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 changes 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 could be important to all stakeholders.

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

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.

in 2003, 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. The target population represents about 26% of this population which, in turn, makes up 2.5% of the entire Australian population.

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%. 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. 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, projecting forward to 2011 using the ABS projection series B. 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).

**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), based on three Tiwi Island communities in the Northern Territory (NT), and Daniel et al. (2002), based on 15 remote communities and total actual food purchases data in the three remote Aboriginal communities (see Supplementary File 3).

**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 (NNSS) 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 1, available online). The energy density and nutrient contents data sourced from the Australian Food and Nutrient Databases (see Supplementary File 2).

**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. and an American study by Smith et al. 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...
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 calorific 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,26 (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).26 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)26 to determine adult population level changes in mortality and morbidity (DALYs) applicable to the 2011 Aboriginal and Torres Strait Islander population 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 evidence31 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.

**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 population32 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 software33 using Monte Carlo simulations34 (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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Table 1: Published price elasticities (Ulubasoglu et al)18 and (Smith et al).19

<table>
<thead>
<tr>
<th>Food item</th>
<th>Fresh fruit</th>
<th>Standard error</th>
<th>Fresh vegetable</th>
<th>Standard error</th>
<th>Preserved fruit</th>
<th>Standard error</th>
<th>Preserved vegetables</th>
<th>Standard error</th>
<th>Beverages Item</th>
<th>Caloric sweetened beverages</th>
<th>Standard error</th>
<th>Diet beverages</th>
<th>Standard error</th>
<th>Juices</th>
<th>Standard error</th>
<th>Bottled Water</th>
<th>Standard error</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh fruit</td>
<td>-1.049</td>
<td>na</td>
<td>-0.215</td>
<td>na</td>
<td>-0.21</td>
<td>na</td>
<td>0.045</td>
<td>na</td>
<td>Preserved fruit</td>
<td>-0.202</td>
<td>-0.526</td>
<td>0.012</td>
<td>-0.11</td>
<td>na</td>
<td>-0.116</td>
<td>na</td>
<td>-1.383</td>
<td>na</td>
</tr>
<tr>
<td>Fresh vegetable</td>
<td>-0.197</td>
<td>na</td>
<td>0.944</td>
<td>na</td>
<td>-0.439</td>
<td>na</td>
<td>-0.116</td>
<td>na</td>
<td>Preserved vegetables</td>
<td>0.49</td>
<td>0.201</td>
<td>-0.094</td>
<td>na</td>
<td>-1.383</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

Note: The rows refer to the price of the item and the columns represent the quantity demanded of the respective product.
Selective discounts may improve Indigenous health

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

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

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.
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.

**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.12

Other studies that examined the impact of price discounting strategies have shown promise, but are difficult to compare with our findings.16,17 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.16 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 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,
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&B, 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 Muddle 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.

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