table 3: Incremental cost-effectiveness ratios (AUD) of fiscal strategies compared to current practice.

Strategies	DALYs Mean (95% UI)	Net Costs $ million Mean (95% UI)	Incremental Cost-Effectiveness Ratio ICER Median (95% UI)
20% Discount without education strategy			
Discount on all fruit	77 (62 to 92)	$2.1 ($1.4 to $2.7)	$27,000 ($17,000 to $40,000)
Discount on fresh vegetables only	61 (50 to 71)	$2.1 ($1.3 to $2.9)	$34,000 ($20,000 to $51,000)
Discount on all vegetables	53 (44 to 61)	$3.6 ($2.8 to $4.5)	$69,000 ($50,000 to $91,000)
Discount on all fruit and vegetables	130 (110 to 150)	$5.7 ($4.6 to $6.8)	$44,000 ($33,000 to $58,000)
Discount on water and artificially sweetened soft- drinks	38 (-120 to 200)	$3.0 ($0.89 to $4.8)	$21,000 (dominated to $480,000)
Discount on fruit and vegetables, water and artificially sweetened soft- drinks	210 (-22 to 440)	$8.2 ($5.2 to $11)	$36,000 (dominated to $320,000)
20% Discount with an education program			
Discount on all fruit	92 (75 to 110)	$4.4 ($3.7 to $5.1)	$48,000 ($36,000 to $63,000)
Discount on fresh vegetables only	73 (61 to 85)	$4.4 ($3.6 to $5.2)	$61,000 ($45,000 to $79,000)
Discount on all vegetables	64 (54 to 74)	$6 ($5.1 to $6.9)	$95,000 ($74,000 to $120,000)
Discount on all fruit and vegetables	160 (130 to 180)	$7.9 ($6.7 to $9.1)	$51,000 ($40,000 to $65,000)
Discount on water and artificially sweetened soft- drinks	45 (-150 to 240)	$5.4 ($3.1 to $7.7)	$34,000 (dominated to $710,000)
Discount on fruit and vegetables, water and artificially sweetened soft- drinks	250 (-26 to 520)	$10 ($6.9 to $13)	$38,000 (dominated to $350,000)

Dominant: Result of a strategy that improves health outcomes and saves costs
Dominated: Result of a strategy that worsens health outcomes and increases costs

Discussion

Several fiscal strategies were estimated to represent 'value-for-money', while acknowledging that the health benefits in total were modest (i.e. <250 DALYs saved). The proposed nutrition education program was cost-effective only when combined with the concurrent discount on F&V, diet drinks and water. Before any particular price discounting strategy is recommended, the goals of the policy makers and the affordability of the budget to cover the cost of the discounts and the education strategy will need to be considered. The net cost of the F&V, diet drinks and water plus nutrition education program is estimated at $10 million. If that net cost is not affordable, a less expensive, within budget, cost-effective option that yields most health gain should be considered.

This project is important in terms of Aboriginal and Torres Strait Islander population health research. For the first time, complete food purchases data have been collected from Aboriginal remote communities and the nutritional composition of the dietary data has been estimated by age and gender. There has been no previous modelling of behaviour change and dietary impact, nor cost-effectiveness analysis of fiscal strategies in this population. This work will contribute to improvements in Aboriginal and Torres Strait Islander population diet and health by showing the potential of fiscal measures to provide 'value-for-money'. There could also be an argument on equity grounds that $50,000/DALY is an inappropriately low threshold when assessing strategies to improve Aboriginal health status.[32]

Other studies that examined the impact of price discounting strategies have shown promise, but are difficult to compare with our findings.[10,11] The discounts were offered via different mediums and in different populations, assessed benefits differently and offered smaller or larger discounts. This current study adds modelled fiscal strategies to the list of modelled vaccination and pharmacotherapy strategies that have been shown to be cost-effective specifically for the Aboriginal and Torres Strait Islander population, using similar economic evaluation methods, which facilitate direct comparison.[13]

This study faced gaps in national level Aboriginal and Torres Strait Islander health status data (BMI, blood pressure) and national dietary composition by age and gender, which have recently been addressed for the first time in ABS Aboriginal and Torres Strait Islander surveys.[36] It highlights useful areas of potential future nutrition research (dietary behaviour response to fiscal strategies and/or nutrition education).

It is important to acknowledge the major assumptions that underpin the modelling and that potentially limit the conclusions of the economic evaluation. Cross-country variations in food markets, food products and consumer characteristics can introduce bias when combining price elasticity data. The consequences and implications of the concurrent application in this study of price elasticity data from two countries are unclear. The effects of income on demand elasticity also remain unclear. In the absence of a systematic review of the effect of socioeconomic variation, or any evidence measured in the Aboriginal and Torres Strait Islander population remote setting, no moderation of the published price elasticity data for this remote and lower income population was incorporated into the modelling. The application of price elasticity data within population-based cost-effectiveness analysis is also a developing area of research, which requires further testing and is open to interpretation. While the conclusions remain unchanged, the degree of confidence (i.e. level of uncertainty) in the findings is affected by our inclusion of non-significant data and reported standard errors when available.

It is possible that the Aboriginal population in these three remote communities sourced other food during the study period from outside the communities. Non-marketed traditional foods were not included. Similarly, other transient populations (visitors, tourists, contractors) may have made purchases at the community stores. We also assumed remote community stores would be able to supply the new quantity of foods and beverages demanded in a timely manner and at an acceptable level of quality. None of these assumptions is expected to alter the conclusions as their impact is likely to be small.

By modelling independent effects of BMI and blood pressure on disease, we may have overestimated the final health benefits. On the other hand, the benefits to some diseases for which we did not have epidemiological data for the Aboriginal and Torres Strait Islander population (e.g. gastrointestinal, endometrial, kidney and thyroid cancers and osteoporosis) would have had a countering effect.

Finally, the cost-effectiveness results should be tempered by an assessment of other considerations important to decision-makers and stakeholders (including Aboriginal and Torres Strait Islander community store owners) – including acceptability, feasibility,

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sustainability, relevance to Aboriginal and Torres Strait Islander populations and other potential positive or negative effects.

Conclusion

The offering of price discounts on healthy food and beverages appears to be a potentially cost-effective way to improve Aboriginal and Torres Strait Islander population health. It is important to reiterate that food costs are higher in remote Australia and health status is poorer than in the rest of Australia. Price discounts on F&V, diet drinks and water need to be considered in this context. The strength of evidence around the response to price changes, with and without supporting nutrition education, is untested in Aboriginal and Torres Strait Islander populations living remotely. The future trialling of such fiscal measures will provide empirical evidence to validate the indicative findings of this modelling study. The NHMRC funded trial (SHOP@RIC) is expected to contribute to this evidence in the near future.

Acknowledgements

We thank the communities and organisations that contributed data to enable this analysis to take place. Dr Gary Sacks from Deakin University provided valuable advice on the application of price elasticity modelling to cost-effectiveness analysis. Professor Moodie is supported by funding from a NHMRC-funded Centre for Research Excellence on Obesity Policy and Food Systems (#1041020).

Sources of support

The Cost of Dietary Improvement project was funded by the National Aboriginal and Torres Strait Islander Health Equality Council. Menzies School of Health Research commissioned Deakin University to conduct the economic analysis.

References

1. Australian Institute of Health and Welfare. *The Health and Welfare of Australia's Aboriginal and Torres Strait Islander People, An Overview 2011*. Canberra (AUST): AIHW; 2011.
2. Vos T, Barker B, Begg S, Stanley L, Lopez A. Burden of disease and injury in Aboriginal and Torres Strait Islander peoples. *Int J Epidemiol*. 2009;38:470-7.
3. Australian Institute of Health and Welfare. *Mortality Inequalities in Australia 2009-2011*. Canberra (AUST): AIHW; 2014.
4. United States Department of Agriculture, United States Department of Health and Human Services. *Dietary Guidelines for Americans, 2010*. 7th ed. Washington (DC): US Government Printing Office; 2010.
5. World Cancer Research Fund. *Food, Nutrition, Physical Activity and the Prevention of Cancer: A Global Perspective*. Washington (DC): American Institute for Cancer Research; 2007.
6. Brimblecombe JK, Ferguson MM, Liberato SC, O'Dea K. Characteristics of the community-level diet of Aboriginal people living in remote northern Australia. *Med J Aust*. 2013;198(7):380-4.
7. Brimblecombe J, Ferguson M, Liberato S, O'Dea K, Riley M. Optimisation modelling to assess cost of dietary improvement in remote Aboriginal Australia. *PLoS ONE*. 2013;8(12):e83587.
8. Ferguson M, O'Dea K, Chatfield M, Moodie M, Altman J, Brimblecombe J. The comparative cost of food and beverages at remote Indigenous communities, Northern Territory, Australia. *Aust N Z J Public Health*. 2015 Apr. doi: 10.1111/1753-6405.12370
9. Brimblecombe J, O'Dea K. The role of energy cost in food choices for an Aboriginal population in northern Australia. *Med J Aust*. 2009;190(10):549-51.
10. Liberato SC, Bailie R, Brimblecombe J. Nutrition interventions at point of sale to encourage healthier food purchasing: A systematic review. *BMC Public Health*. 2014;14:919.
11. An R. Effectiveness of subsidies in promoting healthy food purchases and consumption: A review of field experiments. *Public Health Nutr*. 2013;16(7):1215-28.
12. Cobiac LJ, Vos T, Veerman JL. Cost-Effectiveness of Interventions to promote fruit and vegetable consumption. PLoS ONE. 2010;5(11):1-8.
13. Vos T, Carter R, Barendregt J, Mihalopoulos C, Veerman L, Magnus A, et al. *ACE-Prevention: Assessing Cost-effectiveness in Prevention*. Brisbane (AUST): University of Queensland; 2010.
14. Sacks G, Veerman JL, Moodie M, Swinburn B. 'Traffic-light' nutrition labelling and 'junk-food' tax: A modelled comparison of cost-effectiveness for obesity prevention. *Int J Obes*. 2011;35(7):1001-9.
15. Goss J. *Projection of Australian Health Care Expenditure by Disease, 2003 to 2033*. Welfare Expenditure Series No.: 36. Catalogue No.: HWE 43. Canberra (AUST): AIHW; 2008.
16. Australian Bureau of Statistics. *4713.0. - Population Characteristics of Aboriginal and Torres Strait Islander Australians*. Canberra (AUST): ABS; 2010.
17. Australian Bureau of Statistics. *2011 Census Quick Statistics*. Canberra (AUST): ABS; 2012.
18. Gold M, Siegel J, Russell L, Weinstein M. *Cost Effectiveness in Health and Medicine*. New York (NY): Oxford University Press; 1996.
19. Menzies School of Health Research. *Promotion and Education in Remote Stores Project* [Internet]. Darwin (AUST): Royal Darwin Hospital Campus; 2012 [cited 2014]. Available from: http://www.menzies.edu.au/page/Research/Projects/Nutrition/Promotion_and_Education_in_Remote_Stores_Project/
20. Australian Bureau of Statistics. Population of 3 Communities for CODI Project. In: *Census 2006 by Age, Sex, Locality* [Internet]. Canberra (AUST): ABS; 2006 [cited 2011]. Available from: http://www.censusdata.abs.gov.au/
21. National Health and Medical Research Council. *Nutrient Reference Values for Australia and New Zealand*. Canberra (AUST): Commonwealth of Australia; 2006.
22. Wang Z, Hoy W, McDonald S. Body mass index in Indigenous Australians in remote communities. *Aust N Z J Public Health*. 2000;24:570-5.
23. Daniel M, Rowley K, Mc Dermott R, O'Dea K. Diabetes and impaired glucose tolerance in Aboriginal Australians: Prevalence and risk. *Diabetes Res Clin Pract*. 2002;57:23-33.
24. Australian Bureau of Statistics. *4805.0. - National Nutrition Survey; Nutrient Intakes and Physical Measurements, Australia*. Canberra (AUST): ABS; 1995.
25. Ulubasoglu M, Mallick D, Wadud M, Hone P, Haszler H. *Food Demand Elasticities for Australia*. School Working Paper Economic SeriesNo.: SWP 2010/17. Melbourne (AUST): Faculty of Business and Law, School of Accounting Economics and Finance Deakin University; 2010.
26. Smith TA, Biing-Hwan L, Jonq-Ying L. *Taxing Caloric Sweetened Beverages: Potential Effects on Beverage Consumption, Calorie Intake and Obesity*. Washington (DC): United States Department of Agriculture Economic Research Service; 2010.
27. Food Standards Australia and New Zealand. *AUSNUT 2007 Consumer Information*. Canberra (AUST): FSANZ; 2011 [cited 2011 Dec]. Available from: http://www.foodstandards.gov.au/consumerinformation/ausnut2007/
28. Swinburn B, Jolley D, Kremer P, Salbe A, Ravussin E. Estimating the effects of energy imbalance on changes in body weight in children. *Am J Clin Nutr*. 2006;83:859-63.
29. Swinburn BA, Sacks G, Lo SK, Westerterp KR, Rush EC, Rosenbaum M, et al. Estimating the changes in energy flux that characterize the rise in obesity prevalence. *Am J Clin Nutr*. 2009;89(6):1723-8.
30. Cobiac L, Vos T, Veerman L. Cost-effectiveness of Weight Watchers and the Lighten Up to a Healthy Lifestyle program. *Aust N Z J Public Health*. 2010;34(3):240-7.
31. Dansinger M, Tatsioni A, Wong J, Chung M, Balk E. Meta analysis: the effect of dietary counseling for weight loss. *Ann Intern Med*. 2007;147(1):41-50.
32. Ong K, Kellaher M, Anderson I, Carter R. A cost-based equity weight for use in the economic evaluation of primary health care interventions: Case study of the Australian Indigenous population. *Int J Equity Health*. 2009;8:34-47.
33. *@RISK*: Advanced Risk Analysis for Spreadsheets. Version 4.5. New York (NY): Palisade Corporation; 2005.
34. Briggs A, Mooney C, Wonderling D. Constructing confidence intervals for cost-effectiveness ratios: An evaluation of parametric and non-parametric techniques using Monte Carlo simulation. *Stat Med*. 1999;18:3245-62.
35. Carter R, Vos T, Moodie M, Haby M, Magnus A, Mihalopoulos C. Priority setting in health: Origins, description and application of the assessing cost effectiveness (ACE) initiative. *Expert Rev Pharmacoecon Outcomes Res*. 2008;8(6):593-617.
36. Australian Bureau of Statistics. *4727.0.55.001. - Australian Aboriginal and Torres Strait Islander Health Survey: First Results 2012-2013* [Internet]. Canberra (AUST): ABS; 2013 [cited 2014]. Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/4727.0.55.001

Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary File 1: Table 1: Study food group and corresponding food group reported in Table 1 of the National Nutrition Survey 1995; Table 2: Study beverage groups and corresponding beverage groups reported in Table 1 of the National Nutrition Survey 1995.

Supplementary File 2: Baseline energy density and sodium contents per food group item.

Supplementary File 3: Derived baseline components of remote Indigenous population diet (average kg per person by age and gender).

Supplementary File 4: Cost-offsets per Indigenous cases of disease averted in 2011.

Supplementary File 5: The effect on intermediate health outcomes of each of the interventions.

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