Title: The effect of sugar-sweetened beverage price increases and educational messages on beverage purchasing behavior among adults

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Abstract

There is a paucity of evidence regarding the impact of sugar sweetened beverage (SSB) price increases on beverage consumption, using individual-level data, for the population overall and for different socioeconomic groups. This study aimed to predict the impact of altered beverage prices and educational messages on consumer purchasing behavior. 2,020 adults representative of the Australian population by age, gender and income completed a discrete choice experiment online in 2016. Each subject completed 20 choice scenarios in a hypothetical convenience store setting where subjects chose between seven SSB and non-SSB beverage options or a no beverage option. Beverage prices and volumes varied between scenarios. Half of participants (n=1,012) were randomly exposed to an educational poster discouraging SSB consumption prior to completing choice scenarios. We used discrete choice models to predict purchases under several policy proposals, overall and for income and SSB consumption frequency sub-groups. Compared to baseline prices, a 10% SSB price increase was predicted to reduce SSB purchases by 15.0% [95%CI -15.2, -14.7], and increase purchases of non-SSBs by +11.0% [95%CI 10.8, 11.2] and no beverage by +15.5% [95%CI 15.1, 15.9]. Effects were greater with a 20% SSB price increase. Across all policy scenarios, the highest income quintile had a similar absolute and slightly greater relative decrease in SSB purchases compared to the lowest quintile. Educational poster exposure reduced SSB choice for all groups, with a greater reduction in the lower compared to higher income group, and additively increased response to price changes. Our results support the use of population-wide SSB pricing and educational interventions to reduce demand across all income groups.
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Introduction

Sugar sweetened beverages (SSBs) are generally described as non-alcoholic water-based beverages with added sugar and may include cordials, fruit drinks, flavored milks, sports drinks, energy drinks, vitamin waters, sweetened ice tea, as well as non-diet soft drinks. Differences in SSB consumption across socioeconomic groups in high income countries are a contributor to socioeconomic inequalities in health outcomes including obesity (Gearon, Backholer, Hodge, & Peeters, 2013 Dec) and dental decay (Armfield, Spencer, Roberts-Thomson, & Plastow, 2013). There is increasing acknowledgement that population-level approaches that address environmental drivers of consumption, such as beverage prices, are frequently cost-effective and wide-reaching (Backholer, et al., 2014; Briggs, et al., 2013 Oct; Thow, Jan, Leeder, & Swinburn, 2010 Aug). Whilst several countries have implemented or are considering a tax on SSBs (Backholer, Blake, & Vandevijvere, 2017; Colchero, Popkin, Rivera, & Ng, 2016; Falbe, Rojas, Grummon, & Madsen, 2015), governments are tentative in part due to the lack of evidence describing the likely effectiveness of such a measure and concern that low income groups might pay a greater proportion of their income in SSB tax (financial regressiveness) (World Health Organisation, 2015).

Currently, the evidence for the predicted impact of beverage price changes on SSB purchases for the population, and for different socioeconomic groups, is largely derived from modelled data using historic purchasing patterns (Andreyeva, Long, & Brownell, 2010 Feb; Etilé & Sharma, 2015; Finkelstein, Zhen, Nonnemaker, & Todd, 2010; Powell, Chriqui, Khan, Wada, &
Chaloupka, 2013; Sharma, Hauck, Hollingsworth, & Siciliani, 2014). A review by Andreyeva et al. found mean price elasticities of -0.79 for diet and regular soft drinks (range -0.13 to -3.18), suggesting an 8% decrease in population purchases for every 10% increase in price (Andreyeva, et al., 2010 Feb). A second review by Powell et al. found mean price elasticity of -1.25 for regular soft drinks (range -0.71 to -2.26) and -1.08 for SSBs overall (range -0.87 to -1.26) (Powell, et al., 2013). Sharma et al., who have calculated the only known price elasticity estimates for Australian adults to date, estimated a price elasticity for regular soft drink of -0.63 (Sharma, et al., 2014). These estimates varied due to differences in beverage categorisation, populations, data sources, and analysis methods (Nghiem, Wilson, Genç, & Blakely, 2013).

The estimated impact of SSB taxation on SSB purchasing for different socioeconomic groups is inconsistent from modelling studies (Backholer, et al., 2016), in part because of variation in modelling assumptions, and sometimes the extrapolation of price elasticities beyond the current data price ranges with which they were calculated (Nghiem, et al., 2013). Modelling studies are also subject to multicollinearity by design. Because beverage volume and price tend to be correlated in real-world retail scenarios, isolating the effect of changing just price or volume due to a policy intervention is obstructed by confounding.

There is some suggestion that frequent SSB consumers may preferentially benefit from an intervention that increases the price of SSBs, given the dose-response relationship between SSB consumption and the risk of adverse health-outcomes (Malik, et al., 2010). However, limited evidence from historical modelling studies suggests that more frequent SSB consumers may also be less responsive to SSB price changes than less frequent consumers (Etilé & Sharma, 2015).
There have been few high-quality evaluations of real-world SSB taxes. In Mexico, an approximate 10% SSB tax was associated with a 5.5% average decrease in SSB sales in the first year of the tax compared to predicted sales, and an 9.7% average reduction in the second year (with a 14.3% average reduction in SSB sales for the lowest socioeconomic group two years post policy implementation) (Colchero, et al., 2017). Similarly, in Berkeley an approximate 10% SSB tax was associated with a 9.6% decrease in sales of taxed beverages in the first year (Silver, et al., 2017). Both of these evaluations revealed smaller increases in purchases of untaxed beverages, predominantly driven by increases in bottled water sales (Colchero, et al., 2017; Silver, et al., 2017).

There have been limited experimental or quasi-experimental studies that have examined SSB pricing changes, which are independent from any SSB tax policy. In a hospital cafeteria in Boston, USA, Block et al. (Block, Chandra, McManus, & Willett, 2010) found that a 35% SSB price increase was associated with 26% decrease in SSB purchasing, with an additional decrease when educational posters were displayed. In a convenience store in urban Australia, Blake et al. found that a 20% SSB price increase was associated with a 28% decrease in SSB volume sales (Blake, et al., 2017).

Stated choice experiments (Bollard, Maubach, Walker, & Mhurchu, 2016; Lancsar & Louviere, 2008; Waterlander, Ni Mhurchu, & Steenhuis, 2014), such as Discrete Choice Experiments (DCEs), offer a complement to the totality of evidence. They allow for investigation of the impact of hypothetical pricing changes over a large range of prices and allow isolation of price changes from concurrent interventions such as educational campaigns (Colchero, et al., 2016), unlike historical purchasing data and real-world studies, and are not subject to multicollinearity.
by design unlike historical purchasing data studies. They additionally allow for analysis of the
effect of individual-level characteristics on responses to changes in beverage prices and
preferences (Lancsar & Louviere, 2008).

In this study, we have uniquely used a DCE to examine the impact of a hypothetical increase in
SSB price on adult consumer purchasing behavior. We aimed to predict the impact of (i) altered
beverage prices, and (ii) the additional effect of educational messages on consumer purchasing
behavior for the whole population; (iii) for sub-groups by income level and SSB consumption
frequency.

**Materials and Methods**

DCEs are a stated preference method of modelling choice (Lancsar & Louviere, 2008). They
create a hypothetical scenario or choice context and present a number of alternatives, described
by attributes (characteristics) of interest, between which subjects are asked to choose. Within
each choice scenario, the levels or amounts of the attributes differ across alternatives. DCEs
allow investigation of the effect of different attributes on choice and the trade-offs made
between them. They also allow the influence of participant factors (e.g. demographic factors) on
choice to be quantified (Lancsar & Louviere, 2008). The technique has been used extensively in
pharmaceutical and marketing literature, and is currently an emerging technique in health-
oriented food and beverage studies (Kamphuis, de Bekker-Grob, & van Lenthe, 2015;
Lacanilao, Cash, & Adamowicz, 2011; Papoutsi, Nayga, Lazaridis, & Drichoutis, 2015; Yang,
Sivey, Silva, & Scott, August 2016).
Study sample

The DCE was conducted online with 2,020 adults recruited and enrolled by an external panel provider in May-June 2016. Participant quotas were set based on a representative sample of the Australian adult population by gender, age and income.

Our sample was intentionally not representative of the Australian population based on frequency of SSB consumption. The proportion of regular consumers of SSBs is not well known in Australia, hence we selected a recruitment target of 70% who had purchased a SSB from a convenience store at least a few times in the last month. We recruited a large proportion of SSB consumers in order to ensure that we could predict the effect of the interventions within this high risk-consumer group. We therefore conducted a sensitivity analysis without including baseline frequency of SSB consumption in the model to examine the impact of this variable on income-specific results.

Sample size calculations are not routinely undertaken in the DCE literature since doing so requires parameter value estimations (Louviere, Hensher, & Swait, 2000), which were unavailable. DCE method guides variously suggest samples of at least 50 per analysis sub-sample (de Bekker-Grob, Donkers, Jonker, & Stolk, 2015) \((500*\text{product of attributes levels}/(\text{number of choice scenarios} * \text{number of alternatives})) = (500*(4*4))/(20*8))\); and 20 per block per sub-sample (Lancsar & Louviere, 2008). For the sample of 2000 participants in total, 1000 in each treatment sample, and at least 200 per analysis sub-sample, was much larger than such guides and sufficient to allow for estimation of robust models allowing for participant heterogeneity and sub-sample analyses.
Intervention

From a total of 160 unique choice scenarios (generated using NGene (Rose, Collins, Bliemer, & Hensher, 2009)), each participant was randomly allocated (using a computer generated sequence) to complete one of eight blocks of 20 choice scenarios (approx. 250 participants per block). In each scenario, subjects chose between seven SSB and non-SSB beverage options and a no beverage option (energy drink, plain low-fat milk, flavored milk, bottled water, regular soft drink, diet soft drink, fruit juice, no beverage). Beverages were described by prices and volumes which varied between scenarios with four generic volume levels (200mL, 330mL, 460mL, 600mL) and four alternative-specific price levels. The range of beverage prices for display were selected from the range of prices from a recently conducted study in an Australian convenience store (Blake, et al., 2017)[unpublished data] (+/-35% to allow for predicted probability analysis modelling). Alternative-specific price levels (Table S1) and an example choice scenario (Figure S1) are shown in Supplementary file 1. Participants were not informed of any reason for the beverage price changes with which they were presented.

Prior to the choice scenarios, half of participants were randomly presented with a graphic educational poster designed to discourage SSB consumption with the message “You wouldn’t eat 16 teaspoons of sugar - so why drink it?” (http://www.rethinksugarydrink.org.au/downloads/aboriginal-rethink-poster.pdf). The educational poster was part of a broader print and television campaign that ran in Australia from 2014-2016.
Following the DCE, participants completed a detailed sociodemographic questionnaire. This included questions relating to household income and composition, SSB consumption frequency and other detailed demographic information.

Selection of alternatives, attributes, experimental layout and instructions, were initially developed using focus groups (n=24 participants). The completed survey was piloted with 160 participants prior to recruitment of the full sample.

Ethical approval

This study was approved by the [Removed for blinding] Human Research Ethics Committee. Participants were paid a nominal fee for participating directly by the recruitment company.

Statistical analysis

We used Stata 14 for all statistical analyses [StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP]. We used a mixed logit model (Revelt & Train, 1998) to predict the influence of beverage price, volume and type on choice. We assumed utility to be a function of Alternative Specific Constants (ASCs, which indicate the preference for the beverage type, all else equal), a generic volume, alternative-specific prices, and multiplicative price-volume interactions. Multiplicative interaction effects were also included between each alternative-specific price and categorical variable relating to the consumer subgroups of interest (SSB consumption frequency from convenience stores in the past month, equivalized household income quintiles, gender, and age).
Random utility theory assumes subjects derive the maximum utility from the beverage chosen in each choice scenario (McFadden, 1974). Preferences for different beverages are allowed to vary randomly per participant in the mixed logit model to allow for unobserved heterogeneity of preferences between individuals. Separate models were also estimated for those exposed to the educational message and those not. The ability to pool these two samples based on similarity of preferences and scale (the inverse of the error variance term) was tested using a Swait and Louviere test (Fiebig, 2010; Swait & Louviere, 1993). Independent t-tests were used to compare demographic characteristics between those exposed and not exposed to the educational poster.

Using predicted probability analysis, the model results were used to explore the predicted purchasing distribution across the seven beverage options and no beverage option (and for SSB and non-SSB groups) under different pricing scenarios for the whole sample and for income quintiles and SSB consumption frequency groups. Based on derived models, a range of price changes were tested (10%, 20% and 30% SSB price increases; 10%, 20% and 30% non-SSB price decreases; 10% and 20% combined SSB price increases and non-SSB price decreases). ‘Baseline’ prices used during predicted probability analysis were derived using data provided by participants relating to their most recent beverage purchase in small store settings (such as convenience stores). Using data from all participants, within each beverage category (e.g. regular soft drink), the modal (most frequent) beverage volume was determined (e.g. 375mL), and then the mean price of beverages at that volume calculated. Confidence intervals for predicted probability analyses were manually calculated at the 95% level using standard errors and sample size.
We classified beverages into “SSBs” and “non-SSBs” using World Health Organization (WHO) recommendations on reduction of free-sugar intake, by which classification sugary beverages include fruit juices, flavored milks, regular soft drinks (soda), energy drinks, and exclude bottled water, diet soft drinks (diet sodas) and plain low-fat milks (World Health Organization, 2015). We also conducted a sensitivity analysis using the most common currently implemented classification of SSBs which excludes fruit juices and flavored milks (Colchero, et al., 2016).

For clarity, sub-samples used for each analysis have been labelled Analyses 1-4 both in Figure 1 and in the Results and Discussion sections below.

Results

2,020 adults completed the DCE and associated surveys. 1,012 of these were exposed to the educational poster and 1,008 were not. Demographic characteristics of the sample are given in Table 1. Study flow diagram is found in Figure 1.

Separate models were estimated for the sub-sample who were exposed to the educational poster. These results and the results of the Swait and Louviere test for heterogeneity between sub-samples are available in Supplementary File 2, Table S2. Due to baseline heterogeneity in preferences and scale (choice variability) between those who were and were not exposed to the educational poster, the two sub-samples are not able to be pooled in one model.
Table 1: Comparison of demographic characteristics between those who were exposed to the point-of-sale educational poster and those who were not, May- June 2016, Australia

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Exposed</th>
<th>Not exposed</th>
<th>P-value comparison between sub-samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years, mean (standard deviation)</td>
<td>46.8 (0.6)</td>
<td>45.7 (0.5)</td>
<td>0.15</td>
</tr>
<tr>
<td>Gender, female (%)</td>
<td>511 (50.5)</td>
<td>501 (49.7)</td>
<td>0.72</td>
</tr>
<tr>
<td>Household income tertile, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>309 (30.5)</td>
<td>308 (30.6)</td>
<td>0.99</td>
</tr>
<tr>
<td>Middle</td>
<td>512 (50.6)</td>
<td>508 (50.4)</td>
<td>0.93</td>
</tr>
<tr>
<td>Highest</td>
<td>191 (18.9)</td>
<td>192 (19.1)</td>
<td>0.92</td>
</tr>
<tr>
<td>Highest completed education level, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>153 (15.1)</td>
<td>152 (15.1)</td>
<td>0.98</td>
</tr>
<tr>
<td>High school</td>
<td>170 (16.8)</td>
<td>169 (16.8)</td>
<td>0.98</td>
</tr>
<tr>
<td>Trade qualification or Certificate, diploma</td>
<td>338 (33.4)</td>
<td>330 (32.7)</td>
<td>0.75</td>
</tr>
<tr>
<td>Undergraduate or postgraduate university</td>
<td>351 (34.7)</td>
<td>357 (35.4)</td>
<td>0.73</td>
</tr>
<tr>
<td>Regular sugar sweetened beverage consumers, n (%)</td>
<td>673 (66.5)</td>
<td>660 (65.5)</td>
<td>0.63</td>
</tr>
<tr>
<td>Metropolitan center resident, n (%)</td>
<td>775 (77.0)</td>
<td>763 (76.2)</td>
<td>0.67</td>
</tr>
</tbody>
</table>

*“Regular” sugar sweetened beverage consumption was defined as more than a few times per month.*

Independent t-tests were used to compare characteristics between those exposed and not exposed to the educational poster. As all p-values were >0.05, none of the differences between sub-samples are considered to be significant.

Figure 1. Flow chart of participants and analysis framework for this study, May- June 2016, Australia
5,253 individuals completed screening

- 88 ineligible (less than 18 years)

5,165 eligible

- 2,890 over quota

2,275 participants randomised

1,154 allocated to experiment without educational poster

146 with incomplete data

1,008 with complete data

- Analysis 1- effect of price changes only (n=1,008)

1,121 allocated to experiment with educational poster

109 with incomplete data

1,012 with complete data

- Analysis 2- effect of educational poster only (n=2,020)

- Analysis 3- combined effect of educational poster and price changes (n=2,020)

- Analysis 4- high risk sub-group analysis (extension of Analyses 1, 2, 3) (n=2,020)
Analysis 1: Predicted choice under different pricing scenarios (for sample without educational poster, n=1,008)

Using our predicted probability analysis of the mixed logit models (Supplementary File 2), the effect of different price changes on predicted purchases was estimated (Figure 2). Compared to baseline prices, a 10% SSB price increase was predicted to reduce overall SSB purchases by 15.0% [95%CI -15.2, -14.7], while predicted purchases of non-SSBs increased by 11.0% [95%CI +10.8, +11.2] and no beverage by +15.5% [95%CI +15.1, +15.9]. These effects were larger with a 20% SSB price increase (SSBs: -29.9% [95%CI -30.3, -29.5]). A 10% SSB price increase combined with a 10% non-SSB subsidy reduced predicted SSBs purchases with greater substitution to non-SSBs rather than no beverage option (compared to baseline prices, SSBs: -22.2% [95%CI -22.5, -22.0], non-SSBs: +25.6% [95%CI +25.3, +26.0], no beverage: +4.0% [95%CI +3.6, +4.3]). Our sensitivity analysis applying a 10% price increase to regular soft drink, and energy drink only (excluding flavored milk and fruit juice) found a similar reduction in purchases of those SSBs (-15.5% [95%CI -15.7, -15.3]), but a smaller increase in purchases of beverages not subject to a price increase (+4.0 [95%CI +3.9, +4.1]) (fruit juice, flavored milk, diet soft drink, bottled water, plain low-fat milk), compared to the more inclusive SSB definition scenario. In particular, the more limited SSB definition was associated with lower purchases of bottled water (approx. -2.6 percentage points), and higher purchases of fruit juice (approx.+2.1 percentage points), flavored milk (approx. +3.0 percentage points) and regular soft drink (approx. +1.0 percentage points).
Figure 2: Mean proportion of beverage category purchases under different pricing scenarios (n=1,008), May-June 2016, Australia. Error bars indicate 95% confidence intervals.

Analysis 2: Comparison between participants exposed and not exposed to educational poster without price change (whole sample, n=2,020)

A predicted probability analysis for the sub-sample exposed to the educational poster compared to that conducted for those not exposed, found a lower proportion who would select a SSB (approx. -4%) and a higher proportion who would select a non-SSB at baseline beverage prices (Figure 3). Those exposed to the educational poster had a higher probability of selecting bottled water (approx. +4%) and flavored milk (approx. +3%) and lower probability of selecting regular soft drink (approx. -4%).
Figure 3: Comparison of proportion selecting SSB and non-SSB with/without educational poster exposure (n=2,020), May- June 2016, Australia Error bars indicate 95% confidence intervals. SSB, Sugar sweetened beverages. Remaining proportion not shown corresponds to those selecting ‘no beverage’.

Analysis 3: Combined effect of educational poster and price changes (whole sample, n=2,020)

Compared to pricing changes alone, those additionally exposed to the educational poster were less likely to select a SSB across all pricing conditions tested, compared to those not exposed to the educational poster (Figure 3). We found that the absolute reduction in SSB purchases in response to a 20% SSB price increase was approximately the same for those exposed (-11.5%
suggesting an additive effect of the educational poster (rather than a modified response to price changes after posture exposure). We also found that there were additional reductions in SSB purchases associated with a 20% SSB price increase plus educational poster (relative decrease approx. -35%) compared to the price increase alone (-29.9% [95%CI -30.3, -29.5]). Similarly, there was a greater increase in non-SSBs purchases in response to a 20% SSB price increase for participants exposed to the educational poster (approx. +28%) compared to those exposed to a price increase alone (+19.0% [95%CI +18.5, +19.4]). Compared to a 20% SSB price increase alone, when exposed to both the educational poster and a 20% price increase, we predicted increases in the sample proportion purchasing flavoured milk (+1.9 percentage points), bottled water (+2.4 percentage points) and diet soft drink (+0.6 percentage points), and lower proportion selecting regular soft drink, energy drink and fruit juice (all -1.4 percentage points), and plain milk (-0.6 percentage points).

**Analysis 4: High risk sub-group analysis (whole sample, n=2,020)**

The lowest income quintile had higher SSB (45.1% [95%CI 43.7, 46.5]) and lower non-SSB purchases (36.2% [95%CI 35.2, 37.2]) at baseline prices compared to the highest income quintile (baseline prices: SSBs 41.4% [95%CI 39.8, 43.0]; non-SSBs 40.3% [95%CI 39.2, 41.3]). Across all pricing scenarios those from the lowest income quintile also had a lower predicted decrease in SSB purchases in response to price increases compared to the highest quintile (**Supplementary File 3, Figure S2**).

All income groups had a lower probability of SSB purchase in the group exposed to the educational poster compared to the non-exposed group. Compared to the lowest income quintile,
the highest quintile had higher predicted SSB purchases when exposed to the educational poster (approx. +3% percentage points difference) than without exposure (approx. -4% percentage point difference) at baseline prices (Supplementary File 3, Figure S2). Both the highest and lowest income groups had a larger reduction in predicted SSB purchases in response to an SSB price increase when exposed to the educational poster compared to participants who were not exposed to the educational poster.

We found smaller relative (proportional) and similar absolute (percentage point) reductions in predicted SSB purchases amongst higher frequency consumers of SSBs, compared to lower frequency consumers under a 20% SSB price increase (relative change compared to baseline prices, high consumers: -22.1% [95%CI -22.8, -21.4]; low consumers: -34.1% [95%CI -34.7, -33.5]) (Supplementary File 3, Figure S3). There was a smaller reduction in probability of selecting a SSB amongst high compared to low frequency SSB consumers who were exposed to an educational poster compared to the group who was not (relative effect at baseline prices, high consumers: approx. -5%; low consumers: approx. -15%). Finally, the combination of both a 20% SSB price increase and exposure to an educational poster was associated with a smaller relative and similar absolute reduction in predicted SSB purchases among those from the highest SSB (approx. -29% relative reduction) compared to the lowest SSB consumption frequency group (approx. -45% relative reduction).

Our sensitivity analysis without including participant SSB consumption frequency from convenience stores in the past month as a covariate suggested slightly smaller absolute and greater relative changes to both SSB and non-SSB purchases under the different pricing
scenarios for all income groups compared to the full model (Supplementary File 4, Table S3, Figure S4).

Discussion

Our findings suggest healthier beverage purchasing behavior in response to hypothetical price manipulations, based on a DCE with 2,020 Australian adults. In particular, increasing SSB prices was predicted to reduce their purchase and increase purchases of non-SSB alternatives (Analysis 1). The observed effects increased with increasing price differentials between SSBs and non-SSBs. In addition, we found that a point-of-sale educational poster aimed at reducing SSB consumption reduced choice of SSBs and increased choice of non-SSBs at baseline beverage prices (Analysis 2), and substantially augmented the predicted reduction of SSB choices in all hypothetical pricing scenarios (Analysis 3). We found that those from the highest income quintile had a slightly greater absolute (but similar relative) predicted reduction in SSB purchases compared to the lowest quintile for all pricing scenarios (Analysis 4). Those from higher SSB consumption frequency groups had a lower predicted relative reduction in SSB purchasing compared to lower SSB consumption frequency groups under all pricing scenarios, and a lower response to educational poster exposure (Analysis 4).

A 10% SSB price increase was predicted to reduce SSB purchases by 15% in our entire population (Analysis 1). These main estimates are similar to Blake et al. where the price increase also applied to large serving size juices and flavored milks in a convenience store setting (Blake, et al., 2017). Our sensitivity analysis, which applied the SSB price increase to the same range of beverages as in the Mexican SSB tax, found the equivalent of 7.8% reduction in sales of those beverages in response to a 10% SSB price increase. This is approximately half way between the
estimated 5.5% reduction in SSB purchases in the first year and 9.5% reduction in the second year following the Mexican tax implementation (Colchero, et al., 2016; Colchero, et al., 2017).

Previous controlled experiments have predicted similar or larger responses to SSB taxation scenarios (Bollard, et al., 2016; Waterlander, et al., 2014). Waterlander et al. found in a simulated Dutch three-dimensional supermarket that 11 - 15% SSB price increases were associated with a 28% reduction in SSB purchases compared to the control condition (Waterlander, et al., 2014). Bollard et al. found that a 20% SSB price increase did not reduce SSB purchases amongst New Zealand adolescents (Bollard, et al., 2016). Neither of these experiments examined purchasing differences by income level, but Waterlander et al. found that student status and low or high grocery budget were not significant effect modifiers of the response to a SSB price increase (Waterlander, et al., 2014).

We know of no other studies that have modelled the impact of combined beverage price increases and subsidies on beverage purchases. We found that increasing the price of SSBs and reducing the price of non-SSBs resulted in a greater shift to non-SSBs, compared to the same price differential as a SSB price increase alone (Analysis 1). This may be of interest to individual retailers and the beverage industry, whose profitability may be affected by government-mandated price changes.

Our finding of a higher baseline likelihood of SSB purchases amongst those from lower income groups (Analysis 4) is consistent with the known higher consumption of SSBs amongst lower income groups in the Australian population (Australian Bureau of Statistics, 2014; Waterlander,
et al., 2014). Therefore, although the percentage-point decline in SSB purchases was similar across income groups, this equates to a slightly larger relative reduction amongst higher income groups. Our findings of greater substitution to non-SSBs in response to price changes for higher income quintiles may reflect a lower underlying preference for SSBs amongst these groups (Australian Bureau of Statistics, 2014). Our findings differ from Colchero et al. who found a greater decrease in SSB purchasing among lower income groups in response to the Mexican SSB tax (Colchero, et al., 2017). This contrast may be due to differences in population composition and beverage purchasing patterns, or the relationship between income and beverage purchasing in middle income countries (e.g. Mexico) compared to high income countries (e.g. Australia). Our findings do, however, support other existing literature, which suggests SSB pricing strategies are likely to have similar absolute effect on SSB purchases across all income groups (Backholer, et al., 2016; Briggs, et al., 2013 Oct; Sharma, et al., 2014; Yang, et al., August 2016; Zizzo, Parravano, Nakamura, Forwood, & Suhrcke, 2016).

Further, our findings suggest that SSB price changes are likely to lead to a greater reduction in SSB purchases among those with lower baseline consumption of SSBs (Analysis 4). This finding is consistent with the limited existing literature on price changes in these subgroups (Etilé & Sharma, 2015). Hence focus on the aggregated population effect of SSB pricing policies may overestimate the health benefits for those whose SSB consumption health-policy makers are likely to be most keen to reduce.

Our findings that the point-of-sale educational poster improved the healthiness of beverage purchases (Analysis 2) align with Lacanilao et al. who found that a price increase on snack foods
in a vending machine scenario DCE was more effective when warning labels were displayed as well (Lacanilao, et al., 2011). Further, real-world quasi-experiments have suggested that educational messages may be useful in enhancing effectiveness of pricing interventions (Block, et al., 2010; Budd, et al., 2017). The health-behavior impact of educational messages are likely to differ depending a variety of factors including message framing and target audience (Gallagher & Updegraff, 2012).

The greater impact of the educational poster to reduce predicted SSB purchase (with and without a corresponding beverage price change) for low compared to high income groups was surprising (Analysis 4). Previous research has suggested that some nutritional education strategies may be more effective in higher than lower income or education groups, who are likely to have higher nutrition literacy (Cowburn & Stockley, 2005). Our study used an educational message selected through focus groups with a clear and simple message displaying the amount of sugar in various beverages. Further research is warranted to determine which educational messages may be most effective amongst vulnerable groups (Liberato, Bailie, & Brimblecombe, 2014).

Finally, our study has demonstrated differences in predicted consumer substitution behavior depending on which beverages are subject to price changes. This has implications for the potential health outcomes of beverage pricing policies (Analysis 1). Most real-world SSB pricing policies to date have excluded 100% fruit juices and flavored milks from taxation (Backholer, et al., 2017). However, fruit juices and flavored milks may have similar energy contents to regular soft drinks. As demonstrated in our sensitivity analysis, when extending price increases to 100% fruit juice and flavored milk, the predicted probability of choosing these beverages decreased (as opposed to the increase observed when these beverages were not
subjected to a price increase) and the substitution to water was greater. Substitution to 100%
juice and flavored milk was also reduced when participants were exposed to an educational
poster alongside SSB price changes (Analysis 3). Educational messaging should therefore be
considered as a complementary policy to SSB taxes to maximize population health benefits.

**Limitations**

The use of a DCE in this study allowed the rigorous testing of a variety of policy scenarios
which do not currently exist in the real-world as well as explicit modelling of the effects for
different consumer groups by looking at pricing changes at an individual level (Lancsar &
Louviere, 2008). Our study adds to the totality of evidence, including from limited real-world
studies. While DCEs have been shown to have generally high external validity across a range of
choice decision contexts (Lancsar & Swait, 2014), by their nature, they may be limited by
hypothetical bias, as participants are not required to ‘carry-through’ on their beverage choices
(Lancsar & Swait, 2014), and decisions are necessarily restricted to information provided
(namely beverage alternatives, price and volume). In our study, participants were presented with
general beverage labels rather than brands to allow the isolation of preference for the beverage
type itself rather than brand preference. However, consumer behavior may differ depending on
branding, and the range of beverages presented. Future testing including popular brands, may
help to predict whether consumers would be more likely to substitute to lower cost generic
branded products in response to beverage pricing policies.

Similarly, Random Utility Theory is an underlying assumption of DCEs and is a useful model
for quantifying trade-offs made by individuals in decision-making (McFadden, 1974). However,
decision making may be more complex in reality, for example individuals may seek to satisfy
minimum or maximum thresholds for certain criteria (Tversky, 1972), such as price. Also, we did not inform participants of the reason for the price changes; explicitly labelling the changes as taxes or subsidies may further affect participant preferences (Lacanilao, et al., 2011). Then again, incomplete pass-through of government-mandated pricing changes would reduce actual pricing changes and therefore the predicted effect (Colchero, et al., 2015; Falbe, et al., 2015). Although our results are consistent with the limited real-world data on consumer responses (Colchero, et al., 2016; Colchero, et al., 2017), it is difficult to predict how these complex industry and consumer responses to price restrictions may influence the magnitude of effect of price changes. Finally, we recruited a sample representative of the Australian adult population in age, gender and income and the study was set in a convenience store setting, and results may not be generalizable to other populations or contexts. Our sample was not representative based on SSB consumption frequency, however our sensitivity analysis supported our conclusions overall and for income groups. Further research should investigate the impact of beverage pricing among different populations (e.g. children (Yang, et al., August 2016) and adolescents); in a variety of purchasing contexts in which purchasing behavior, including impulsivity (Muruganantham & Bhakat, 2013), may differ (e.g. schools, restaurants, and sports and recreation centres).

Conclusions
This DCE is the first to our knowledge to examine beverage purchases in a convenience store setting or to explore the effect of combined beverage price increases and subsidies on beverage purchasing. We demonstrate that in Australia, SSB price increases are likely to reduce demand across all income groups and an accompanying educational message is likely to have an additive effect and improve the equity effect compared to pricing changes alone. Pricing policies may not
reduce consumption more in higher risk income and SSB consumption groups compared to lower risk groups. Similar studies should be replicated across different countries and cultures as response to price manipulations may vary due to a number of factors including variable SSB consumption and baseline beverage prices. Finally, the effect of explicitly informing consumers of the reason for price increase should be evaluated as a further means of enhancing the effect of beverage pricing strategies.
References


