RESEARCH ARTICLE

Framing and signalling effects of taxes on sugary drinks: A discrete choice experiment among households in Great Britain

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Abstract

Taxes on sugar-sweetened beverages (SSBs) are in place in many countries to combat obesity with emerging evidence that these are effective in reducing purchases of SSBs. In this study, we tested whether signalling and framing the price increase from an SSB tax explicitly as a health-related, earmarked measure reduces the demand for SSBs more than an equivalent price increase. We measured the demand for non-alcoholic beverages with a discrete choice experiment (DCE) administered online to a randomly selected group of $n = 603$ households with children in Great Britain (GB) who regularly purchase SSBs. We find a suggestive evidence that a price increase leads to a larger reduction in the probability of choosing SSBs when it is signalled as a tax and framed as a health-related and earmarked policy. Respondents who did not support a tax on SSBs, who were also more likely to choose SSBs in the first place, were on average more responsive to a price increase framed as an earmarked tax than those who supported the tax. The predictive validity of the DCE, to capture preferences for beverages, was confirmed using actual purchase data. The findings imply that a well-signalled and earmarked tax on SSBs could improve its effectiveness at reducing the demand.

KEYWORDS
demand analysis, discrete choice experiment, framing and signalling, sugar-sweetened beverage tax, United Kingdom

1 | INTRODUCTION

Excessive consumption of added sugars has been associated with growing prevalence of ill-health, including obesity, cardio-vascular diseases, diabetes and dental caries globally (WHO, 2018). Taxes on sugar-sweetened beverages (SSBs) have become a popular measure to reduce sugar consumption with over 30 countries or local jurisdictions having announced or already implemented such a policy in recent years (WCRF, 2018). Existing evidence from countries that have implemented such taxes indicates that they result in a small reduction in the purchases of the taxed products; the magnitude of which seems to depend on the tax rates and the local context. A recent estimate from a meta-analysis

suggests that the demand for SSBs decreases by 10% in response to a 10% tax (Caro et al., 2018; Colchero, Popkin, Rivera, & Ng, 2016; Nakamura et al., 2018; Redondo, Hernandes-Aguado, & Lumbreras, 2018; Silver et al., 2017; Teng et al., 2019). To date, little attention has been paid to the impact of the way in which taxes are framed and communicated to the public. By this, we mean not only whether the tax is signalled to the consumer but also if the reasons for introducing it are explained. This is important as both aspects could affect consumer behaviour and demand towards different beverages.

Some experimental studies have looked at this issue in the broader context of food choice, producing mixed evidence. For example, subsidies on healthier foods have been found to be effective in combination with framing or signalling interventions (e.g., advertising or promoting price change and providing nutrition education or improved labelling) (Afshin et al., 2017). There was no equivalent evidence for taxes, because few studies have tested their effect in combination with framing or information (Afshin et al., 2017). Meanwhile, the behavioural economics literature also provides mixed evidence on the effectiveness of 'priming' and 'salience' nudges to encourage consumers to healthier choices (Papoutsi, Nayga, Lazaridis, & Drichoutis, 2015; Seah et al., 2018; Wilson, Buckley, Buckley, & Bogomolova, 2016).

In practice, the framing of existing taxes on SSBs in various countries seems to have varied over time. In the earlier examples of Hungary (tax on unhealthy food and SSBs from 2011), Finland (tax on sweets and SSBs between 2011 and 2017) and France (tax on all added sugar or artificially sweetened beverages from 2012), the framing—followed partly from the aim or the purpose of the tax—had a strong emphasis on general revenue collection (Cornelsen & Carreido, 2015). In recent years, SSB taxes have been more explicitly framed as a public health measure to reduce sugar consumption, prevalence of obesity and associated negative health outcomes, especially for children (e.g., Mexico, local taxes in the United States, South Africa and the UK).

Another possible frame comes from combining the two aspects in which tax revenues are specifically earmarked to finance interventions or treatment of obesity and related diseases (e.g., UK levy on sugary drinks producers and some local taxes in the United States). A recent meta-analysis estimated that public support for SSB tax increases from 42% to 66% if revenues are used for health initiatives (Eykelenboom et al., 2019). In fact, Cremer, Goulao, and Roeder (2016) demonstrate, in a theoretical framework, that earmarking a fraction of tax proceeds to reduce health insurance premiums and retaining revenues to subsidise healthier goods can be welfare maximising (Cremer et al., 2016). Another recent study provided suggestive evidence of the potential effect of framing and information on earmaking tax revenue for health from Berkeley, California, where a penny-per-ounce tax on SSBs was introduced in 2015, with its revenues to be used for nutritional or other public health programs. The authors of the study observed a significant reduction in purchases of SSBs already after the local political campaign and vote for the tax few months earlier, suggesting that purchasing behaviours started to change before the tax was implemented.

Signalling of the tax to the consumer can take place in many ways, including through messaging on packages (e.g., as for cigarettes), or general information concerning the policy being provided on the shelf or directly on price labels (e.g., sales taxes in the United States). Clear signalling of the tax-inclusive price at the point of choice has been shown in different contexts (e.g., road tolls, nonfood retail and alcohol) to make it more salient, which means that the response to it is stronger in comparison with when the tax is signalled at the point of payment (Chen, Kaiser, & Rickard, 2015; Chetty, Looney, & Kroft, 2009; Homonoff, 2018). In the UK, consumers face tax-inclusive prices in shops, where the price on the shelf (or package) does not show either the tax-exclusive price or the tax rate. However, when the levy on sugary drinks producers was introduced in the UK in April 2018, many major retailers chose to use voluntary signage on beverage shelfs explaining that SSBs were priced higher because of the levy. Therefore, signalling need not take place only via price or price tags to inform or remind consumers of the policy.

The likely direction of the signalling and framing effects is difficult to determine a priori because, for example, improving knowledge of the negative health effects of high-sugar consumption could reinforce the price effect, whereas attitudes that oppose government intervention in consumer choice could undermine this (i.e., buying despite the higher price as a 'protest' against taxation). Equally, knowing that revenues are earmarked for a good cause, such as improving children's health or education, might, for some consumers, create a reverse incentive to support the cause and even increase purchase of the taxed product. Impact evaluations of existing taxes identify both price- and context-specific framing and signalling effects and are rarely able to disentangle these two separate effects. This is because appropriate control groups are in practice difficult, if not impossible, to find.

This study targets this gap in the literature and aims to compare the effect of a framed and signalled tax with an unsignalled and unframed equivalent price increase on the demand for SSBs and other non-alcoholic beverages. To measure responses in the demand to price changes, we use a discrete choice experiment (DCE). DCEs are common in marketing research, including in the analyses of demand for foods and beverages and consumers' willingness to pay for

product attributes (e.g., organic certification, health-related claims or environmental sustainability of foods) (Colson & Grebitus, 2016; Jenssen & Hamm, 2012; Krystallis & Chrysochou, 2012; Tait, Saunders, Guenther, & Rutherford, 2016). It is well suited for the UK context as at the time of the study, in September 2017, the levy on sugary drinks producers had been announced but had not yet taken effect. In our study, we implemented a survey experiment to contrast two alternative frames: one informs the respondent of the health-related reasons for introducing an SSB tax, and the second included further information on how the revenues from the tax would be used. By conducting the DCE among a sample drawn from a panel of consumers who regularly report their food and beverage purchases (GB Kantar Fast Moving Consumer Good panel), we were able to take into account participants usual beverage purchasing behaviour and assess the validity of the DCE in making beverage choices.

2 | METHODS

2.1 | Survey experiment

In an online survey (Appendix S1), study respondents were presented with a series of choice tasks asking them to consider a typical shopping occasion at a supermarket for their household and indicate the drink they would most likely prefer for their family from a set of alternative beverages (described in detail below). To test the effect of the tax signalling and framing on their choice, we randomised respondents to one of three groups, which differed in the way the price of SSBs were presented: control (no frame), 'health' frame or 'health and earmark' frame. The surveys presented to respondents in each group were identical with two exceptions. First, respondents in the 'health' and 'health and earmark' frame groups were informed before seeing any of the beverage choice sets that the price of SSBs included a tax, introduced for health reasons (see Table 1). In the 'health and earmark' frame group, the message further indicated that the revenues from the tax would be used to support school sport and nutrition education. Second, for the two frame groups, the tax on SSBs—at a 20% or 40% rate—was also signalled on the choice set (Figure 1).

2.2 | DCE design

We used a labelled DCE design, where each choice set included four alternative groups of beverages: sugary drinks (SSB), diet/low-sugar drinks, pure (100%) juice, water and an opt-out option (labelled as 'no choice'). The labelled design allowed more flexibility than a generic design to define the specific characteristics of each type of beverage. The

TABLE 1 Survey experiment design

Group	Price	Framing message shown prior to DCE
Control	Market price	n/a
'Health frame'	Market price, including a tax of 20% or 40% on SSBs	The **price of sugary drinks includes a tax** ranging from 20% to 40%. The tax has been applied because consuming high levels of added sugar has been shown to have links to weight gain, obesity, poor oral health and higher risk of diseases such as diabetes and cardio-vascular diseases. Sugar-sweetened beverages are the largest source of added sugar in diet. A tax on sugary drinks has been shown to be an effective measure to reduce consumption in countries where it has been implemented (Mexico, for example).
'Health and earmark frame'	Market price, including a tax of 20% or 40% on SSBs	The **price of sugary drinks includes a tax** ranging from 20% to 40%. The tax has been applied because consuming high levels of added sugar has been shown to have links to weight gain, obesity, poor oral health and higher risk of diseases such as diabetes and cardio-vascular diseases. Sugar-sweetened beverages are the largest source of added sugar in diet. A tax on sugary drinks has been shown to be an effective measure to reduce consumption of these drinks in countries where it has been implemented (Mexico, for example). **Revenues from the tax** would be used to support nutritional education and physical sport activities of school-aged children.

Abbreviations: DCE, discrete choice experiment; SSBs, sugar-sweetened beverages.
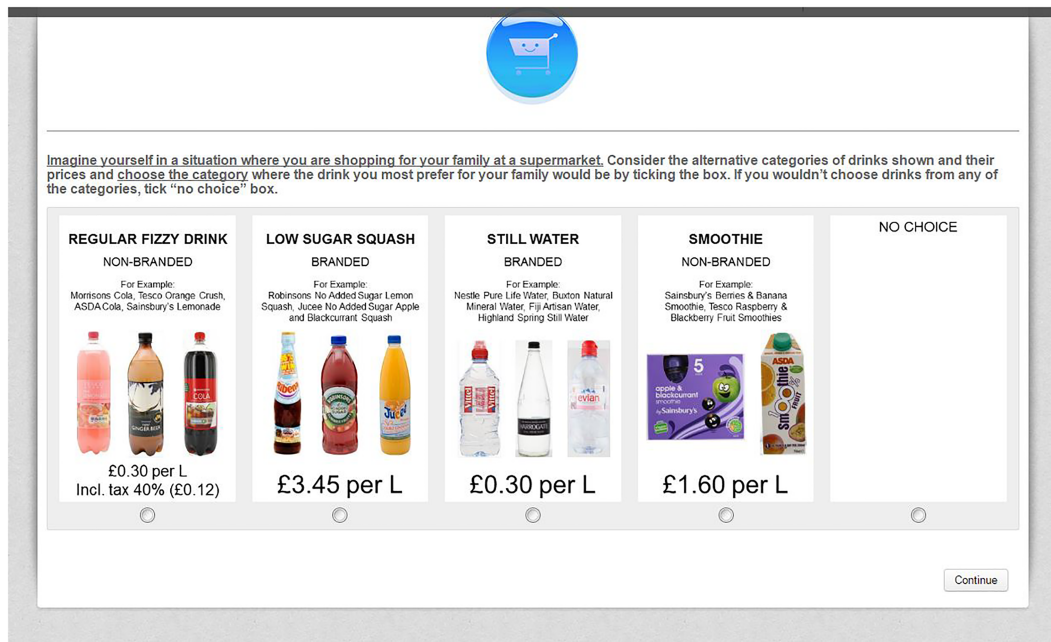
FIGURE 1 Example of a choice set for 'health' and 'health and earmark' tax frame groups [Colour figure can be viewed at wileyonlinelibrary.com]

selection of alternatives was informed by the typical structure of taxes on sugary drinks whereby diet/low-sugar beverages and juices with no added sugar are not taxed but represent different substitutes based on sugar content (see Table 2).

The price range of each alternative was chosen by analysing the lowest and highest prices charged in online supermarkets (March 2017) for the range of products under each type. Because prices varied depending on the type of the beverage as well as whether they were branded or nonbranded (e.g., store own label), price was introduced as a nested attribute and its levels were chosen dependent on the values of the branding and type attributes. To keep the decision setting more real-world like, the squash/cordial category prices were kept at product level rather than converted to ready-to-drink price using a dilution ratio. A tax rate of either 20% or 40% was included for the SSBs only. The former level is typically found as sufficient to effect significant changes in demand (Briggs et al., 2016) and commonly used in studies simulating the effects of SSB or nutrient-based taxes (Briggs et al., 2013; Harding & Lovenheim, 2017). The latter was added to test whether a higher tax rate would lead to non-linear effects. We did not use the rates for the UK levy on soft drinks producers because, at the time the study was designed, these rates were not yet officially confirmed.

TABLE 2 Alternatives, attributes and attribute levels

Alternative/Attribute	SSB	Diet (no/low-sugar) beverage	Pure fruit juice	Water
Type of product	Fizzy Juice drink Squash/cordial	Fizzy Juice drink Squash/cordial	Pure juice Smoothie	Still Sparkling
Branding	Branded Nonbranded	Branded Nonbranded	Branded Nonbranded	Branded Nonbranded
Price per litre (£)	Nonbranded fizzy and juice drinks (0.3, 0.4, 0.5, 0.6) Branded fizzy and juice drinks (0.6, 0.8, 1.1, 1.4) Nonbranded squash (0.6, 0.8, 1.1, 1.4) Branded squash (1.4, 2.3, 3.0, 3.5)		Nonbranded (1.6, 2.0, 2.5) Branded (2.5, 2.8, 3.1)	Nonbranded (0.1, 0.15, 0.3) Branded (0.3, 0.5, 0.8)
Tax[a]	20%, 40%	n/a	n/a	n/a

Abbreviation: SSB, sugar-sweetened beverage.

[a]The tax attribute applied only in 'health' and 'health and earmark' frame.

The ease and clarity of choice sets (see example in Figure 1) were tested in an online pilot study ($n = 69$) recruited with the same characteristics as the full study (see Section 2.4). Overall, 93% of the pilot sample felt the questions were relevant to them and 89% felt they could give all or most answers they wanted to give, which we considered as sufficient to proceed with the design.

To generate the final DCE questionnaires, we used a D-efficient design using priors estimated from the pilot study (the pilot study used the same design but zero priors). The designs for the pilot and the main survey were created using NGENE software (ChoiceMetrics, 2012). The nested price attribute was coded in the design through imposed conditions depending on the type of the drink and its branding.

Following principles of experimental design theory, the final survey included 24 choice sets, a number divisible by the number of attribute levels (2, 3, 6 or 8), to obtain a balanced design where each attribute level appears an equal number of times (Reed Johnson et al., 2013). As this was considered too large for any one respondent to complete, we blocked the design into two blocks of 12 choice sets each. Blocks, order of choice sets in the questionnaire and the order of alternatives within each set, were randomised.

2.3 | Additional information

In addition to the DCE, the questionnaire included a further two series of questions. First, before starting the DCE, respondents were asked whether they had diabetes, were on a diet or were pregnant or breastfeeding. Answers to these questions were used to control for potential external health-related factors affecting beverage choices. Second, respondents were also asked, after they had completed the DCE, whether they knew about the UK Government plans to introduce the levy from April 2018 (answer options: yes/no/have heard of it but not sure what it means) and whether, in general, they supported plans to introduce this levy (answer options: yes/no/unsure). These questions were introduced to understand overall knowledge about the policy among the respondents and whether there could be differences in the response to the DCE based on the self-reported support towards the policy.

2.4 | Study sample

The sample was drawn from GB Kantar Fast Moving Consumer Goods (FMCG) panel of households. Annual panel size is approximately 32,000 households, and the panel is nationally representative with respect to geographical region, age of the main shopper, household size and occupational socio-economic status. Access to the panel was provided by Kantar, one of the world's leading data, insight and consultancy companies that has been operating the FMCG panel since 1991. The panellists provide records on their day-to-day purchases of consumer goods, including foods and beverages for consumption at home (we refer to these data later as home-scan). Kantar regularly conducts market research surveys among this panel for their own research and when commissioned by clients.

The sample for the DCE was restricted to households who had purchased at least 2 L of SSBs every month in 6 months preceding the survey (based on home-scan purchases) and who had at least one child under the age of 18. These criteria were set, first because, nationally, the policy direction in the UK is focused on preventing childhood obesity and therefore we considered households with children as a key population subgroup. Second, we wanted to capture in the sample households that were regular purchasers, regardless of being heavy consumers or not (again as key target to the policy), and the criteria of having purchased at least 2 L of SSBs monthly allowed us to exclude households who never purchase SSBs or do so irregularly. Participants meeting these two criteria were then randomly selected for invitation into the DCE. Although not necessarily representative of the whole population, this sample informs preferences of the population generally targeted by these policies. Assuming a response rate of ~70% the survey was made available for 780 households through a weblink. We assumed that it was the main respondent (shopper) to the FMCG panel who also completed the survey.

The survey was conducted during a 10-day period in September 2017 by Kantar who collected the survey results and further provided socio-demographic data (household size, number of children, income bracket, region, highest qualification, tenure and socio-economic status) as well as home-scan purchase records of non-alcoholic beverages in 2017 (for consumption at home). On the basis of the home-scan purchase records, we created a variable representing the average weekly volume in litres of beverages purchased per household member in each of the four alternative beverage categories, which we used in the modelling stage to control for household usual behaviour in choosing the beverages.

2.5 | Analytical plan

We first compared the unadjusted choices of each alternative across the three groups. We then used the multinomial logit (MNL) model to build the adjusted model structure and confirmed using the MNL model that blocking did not have significant effects on choices via a dummy variable indicating the different block. We then proceeded to estimate the model using the mixed (random effects) logit (MXL) model, which allows consideration of respondent heterogeneity in preferences towards different beverages.

We assumed that individual i ($i = 1, ..., 603$) makes choices such that they maximise utility over the four alternatives presented ($j = 1, 2, 3, 4$). The utility U_{ijc} derived from choosing a particular alternative c can be decomposed into the linear combination of attributes of this alternative and an error term (McFadden, 1973):

$$U_{ijc} = X_{ijc}\beta + \varepsilon_{ijc},$$

where vector X_{ijc} consists of observable product attributes and respondent characteristics:

$$X_{ijc} = \beta_0 \text{ASC}_j + \beta_1 \text{Type}_j + \beta_2 \text{Brand}_j + \beta_3 \text{Price}_j + \beta_4 \text{Tax}_j + \beta_5 \text{Vol}_{ij} + \beta_6 H_{ij} * \text{ASC}_j + \beta_7 \text{HE}_{ij} * \text{ASC}_j + \sum \gamma_i Z_i, \quad (1)$$

where β_0 are coefficients for alternative specific constants (ASCs) for each alternative j. Coefficient(s) for β_1 showed respondent sensitivity to attributes regarding type. For SSBs and diet drinks, three 'type' categories were included (fizzy, juice drink and squash) and two 'type' categories were included for juice (juice and smoothie) and water (still and sparkling). Coefficient for β_2 showed preference for branding (branded/nonbranded). Coefficient for β_3 showed respondent price sensitivity of alternative beverages j, and coefficient for β_4 showed sensitivity to the tax rate shown with the price of SSBs in 'health' and 'health and earmark' frame group only (20% or 40%). Coefficient β_5 measured the extent to which respondent average weekly purchases of each of the alternative beverages j influenced the choice. Coefficients β_6 and β_7 indicated effects from the respondent i belonging into either 'health' (H) or 'health and earmark' (HE) frame group, respectively, via interaction with ASCs. These variables were, in the estimated model, also further interacted with all the attributes and respondent characteristics to allow for differences between the three groups.

Z_i are variables describing the respondent (or their household). Two of these variables —the number of children and if the respondent had not indicated any of the conditions asked pre-DCE (on diet, diabetes, pregnant or breastfeeding)—were included because of the slight differences between the groups in these characteristics. We further included income as this tends to be associated with SSB consumption in the literature (Smith, Cornelsen, Quirmbach, Jebb, & Marteau, 2018). In the initial model building, we also tested inclusion of variables indicating whether respondents knew about the UK levy, household occupational socio-economic status, age and sex of the main respondent. These did not improve the model fit based on the log-likelihood.

Although support towards the levy could affect the reaction to price increase or a tax, we did not include it as an explanatory variable in the model because the question was asked after the DCE, and its answer could be influenced by the choice experiment. Rather, we repeated the estimation in subsamples according to the response to the question on support (yes, no, unsure) to understand if there are differences in the response to the price increase and framing based on self-reported support.

All the categorical variables in the model were effects coded. These entered the model with still one category omitted, but its coefficients were interpreted independently, rather than as compared with the excluded category. Given the heterogeneous preferences towards the beverages across individuals, the MXL estimation treated price, volume and ASCs as random parameters with normally distributed coefficients and the remaining variables were treated as fixed. Normal distribution for price means that we allow also positive response to price increase, which could be a possible outcome if consumers continue to choose beverages despite the tax.

Finally, we explored how the choice of SSBs varied at different levels of price and predicted marginal effects on the choice of SSBs and other beverages from a 20% and 40% price increase (control group) or tax ('health' and 'health and earmark' frame groups). Models and marginal effects were estimated using Stata 16 choice modelling commands (StataCorp, 2019).

2.6 | Assessment of validity of stated preferences in comparison with revealed preference data

Access to home-scan data on respondent beverage and total food expenditure allowed us to test the (predictive) validity of stated choices. This is important because although DCEs can provide a useful framework for eliciting preferences where choices are limited (e.g., health care treatment options), it may not adequately capture choice in the context of many possible alternatives, such as beverages on a supermarket shelf. Our analysis, comparing the stated and actual choices, aims to provide evidence concerning the validity of stated choices. This analysis was conducted only in the control group, which is the best comparator for the real-world choices observed in home-scan purchases, as respondents were not influenced by the tax or its framing.

We started by creating a dataset from home-scan purchase data in the same structure as the DCE data, by categorising the product level purchases of beverages into the four alternative categories (SSBs, diet beverages, 100% fruit juice and bottled water). We used the full year (2017) of home-scan data to avoid picking a subset of the data with seasonal effects. A choice set was then created as any 'occasion' where households had shopped for any foods or beverages (i.e., they were in a shop and had the opportunity to purchase a beverage). A binary choice variable was created for each of the four beverage categories if at least one product belonging to these groups had been purchased during the occasion. 'No purchase' was identified as those occasions where no beverages in any of the alternative groups were purchased.

We then created a price variable using average purchase prices in each alternative category. Where price was not observed (i.e., purchase was not made in a particular shopping occasion for a specific alternative), we used an average weekly price in the postcode area where the respondent resided. Price was capped at £4/L to keep the price range

TABLE 3 Descriptive statistics and balance checks

	Control (n = 205)	Health frame (n = 211)	Health and earmark frame (n = 187)	p Value of test of difference across the three groups[a]
Household size (SD)	4.15 (0.96)	3.96 (1.03)	4.07 (1.08)	0.038**
Number of adults (SD)	2.23 (0.67)	2.22 (0.65)	2.23 (0.72)	0.959
Number of kids (<18 years old) (SD)	1.92 (0.85)	1.74 (0.88)	1.84 (0.85)	0.034**
Age of main shopper	44 (8.1)	43 (8.3)	45 (8.3)	0.197
Health related (%)				
Has diabetes	3.41	5.21	6.42	0.386
Is on a diet	2.44	3.79	10.16	0.001**
Is pregnant or breastfeeding	2.44	1.90	2.67	0.868
Usual purchases (litre per household member/week, SD)[b]				
SSB	0.67 (0.68)	0.70 (0.62)	0.62 (0.62)	0.529
Diet/low sugar	0.89 (0.85)	0.98 (0.97)	0.85 (1.03)	0.115
Pure juice	0.08 (0.17)	0.11 (0.20)	0.08 (0.16)	0.432
Water	0.26 (0.50)	0.31 (0.58)	0.33 (0.65)	0.618
Knows UK levy (%)				0.346
Yes	47.32	38.39	45.45	
No	25.85	31.28	29.95	
Yes, but not sure what it means	26.83	30.33	24.60	
Support towards UK levy (%)				0.001**
Supports	28.29	30.81	45.45	
Does not support	48.78	32.70	31.02	
Unsure	22.93	36.49	23.53	

[a]For continuous variables, we performed a Kruskal–Wallis Chi-square test; for categorical variables, we used a Pearson Chi-square test.
[b]Calculated from home-scan data for 2017.
*$p < 0.1$.
**$p < 0.05$.

comparable with DCE, which excluded less than 1% of observations. We used an MNL model, including ASCs and price in the model for actual purchase data, to compare the direction of the coefficients and predicted market shares (choice probabilities) with those estimated from the DCE data (the MNL model for DCE data included design attributes but not usual purchase volumes or socio-demographic characteristics). ASCs were also effects coded to match the DCE data setup. We estimated MNL on the (a) full sample of actual purchases, which included 24% of shopping occasions where more than one beverage was bought, and (b) shopping occasions where only one beverage was purchased. Where more than one product was purchased in one occasion, the likelihood was estimated using a recursive computation algorithm (StataCorp, 2017).

3 | RESULTS

Table 3 describes the main characteristics of respondents and tests for differences across the three groups. There was a difference in the overall household size, which appeared to be driven by small differences in the number of children. Responses to health-related questions indicated differences in the share of people who were on a diet, which was highest in the 'health and earmark' group. For the remaining socio-demographic characteristics (income, occupational socio-economic status, region, highest qualification and tenure), there were no statistically significant differences across the three groups (Table S1).

Average weekly consumption per household member varied from 0.62 to 0.70 L for SSBs, 0.85 to 0.98 L for low-sugar/diet drinks, 0.08 to 0.11 L for juice with no added sugars and 0.26 to 0.33 L for bottled water. Differences across the groups were not significant. Although knowledge of the UK levy (asked after the DCE) did not vary significantly across the three groups ($p = 0.350$), support towards the policy did ($p < 0.001$) and was the highest in the 'health and earmark' frame group (45.5%) and the lowest in the control group (28.2%). To the contrary, the control group had the highest share of respondents who did not support the levy (48.8%).

Looking at unadjusted choices (Figure 2), framing the price increase as a tax appears to reduce the choice of SSBs in 'health' and 'health and earmark' groups, in comparison with the control, while increasing the choice of diet, water or not choosing a beverage. Chi-square test confirmed that choices were significantly different across the three groups for SSBs ($p = 0.04$), diet beverages ($p = 0.048$) and water ($p = 0.001$).

3.1 | DCE results

The MNL and MXL models appeared relatively robust, with only small differences in both the magnitude and significance of the coefficients. We interpreted MXL (Table 4) as the main outcome model as it had a better fit than the MNL (smaller log-likelihood and Akaike information criterion). The MNL results are shown in Table S2.

In the MXL model, looking at the ASCs (Table 4, where each column shows the output for each alternative), respondents were more likely to choose SSBs or diet beverages and less likely to choose pure juice or bottled water in
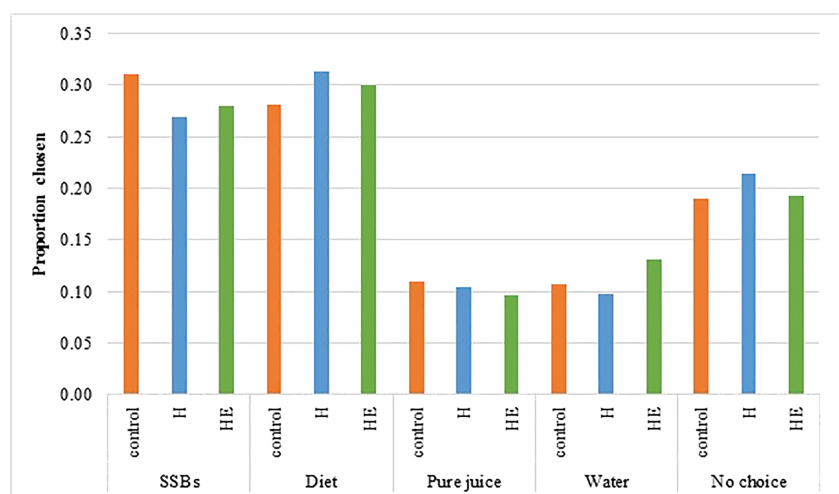
FIGURE 2 Unadjusted choices of beverages in the discrete choice experiment, by tax frame [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 4 Mixed logit estimates

Variable	SSBs		Diet beverages		Pure juice		Water	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
ASC	1.095**	0.314	1.490**	0.387	−1.261**	0.622	−2.491**	0.482
SD	0.465	0.064	0.591	0.057	0.742	0.101	0.733	0.079
x frame H	−0.665	0.457	−0.298	0.522	−1.499*	0.895	2.447**	0.658
x frame HE	−0.185	0.467	−0.089	0.538	−0.157	0.922	0.742	0.668
Beverage type (a)[a]	−0.085	0.082	−0.894**	0.189	0.840**	0.091	0.787**	0.090
x frame H	0.019	0.117	−0.159	0.254	−0.004	0.127	−0.192	0.131
x frame HE	−0.208*	0.123	−0.263	0.265	0.273*	0.137	0.152	0.129
Beverage type (b)[a]	−0.311**	0.086	−1.407**	0.185				
x frame H	−0.112	0.121	−0.272	0.255				
x frame HE	−0.023	0.126	−0.485*	0.267				
Branded beverage	0.231**	0.075	0.006	0.081	−0.724**	0.122	0.100	0.127
x frame H	−0.018	0.106	0.096	0.110	−0.037	0.177	−0.357**	0.177
x frame HE	−0.055	0.109	0.019	0.115	0.031	0.188	−0.223	0.167
Tax 40% frame H	−0.032	0.053						
Tax 40% frame HE	0.092	0.057						
Price	−0.602**	0.141	−0.624**	0.150	−0.627**	0.246	−3.811**	0.779
SD	0.748	0.067	0.721	0.069	0.624	0.059	3.858	0.403
x frame H	−0.087	0.198	0.047	0.197	0.383	0.342	0.570	0.984
x frame HE	−0.358*	0.208	0.096	0.209	−0.340	0.354	1.593*	0.911
Volume	0.359**	0.137	0.552**	0.125	0.236	0.970	2.490**	0.390
SD	0.238	0.139	0.248	0.062	0.973	1.013	0.925	0.141
x frame H	0.200	0.204	0.184	0.160	1.392	1.248	−0.892**	0.452
x frame HE	0.028	0.253	0.008	0.158	0.078	1.387	−0.897*	0.519
No health cond.[b]	0.056	0.136	−0.154	0.143	0.240	0.219	−0.026	0.251
x frame H	−0.020	0.188	0.148	0.190	−0.460	0.297	0.285	0.319
x frame HE	0.009	0.174	0.132	0.182	−0.217	0.293	−0.022	0.303
Income	−0.005	0.004	−0.010**	0.005	0.008	0.007	0.020**	0.007
x frame H	0.008	0.006	0.010	0.007	0.011	0.011	−0.035**	0.010
x frame HE	0.011*	0.006	0.001	0.007	0.001	0.010	−0.020*	0.010
Number of kids	0.026	0.084	0.192**	0.090	−0.037	0.133	0.059	0.138
x frame H	0.182	0.122	0.027	0.126	0.272	0.198	−0.717**	0.216
x frame HE	−0.150	0.127	−0.003	0.132	0.227	0.221	−0.128	0.208

Note. Frame H ('health') and frame HE ('health and earmark'). Alternatives are presented in columns for presentational purposes; the model was estimated including all the variables listed in each row for each of the alternative beverage groups. $N = 7{,}236$; log-likelihood −9,018.4; normally distributed random parameters. Categorical variables were effects coded.

Abbreviation: ASC, alternative specific constants.

[a]Beverage types for SSBs: fizzy (a), juice drink (b), squash/cordial (excluded); for diet beverages: fizzy (a), juice drink (b), squash/cordial (excluded); for juice: pure juice (a), smoothie (excluded); water: still (a), sparkling (excluded).

[b]'No health conditions' indicates those respondents who did not indicate any conditions (on diet, with diabetes, pregnant/breastfeeding).

*$p < 0.1$.

**$p < 0.05$.

comparison with choosing nothing ($p < 0.01$). This was not surprising, as the sample was selected as those who regularly purchase SSBs. In comparison with the control group, the 'health' frame group appeared to be more likely to choose water ($p < 0.001$) but less likely to choose juice ($p = 0.037$).

In relation to the type of beverage, for SSBs, respondents were less likely to choose a juice drink ($p < 0.001$) but more likely to choose a branded SSB ($p = 0.002$). Neither attribute had significant differences for the tax frame groups. Price coefficient was, as expected, negative ($p < 0.001$) indicating that respondents were less likely to choose SSBs if price was higher. Price coefficients for both 'health' and 'health and earmark' groups were more negative indicating that the respondents were likely to be more price sensitive, although this was significant ($p < 0.1$) only for the 'health and earmark' group. Greater usual purchase volumes of SSBs were associated with higher likelihood of choosing SSBs ($p = 0.009$), but again, the difference between groups was not significant. Household characteristics, although in

expected directions, did not have any associations with the likelihood of choosing SSBs at conventional statistical significance levels.

For diet beverages, respondents had a lower likelihood of choosing this alternative if type was fizzy or juice drink ($p < 0.001$). Branding did not appear as a significant attribute in diet beverage choice. As for SSBs, an increase in the price was associated with lower likelihood of choosing the diet beverage alternative, and a higher usual purchase volume was associated with a higher likelihood of choosing this alternative (both $p < 0.001$). Higher income was associated with a lower likelihood of choosing a diet beverage ($p = 0.042$), and conversely, a larger number of children in the household was associated with a higher likelihood of choosing a diet beverage ($p = 0.033$).

The likelihood of choosing pure juice alternative was greater if the type was juice ($p < 0.001$), and this was even greater for the 'health and earmark' group ($p = 0.046$). Respondents were less likely to choose a branded juice alternative ($p < 0.001$) and, as before, less likely to choose it when prices increased ($p = 0.01$). Usual purchase volumes or household characteristics were not associated with the likelihood of choosing juice, and there were no differences between the three groups.

Finally, there was a higher likelihood of choosing still water ($p < 0.001$). An increase in price and usual purchase volumes were again associated with lower and greater likelihood of choosing water, respectively ($p < 0.001$). The association with usual purchase volumes was smaller for both tax frame groups ($p < 0.08$). Those with higher income in the control group were more likely to choose water ($p = 0.006$), but this was not the case for the tax frame groups ($p < 0.05$). More children in the household were associated with a lower likelihood of choosing water in the 'health' frame group only in comparison with control group ($p = 0.001$).

As noted before, ASCs, price and usual purchase volumes were entered in the model with random coefficients, and these all had, with the exception of volumes for SSB and juice alternative, significant variation indicating heterogeneity in consumer preferences with respect to these variables.

To interpret the model estimates, we first explore SSB choice at different price levels across the three groups. We derive the demand curve from the predicted probability of choosing SSBs at different price values ranging from £0.5/L to £4/L. Figure 3 shows that tax frame groups were consistently less likely to choose SSBs in comparison with the control group.

All three groups show a downward sloping demand curve; they were increasingly less likely to choose SSBs as prices increased. At sample average price levels (£1.06/L), the probability of choosing SSBs was similar in 'health' (26.2%, 95% CI [23.3, 29.0]) and 'health and earmark' (27.2%, 95% CI, [24.2, 30.2]) frame group, and both were lower compared with control group (30.7%, 95% CI [27.8, 33.6]). At low prices (£0.5/L), the difference with the control group reduces for the 'health and earmark' frame group. Across the groups, the slope of the curve becomes steeper as price grows suggesting that demand is less sensitive to price changes at high prices (>£2/L). Although the demand for SSBs among the two tax frame groups at every price level is lower in comparison with the control group, these differences were not statistically significant at conventional levels with 95% confidence intervals overlapping across the three groups.

Next, we simulated the change in the probability of choosing alternatives after a 20% and 40% price increase (or tax in tax frame groups) using MXL model estimates. Figure 4 shows that a 20% price increase would lead to a significant decrease in the choice probability of SSBs in all three groups. The probability of choosing SSBs is predicted to fall by 1.3 percentage points (pp) in the control group (95% CI [−2.0, −0.5]), 1.2 pp in the 'health' frame group (95% CI [−1.9, −0.6]) and 1.9 pp (95% CI [−2.6, −1.2]) in the 'health and earmark' frame group. To obtain the corresponding price elasticity, we calculated the relative percentage changes (−4.1% in control group, −4.7% in 'health' frame and −6.9% in
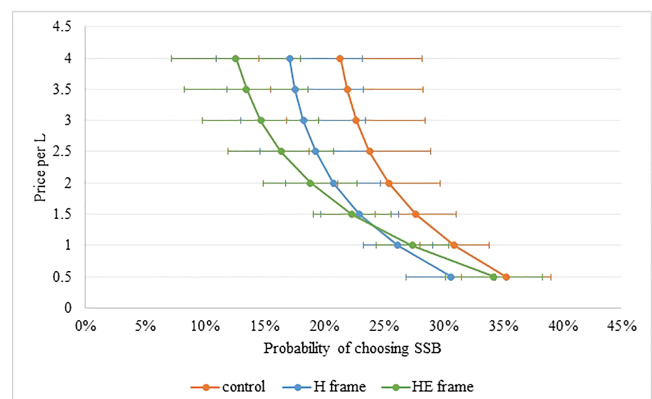
FIGURE 3 Predicted demand for sugar-sweetened beverages (SSBs), under different tax frames [Colour figure can be viewed at wileyonlinelibrary.com]
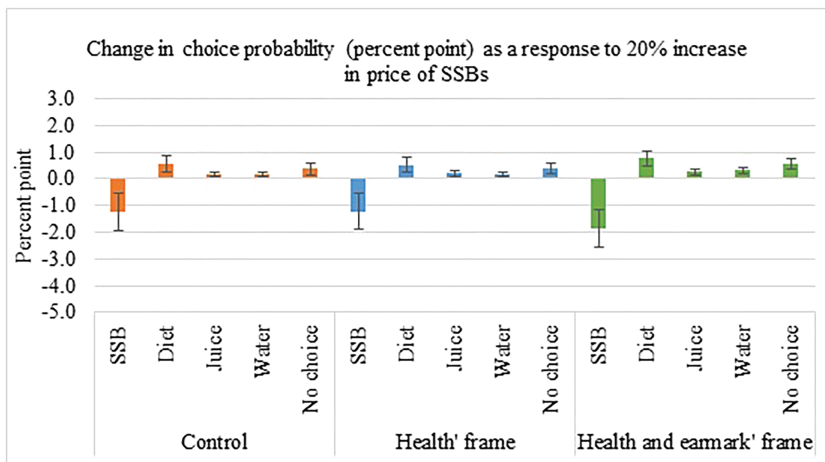
FIGURE 4 Simulated effects of a 20% or 40% (tax) price increase of sugar-sweetened beverages (SSBs) on the predicted choices of beverages [Colour figure can be viewed at wileyonlinelibrary.com]
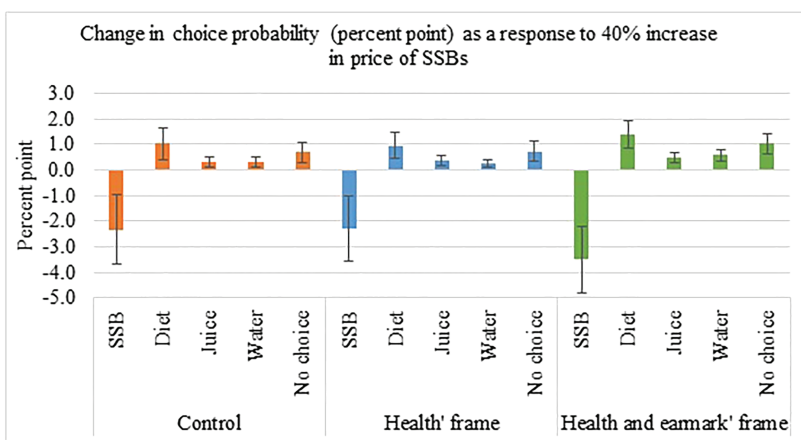
FIGURE 5 Simulated effects of a 40% (tax) price increase of sugar-sweetened beverages (SSBs) on the predicted choices of beverages [Colour figure can be viewed at wileyonlinelibrary.com]

'health and earmark' group), yielding estimates of the price elasticity of the demand for SSBs of −0.21, −0.24 and −0.35, respectively.

Figure 5 suggests that the effect of a tax increase on the demand may not be linear, as the effect of a 40% tax is slightly less than twice the effect of a 20% tax with a reduction in the probability of choosing SSBs by −2.3 pp (95% CI [−3.7, −0.1]) in the control group and 'health' frame group (95% CI [−3.5, −0.1]) and −3.5 pp (95% CI [−4.8, −2.2]) in the 'health and earmark' frame group. Across the groups, the most common substitute was diet beverage, followed by no choice.

Finally, we looked at differences in beverage preferences, according to respondents' support of the levy. As before, using the MXL estimates (Table S3), we found the predicted probability of choosing SSBs and simulated the impact of a 20% price change of SSBs (tax).[1] Looking at Figure 6, it is clear that those who did not support the policy had the highest proportion of SSBs in their choices (30%–37% across the three groups) in comparison with those who did (22%–24%) or were unsure (25%–30%).

Among respondents who supported the levy (see Figure 7), there was a significant reduction in the demand for SSBs following the price increase only in the presence of the 'health' and 'health and earmark' frames (demand was reduced by −1.7 pp, 95% CI [−2.8, −0.5], and −1.6 pp, 95% CI [−2.6, −0.6], respectively) but not when the price change was not signalled or framed (−1.2 pp, 95% CI [−2.4, 0.2]). Those who were unsure were showed a similar pattern. Among those who did not support the levy, the demand for SSBs decreased most in the presence of 'health and earmark' frame (−2.6 pp, 95% CI [−4.0, −1.2]) or without any frame (reduction by −1.6 pp, 95% CI [−2.7, −0.5], in the control group). The effect of the 20% price increase on the demand with the 'health' frame (−0.7 pp, 95% CI [−1.9, 0.6]) was not significant.

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[1]In order for the MXL to converge in the subsamples, we had to simplify the model by removing demographic variables (income, presence of children and health conditions) and moved 'volume' in to the fixed part of the model.

FIGURE 6 Probability of choosing sugar-sweetened beverages (SSBs) by support to policy taxing sugary drinks (yes/unsure/no) [Colour figure can be viewed at wileyonlinelibrary.com]
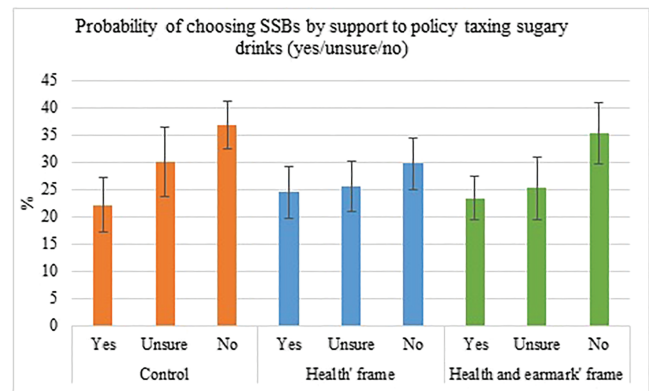
FIGURE 7 Change in choice probability (percent point) as a response to 20% increase in price of sugar-sweetened beverages (SSBs) by support to policy taxing sugary drinks (yes/unsure/no) [Colour figure can be viewed at wileyonlinelibrary.com]
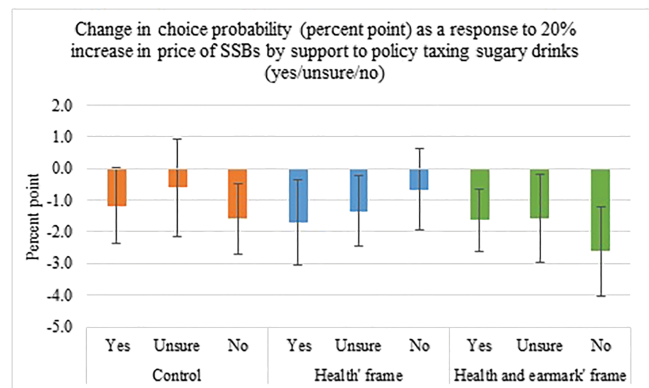
3.2 | Comparison of revealed and stated choices

Comparing actual purchases obtained through home-scan data and stated preferences from the DCE, we found some notable differences (Table 5). Predicted demand based on the DCE suggests that fewer people would choose none of the beverages offered, compared with what they actually do (19% vs. 35.2% in home-scan data). Because respondents do not have to make a real purchase in the DCE, it is not surprising that they would choose "no-choice" less often. Because the drink categories are broad, they could also imagine that their preferred drink within a category is available, although this might not be the case when they actually shop. Meanwhile, the DCE appears to predict relatively well drink preferences, and the market shares for the SSBs (26.3% in home-scan data vs. 31.1% in the DCE) and diet beverages (29.9% in home-scan data vs. 28.2% in the DCE).

The price coefficient in home-scan data indicated slightly greater price responsiveness in comparison with the DCE, which again is intuitive as DCE did not involve an actual purchase, but the difference in the magnitudes is relatively small. Price elasticity of demand from home-scan data was −0.33 (−0.32 if only one alternative was chosen per occasion) in comparison with −0.21 from the DCE. This does suggest that the results of the DCE above are, if anything, underestimating the impact from a price increase.

4 | DISCUSSION

Framing and signalling are potential ways of influencing (or nudging) consumer choices beyond the effects of the price change itself. We measured these relatively little studied effects for a tax on SSBs, which has become a popular policy aimed at reducing sugar consumption. Our findings were mixed. When the tax for SSBs was not framed or signalled (control group), we found suggestive evidence that the predicted demand for SSB was higher (30.7% choice probability) compared with situations where a tax was introduced and signalled ('health' and 'health and earmark' frames, 26.2% and 27.2%, respectively). However, these estimates had overlapping confidence intervals. A 20% price increase was estimated to reduce the probability of choosing SSBs both in the control and 'health' frame groups by 1.2 pp, compared with a 1.9 pp reduction in the health and earmark frame. Although the effects of price changes itself were

TABLE 5 Comparison of revealed and stated choices in the control group

	Home-scan data, all observations		Home-scan data, one alternative chosen per shopping occasion		DCE data	
	MNL estimates					
Variable	Coef.	SE	Coef.	SE	Coef.	SE
ASC (SSB)	0.808**	0.016	0.887**	0.026	0.787**	0.082
ASC (diet)	0.827**	0.013	0.962**	0.023	1.115**	0.085
ASC (juice)	−1.225**	0.023	−2.009**	0.058	−0.481**	0.123
ASC (water)	−1.065**	0.021	−1.447**	0.043	−1.271**	0.117
Price	−0.415**	0.020	−0.353**	0.028	−0.294**	0.057
Alternative	Predicted choice probability at sample averages					
SSB	0.263		0.186		0.311	
Diet	0.299		0.221		0.282	
Juice	0.039		0.012		0.110	
Water	0.054		0.023		0.107	
No choice	0.352		0.563		0.190	
Pseudo r^2	0.180		0.315		0.097	
n	22,936		17,499		2,460	
Price elasticity	−0.33		−0.32		−0.21	

**$p < 0.05$.

significantly different from zero for all three groups, the comparisons between the groups again were not. This means that we cannot confidently associate the relatively large drop in health and earmark group with the signalling and framing.

However, our result of a larger effect from a health and earmarked tax frame would be consistent with other studies suggesting that earmarking SSB taxes could make the tax more effective at reducing the demand for SSBs. Yet the social welfare implications depend on whether the reduction in SSBs consumption translates into actual healthcare cost savings and how those as well as tax revenue are allocated (Cremer et al., 2016). We also found that the greatest response to a 20% price increase among those who did not support a tax was when the health objective and earmarking of the tax was underlined, indicating that efforts to explain the tax purpose and investing proceeds into relevant cause may increase its objectives among the most sceptical. Nonetheless, these subgroup effects should be interpreted cautiously as the interaction terms in the model between price and group were not significant, although this could be due to small effect and sample sizes.

Access to revealed (home-scan) purchase data meant that we were able to test the validity of the stated preferences in this context. From this analysis, we found that the DCE was able to predict preferences for the different beverage categories reasonably well, both in terms of relative ranking to one another and the absolute demand levels for the two preferred options (SSBs and diet drinks). The unique noticeable difference was that the DCE underestimated the proportion of those who would choose none of the beverages offered. This could potentially be corrected in future studies by either calibrating the DCE data or making DCE choice more realistic by adding a real purchase to the study design. In this case, we did not choose to calibrate the DCE data as we were explicitly testing how the preferences would change because of a policy, and calibrating to preferences from a context of 'no policy' would have undermined this objective.

Our study provides valuable insights into how those households who are the key target of the SSB tax—that is, those who consume SSBs regularly and have children—are likely to respond to a tax framed in different ways. Because a subsample like this is rarely studied, there is limited literature to compare our findings with. The closest experimental study to ours, analysing the response to fiscal policies in parental choices between healthier and less healthy foods for children in Greece, concluded as well that providing information about the policy further increased the impact of the policy intervention (Papoutsi et al., 2015). In an evaluation of the effects of the SSB tax in Philadelphia, Cawley, Frisvold, Hill, and Jones (2019) looked at the changes in purchases and consumption of beverages of households who have children. They found that purchases of taxed beverages from stores in Philadelphia dropped but increased outside of the city. Frequency of adult soda consumption reduced by 31% overall, but among children consumption of added sugars reduced (by 22%) only among the subgroup of high consumers (those who consumed more than 20 ounce per day).

We estimate that the demand price elasticity ranges from −0.21 to −0.35. These estimates are smaller than those obtained from large-scale observational studies, where price elasticity of the demand for SSBs ranges from −0.8 to −1.2 (Andreyeva, Long, & Brownell, 2010). Two reasons can explain this discrepancy. First, our sample was restricted to regular consumers, who have been shown to be less price sensitive (Dubois, Griffith, & O'Connell, 2017). By contrast, estimates from observational studies come from both regular and irregular customers. Second, the discrepancy could come from differences in the choice sets faced by customers in the DCE compared with the real-world setting (larger number of options to choose from in the latter would yield to larger responses to price changes) as well as considerations of budget constraint.

The study presents a number of limitations. First, despite randomising respondents to the three frame groups, there were significant differences in some observable characteristics. However, we were able to control for most of these factors through modelling, and these did not appear to have large effects on estimates. Second, the price changes we applied were relatively small in absolute terms and reflected market prices to keep the experiment realistic for the control group. This meant that tax rates were already included in the market prices and respondents in tax frame groups could have perceived the prices without the tax as relatively small and therefore exhibit lower price responsiveness. Also, the choice cards had slightly smaller font size for price where tax was indicated, which could have influenced choices, probably leading to a weaker responsiveness to price. Third, the study asked about choices for the whole family and therefore would exclude the specific beverage choices respondents may make when they consider only themselves. It is therefore difficult to extrapolate our findings to SSB purchases for children specifically. Fourth, respondents could only choose one beverage in the DCE, whereas actual purchase data showed that, in 24% of shopping occasions, households purchased more than one drink. Thus, restricting choices may lead to an unrealistic situation and misrepresent actual preferences. Finally, despite a relatively large sample size of 603 respondents, the small effect sizes meant that the differences between the three groups were harder to detect at conventional statistical significance levels.

To conclude, our findings have potentially important policy implications suggesting that when SSB taxes are introduced, signalling and framing the tax as a health-related and earmarked measure may be effective in incentivising a greater reduction in purchases of SSBs than a tax alone.

CONFLICT OF INTEREST
All authors report no conflict of interest.

ETHICAL APPROVAL
Ethical approval (LSHTM Ethics Ref: 11709) for this study was obtained from the London School of Hygiene and Tropical Medicine, UK.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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