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Sociodemographic, lifestyle and behavioural factors associated with consumption of sweetened beverages among adults in Cambridgeshire, UK: the Fenland Study

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Abstract

Objective: We aimed to identify sociodemographic, lifestyle and behavioural determinants of consumption of sugar-sweetened beverages (SSB) and artificially sweetened beverages (ASB) among adults in Cambridgeshire, UK.

Design: Cross-sectional data were obtained from a cohort of 9991 adults born between 1950 and 1975. An FFQ was used to assess consumption of beverages and other dietary factors. Multivariable logistic regression was used to examine potential determinants of consuming SSB and ASB (≥1 serving/d).

Setting: Recruitment from general practice surgeries to participate in the ongoing population-based Fenland Study.

Subjects: Adults (*n* 9991) aged 30–64 years from three areas of Cambridgeshire, UK.

Results: Prevalence estimates for daily SSB and ASB consumption were 20·4 % (*n* 2041) and 8·9 % (*n* 893), respectively. SSB consumption (OR; 95 % CI) was more common in men than women (1·33; CI 1·17, 1·50) and among those reporting lower income (<£20 000/year) than those reporting higher income (>£40 000/year; 1·31; 1·09, 1·58). In contrast, daily ASB consumption was more common among women than men (1·62; 1·34, 1·96), those on weight-loss diets than those who were not (2·58; 2·05, 3·24) and those reporting higher income than lower income (1·53; 1·16, 2·00). Factors associated with higher consumption of each of SSB and ASB included being a younger adult, being overweight/obese, having shorter education, eating meals or snack foods while watching television, and skipping breakfast ($P<0·05$ each).

Conclusions: Frequent consumers of SSB and ASB differ by several sociodemographic characteristics. However, increased BMI, younger age and unhealthy eating behaviours are common to both groups.

Keywords
Sugar-sweetened beverages
Artificially sweetened beverages
Carbonated beverages
Sociodemographic
Lifestyle
Feeding behaviour

Consumption of sugar-sweetened beverages (SSB) has increased both in the UK and internationally in recent decades[1–3]. SSB are a major source of added sugars and their frequent consumption has been linked to weight gain and obesity[4–6] and risks of diabetes mellitus[4,7–9], dental caries[10,11] and other health problems[12–16]. Globally, SSB have been identified as a single, modifiable component of diet that can impact on preventable death and disability in adults[17]. The importance of reducing sugar intake from SSB has been highlighted in national and international public health guidance[18–20]. Preventive actions have been initiated at a population level in the UK to begin to address the challenge, including awareness campaigns, food labelling recommendations and a commitment by government to introduce an SSB industry levy as a fiscal measure.

The consumption of artificially sweetened beverages (ASB) has also increased in recent years in the UK and elsewhere[1,21,22]. Although ASB are unlikely to offer any nutritional benefit they are promoted as a substitute for SSB for weight control[23]. ASB are considered a less harmful alternative to SSB, although little is known about the long-term consequences of habitual ASB consumption.

There is a need to identify social and behavioural determinants of SSB and ASB consumption. Understanding consumers' characteristics can help identify the groups most likely to benefit from public health interventions. Much of

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the existing research on social and behavioural correlates with sweetened beverage consumption has been conducted in North America and has focused on consumption of SSB only, particularly among children and adolescents[24–27]. Less is known about social and behavioural factors underlying sweetened beverage consumption in adults in European settings, particularly ASB consumption. To fill this knowledge gap, we aimed to identify the sociodemographic and behavioural factors associated with consumption of SSB and ASB in adults in a population-based cohort in the UK.

Methods

Study design

We conducted cross-sectional analyses in the Fenland Study, a population-based prospective cohort of adults born between 1950 and 1975 in Cambridgeshire, UK. The study was initiated to investigate the influence of lifestyle and genetic factors on the development of cardiometabolic disorders (http://www.mrc-epid.cam.ac.uk/research/studies/fenland/)[28]. Briefly, baseline recruitment and assessment were conducted over 2005–2013 for 10 452 adults, after contacting residents listed with a participating general practice surgery in the Cambridge, Ely and Wisbech areas (27 % response rate). As UK adults are registered with a general practitioner, these registers formed a population-based sampling frame. Adults were not invited if they had a known diagnosis of diabetes since the purpose of the cohort was to examine the risk of cardiometabolic disorders. The other exclusion criteria included: terminal illness with a prognosis of less than 1 year, psychotic illness, or being pregnant, lactating or unable to walk unaided. Participants gave written informed consent.

The current study sample included data on 9991 participants aged 30–64 years. Participants were excluded for the following reasons: missing data on consumption of SSB or ASB (*n* 355), missing data related to nutrient intake (*n* 6) or implausible data related to nutrient intake based on responses to an FFQ (*n* 100). Implausible responses were defined by <0·5th percentile or ≥99·5th percentile of a ratio of total energy intake to BMR[29].

Assessment of dietary intake

Data on consumption of SSB and ASB were collected at baseline visit using a previously validated FFQ[30]. For each of 130 food/beverage items, participants were asked to report frequency of consumption over the previous year by selecting one of nine categories: never or less than once/month, 1–3/month, once/week, 2–4/week, 5–6/week, once/d, 2–3/d, 4–5/d and ≥6/d. SSB consumption was based on the sum of frequency of consuming two items: 'fizzy soft drinks (e.g. Coca cola, lemonade)' and 'fruit squash or cordial'. ASB consumption was based on responses to one item: 'low calorie or diet fizzy soft drinks'.

Diet quality, a potential determinant of SSB or ASB consumption, was assessed by a score representing the degree of adherence to the Mediterranean diet (possible range 0 to 18). The score was created using responses to the FFQ and cut-offs described by Sofi *et al.*[31]. A higher score was assigned if participants reported higher consumption of fruits, vegetables, cereals, legumes and fish, and lower consumption of dairy products, meat and meat products, moderate consumption of alcohol, and more regular use of olive oil[31].

Assessment of lifestyle and eating behaviours

The Fenland Study General Questionnaire was used to assess smoking status (current, former, never) and the frequency of the following seven eating behaviours: eating breakfast, home-delivery/takeaway meals, ready-made meals, home-cooked meals, meals outside the home, meals while watching television and snack foods while watching television. Different frequency categories were used for each of the eating behaviours. Information was also collected on daily intake of alcoholic beverages. Data relating to intake of beer, cider, wine, spirits (e.g. whisky, vodka) and other alcoholic beverages (e.g. port, sherry) were collected using the FFQ, and responses were summed to calculate total daily servings of alcoholic beverages.

Assessment of sociodemographic factors

Demographic variables (age, sex) and socio-economic variables were collected by questionnaire. Seventeen categories of ethnic origin were assessed and collapsed into two groups: white (97·6 %) and non-white ethnicity. Education level, income and other social factors were evaluated as indicators of socio-economic conditions which relate to dietary habits, including daily consumption of SSB or ASB. These included age finishing education, current work status (full-time, part-time, keeping house, not currently working), employment type (employee, self-employed), total combined annual household income (<£20 000, £20 000–£40 000, >£40 000), marital status (single, married, separated/widowed/divorced), number of people in household, car ownership (yes, no) and home ownership (yes, no). Eight occupation types were collapsed to lower, middle or higher socio-economic class in concordance with the National Statistics Socio-Economic Classification (NSSEC)[32]. Individuals with occupations in NSSEC I/II were considered to be in the higher socio-economic class; in NSSEC III/IV, the middle socio-economic class; and in NSSEC V/VI/VII, the lower socio-economic class.

Anthropometry and physical activity

Body weight and height were measured objectively by trained research staff and used to compute BMI as weight/height^2 (kg/m^2). Physical activity was objectively measured for 6 d with a combined heart-rate and acceleration sensor

(Actiheart; CamNTech, Cambridge, UK). A treadmill test was used for individual calibration of these data to model energy expenditure due to physical activity, expressed as metabolic equivalents of task (MET) and summarised as average hours per day spent in sedentary or resting time (<1·5 MET), light physical activity (≥1·5 and <3·0 MET) or moderate/vigorous physical activity (≥3·0 MET)[33].

Statistical analysis

All analyses were undertaken using the statistical software package Stata version 13.1 (α two-sided = 0·05). For each of SSB and ASB, participants were classified to daily consumers (≥1 drink/d) and non-daily consumers (<1 drink/d, including non-consumers) based on their responses to frequency of consumption. The association between sociodemographic factors and lifestyle/behavioural factors and daily or non-daily consumption of each of SSB and ASB was evaluated using logistic regression, in line with previous approaches[34–36]. OR and 95 % CI were estimated by exponentiating regression coefficients, followed by calculating *P* values based on Wald tests.

Multivariable-adjusted logistic regression models were built sequentially. All models included age, sex and test site (Cambridge, Ely or Wisbech). In analysis of sociodemographic factors as independent variables, the model included other sociodemographic factors simultaneously for mutual adjustment. Individual behaviour factors were not adjusted for in these models, as they may be intermediate factors in the associations between sociodemographic factors and sweetened beverage consumption. For example, watching television may mediate the association between socio-economic status and SSB consumption. In analysis of lifestyle factors and eating behaviours as independent variables, sociodemographic variables were included in the logistic regression models as potential confounders. The seven eating behaviours and BMI were evaluated categorically and also continuously in logistic regression models to examine a linear relationship of each of the variables with the odds of daily SSB and ASB consumption.

To account for correlations between SSB and ASB consumption, logistic regression models were additionally evaluated after including both variables together in the same model (one as the outcome and the other as a covariate). We adjusted for calendar year and date of baseline visit, and medication use for hypertension or dyslipidaemia, to assess their influence on results because calendar time and co-morbid status may have influenced errors in responses to questionnaires and distorted true associations of interest. Total energy intake reflects consumption of foods and beverages overall, and was thus adjusted for in the most adjusted model to obtain results independent of the total amount of foods consumed. To account for missing information on independent variables we created dummy variables indicating missing information and included the indicator variables in all logistic regression models. The χ^2 test was used to examine whether the presence of missing data was associated with daily consumption of sweetened beverages.

As sensitivity analysis, we repeated analyses by classifying consumers as those consuming SSB and ASB ≥3 servings/d, respectively; and by defining only fizzy drinks as SSB, because fruit squash/cordial may be consumed after being diluted to contain low sugars. We also repeated analysis by evaluating consumers of both SSB and ASB (≥1 serving/d for both beverage types) to characterise adults who did not consider how soft drinks were sweetened.

Results

Of 9991 participants, 54·0 % were women. The mean age was 47·8 (SD 7·4) years. The prevalence of obesity (BMI ≥30 kg/m^2) was 21·1 %; of overweight (BMI = 25·0–29·9 kg/m^2), 39·7 %; of current smoking, 12·9 %; and of former smokers, 32·3 %. SSB and ASB consumption was skewed to the right (see online supplementary material, Supplementary Fig. 1). Daily consumption of SSB and ASB was reported by 20·4 and 8·9 % of participants, respectively. Among daily consumers, mean SSB consumption and mean ASB consumption were 2·2 (SD 1·4) servings/d and 2·0 (SD 1·3) servings/d, respectively.

In unadjusted analysis (Tables 1 and 2), daily SSB consumption was positively associated with being male, whereas daily ASB consumption was positively associated with being female (P<0·001). SSB and ASB consumption was each similarly associated with younger age, white ethnicity and all eating behaviours (P<0·001 each), apart from eating outside the home (P > 0·1). Mean BMI was higher among daily SSB consumers than SSB non-consumers (27·6 (SD 5·0) *v.* 26·6 (SD 4·7) kg/m^2, respectively) and among daily ASB consumers than ASB non-consumers (29·5 (SD 5·6) *v.* 26·6 (SD 4·6) kg/m^2).

In multivariable-adjusted analysis (Table 3), daily SSB consumers were significantly more likely to be men, of lower socio-economic class and have a younger age of finishing education. They were less likely to own their home and more likely to have lower household income and live in a larger household. Daily consumption of ASB showed significant associations with age of finishing full-time education, but not with socio-economic class and home ownership. Longer duration of education was associated with lesser SSB and ASB consumption (OR = 0·52 and 0·43, respectively, in comparison between extreme categories). Significant trends in an opposing direction for SSB and ASB were observed for sex and household income. Comparing men with women, OR for daily consumption of ASB was 0·66 (95 % CI 0·56, 0·79); and of SSB, 1·33 (95 % CI 1·17, 1·50). Comparing those with higher income with those with lower income, OR for daily consumption of SSB and of ASB were 0·76 (95 % CI 0·63, 0·91) and 1·53 (95 % CI 1·16, 2·00), respectively.

Table 1 Sociodemographic characteristics, stratified by daily consumption of sugar-sweetened beverages (SSB) and artificially sweetened beverages (ASB), of adults (*n* 9991) aged 30–64 years in the Fenland Study, Cambridgeshire, UK, 2005–2013

	SSB*			ASB*		
	Daily (*n* 2041)	Less than daily (*n* 7950)	*P*	Daily (*n* 893)	Less than daily (*n* 9098)	*P*
Age (years)	45·8	48·4	<0·001	46·6	48·0	<0·001
Sex (% women)	49·8	55·0	<0·001	62·0	53·1	<0·001
Test site (%)						
Cambridge	24·4	36·4		20·8	35·2	
Ely	40·4	37·1		40·9	37·5	
Wisbech	35·2	26·5	<0·001	38·3	27·3	<0·001
Ethnicity (%)						
White	92·4	90·7		91·8	91·0	
Non-white	0·9	2·8		0·8	2·5	
Unknown	6·7	6·5	<0·001	7·4	6·5	<0·001
Age finishing education (%)†						
≤16 years	45·9	37·9		47·9	38·7	
17–19 years	27·0	23·8		30·4	23·9	
20–23 years	18·3	23·8		14·7	23·4	
≥24 years	6·4	11·7	<0·001	5·0	11·1	<0·001
Socio-economic class (%)						
Lower	32·0	23·9		25·8	25·5	
Middle	18·7	18·6		24·2	18·1	
Higher	43·0	51·0		42·6	50·0	
Unknown	6·4	6·6	<0·001	7·5	6·4	<0·001
Current work status (%)†						
Full-time work	64·4	64·3		64·8	64·3	
Part-time work	17·7	16·8		16·5	17·1	
Keeping house	10·0	9·6		11·3	9·5	
Not currently working	7·7	9·0	0·32	6·9	8·9	0·097
Employment type (%)†						
Employee	78·6	78·2		82·0	77·9	
Self-employed	20·8	20·8	0·48	17·0	21·2	0·009
Total combined annual household income†						
<£20 000	15·2	12·9		11·3	13·6	
£20 000–£40 000	37·4	34·6		37·9	34·9	
>£40 000	44·7	49·6	<0·001	48·7	48·5	0·064
Marital status (%)						
Single	6·3	7·0		4·9	7·1	
Married	58·1	58·5		55·7	58·7	
Separated/widowed/divorced	5·8	6·9		5·9	6·8	
Unknown‡	29·8	27·6	0·064	33·5	27·5	<0·001
No· of people in household (%)						
1 person	6·5	9·4		6·6	9·0	
2 people	25·3	31·9		29·5	30·6	
3 people	22·1	18·2		19·7	18·9	
4 people or more	39·6	34·0		36·7	35·0	
Unknown	6·7	6·5	<0·001	7·5	6·5	0·077
Car ownership (%)†						
No	5·3	7·0		3·7	6·9	
Yes	94·5	92·8	0·009	96·1	92·9	<0·001
Home ownership (%)						
No	3·8	4·4		3·4	4·4	
Yes	88·0	88·0		89·6	87·8	
Unknown	8·2	7·6	0·153	7·1	7·8	0·812

*Values are percentage of each characteristic among daily consumers or non-daily consumers, except age (years). *P* values were computed by logistic regression analysis in which daily consumption (yes or no) was an outcome and each characteristic was a predictor.
†Missing information among <5 % of adults is not presented.
‡Marital status was not assessed among 28·0 % of the study population because a questionnaire for those participants did not include the question about marital status, but was revised to include the question for the rest of the participants.

Results for lifestyle characteristics are presented in Table 4. Obese or overweight adults were more likely to consume SSB and ASB than normal-weight adults. Current smoking was associated with lesser likelihood of consuming SSB daily, with OR = 0·79 (95 % CI 0·66, 0·93), compared with non-smokers. Those on a weight-loss diet were more likely to consume ASB daily, with OR = 2·58 (95 % CI 2·05, 3·24), compared with those not on a weight-loss diet. Among eating behaviours (Figs 1 and 2), skipping breakfast and having meals or snacks while watching television were associated with daily consumption of SSB or ASB (P <0·02).

Table 2 Lifestyle/behavioural characteristics, stratified by daily consumption of sugar-sweetened beverages (SSB) and artificially sweetened beverages (ASB), of adults (*n* 9991) aged 30–64 years in the Fenland Study, Cambridgeshire, UK, 2005–2013

	SSB*			ASB*		
	Daily (*n* 2041)	Less than daily (*n* 7950)	*P*	Daily (*n* 893)	Less than daily (*n* 9098)	*P*
BMI group (%)						
<25·0 kg/m^2	33·3	40·8		20·5	41·1	
≥25·0 and <30·0 kg/m^2	39·8	39·6		39·8	39·6	
≥30·0 and <35·0 kg/m^2	19·2	14·2		25·1	14·3	
≥35·0 kg/m^2	7·7	5·4	<0·001	14·7	5·0	<0·001
Physical activity (PA; h/d)						
Sedentary time, mean	16·1	16·6	<0·001	16·4	16·5	0·17
SD	2·5	2·4		2·4	2·4	
Light PA, mean	6·0	5·7	<0·001	6·0	5·8	<0·001
SD	1·9	1·8		1·9	1·8	
Moderate or vigorous PA, mean	1·9	1·7	<0·001	1·6	1·7	0·004
SD	1·5	1·3		1·3	1·3	
Alcoholic beverages (servings/d), mean	0·7	0·8	<0·001	0·7	0·8	0·017
SD	1·0	1·1		1·1	1·1	
Mediterranean diet score, mean†	6·4	6·7	<0·001	6·4	6·7	<0·001
SD	2·2	2·2		2·2	2·2	
Smoking, %						
Current smoker	13·1	12·8		14·2	12·7	
Ex-smoker	32·0	32·4		34·4	32·1	
Never smoked	54·0	53·5	0·22	50·3	54·0	0·19
Anti-hypertensive drug use (%)						
No	68·1	65·7		67·5	66·0	
Yes	7·8	7·5		9·1	7·4	
Unknown	24·1	26·8	0·045	23·4	26·5	0·47
Lipid-lowering drug use (%)						
No	97·0	96·8		96·2	96·9	
Yes	3·0	3·1		3·8	3·0	
Unknown	<0·1	0·0	0·47	<0·1	0·0	0·40
On weight-reducing diet (%)‡						
Yes	6·2	5·4		15·0	4·6	
No	93·8	94·6	0·14	85·0	95·4	<0·001
Eating breakfast (%)						
Never/rarely	11·5	9·5		13·4	9·6	
1–2 times/week	10·3	8·3		11·8	8·4	
3–5 times/week	11·9	11·0		13·7	10·9	
>5 times/week	66·2	71·1	<0·001	61·1	71·0	<0·001
Eating home-delivery/takeaway meals (%)§						
Never/rarely	60·7	70·2		57·5	69·3	
1–2 times/week	33·1	23·6		36·6	24·4	
≥3 times/week	6·1	6·0	<0·001	5·7	6·0	<0·001
Eating ready-made meals (%)§						
Never/rarely	53·3	58·9		50·3	58·5	
1–2 times/week	40·0	35·2		42·0	35·6	
≥3 times/week	6·4	5·6	<0·001	7·4	5·6	<0·001
Eating home-cooked meals (%)§						
≤2 times/week	7·3	6·2		10·0	6·1	
3–5 times/week	38·9	31·6		40·9	32·3	
>5 times/week	53·8	62·1	<0·001	49·2	61·5	<0·001
Eating outside the home (%)§						
Less than once/week	70·5	68·0		66·7	68·7	
Once/week	22·0	23·5		25·2	23·0	
≥2 times/week	7·5	8·5	0·14	8·0	8·3	0·49
Eating meals while watching television (%)§						
Less than once/week	28·9	34·0		25·0	33·8	
Once/week	12·5	12·4		10·9	12·6	
2–4 times/week	27·2	25·1		28·0	25·3	
≥5 times/week	31·2	28·2	<0·001	36·1	28·1	<0·001
Eating snack foods while watching television (%)§						
Never/rarely	22·2	32·2		17·9	31·3	
Occasionally	62·9	56·6		62·6	57·4	
Usually/always	15·0	11·1	<0·001	19·5	11·2	<0·001

*Values are mean and SD for continuous variables and proportions for categorical variables. *P* values were computed by crude logistic regression analysis relating daily consumption of SSB or ASB (yes or no) to each characteristic.
†Mediterranean diet score was an 18-point scale representing adherence to the Mediterranean diet, used as a marker of diet quality.
‡Participants were considered to be on a weight-reducing diet if they responded that they were on any of the following diets: 'Weight Watchers', 'Slimming World', low-fat diet, low-carbohydrate diet (e.g. 'Atkins diet').
§Missing information among <5 % of adults is not presented.

Table 3 Associations of sociodemographic characteristics with daily consumption of sugar-sweetened beverages (SSB) and artificially sweetened beverages among adults (*n* 9991) aged 30–64 years in the Fenland Study, Cambridgeshire, UK, 2005–2013

		SSB			ASB		
Variable	Categories*	% daily consumers	OR†	95 % CI	% daily consumers	OR†	95 % CI
Age, per 10 years		20	0·57	0·52, 0·61	9	0·74	0·66, 0·82
Sex	Women	19	1·00	Ref.	10	1·00	Ref.
	Men	22	1·33	1·17, 1·50	7	0·66	0·56, 0·79
Test site	Cambridge	15	1·00	Ref.	5	1·00	Ref.
	Ely	22	1·42	1·23, 1·63	10	1·42	1·16, 1·73
	Wisbech	25	1·52	1·31, 1·77	12	1·81	1·46, 2·23
Ethnicity	White	21	1·00	Ref.	9	1·00	Ref.
	Non-white	8	0·40	0·25, 0·65	3	0·45	0·21, 0·97
Age finishing full-time education	≤16 years	24	1·00	Ref.	11	1·00	Ref.
	17–19 years	23	0·93	0·82, 1·06	11	0·92	0·78, 1·09
	20–23 years	17	0·72	0·61, 0·84	6	0·54	0·43, 0·68
	≥24 years	12	0·52	0·41, 0·64	4	0·43	0·31, 0·61
Socio-economic class	Higher	18	1·00	Ref.	8	1·00	Ref.
	Middle	20	1·02	0·88, 1·19	12	1·16	0·96, 1·41
	Lower	26	1·15	1·00, 1·32	9	0·98	0·80, 1·20
Current work status	Full-time	20	1·00	Ref.	9	1·00	Ref.
	Part-time work	21	1·13	0·97, 1·32	9	0·77	0·62, 0·95
	Keeping house	21	1·02	0·84, 1·23	10	0·86	0·67, 1·10
	Not working	18	1·07	0·88, 1·31	7	0·87	0·65, 1·16
Employment type	Employee	21	1·00	Ref.	9	1·00	Ref.
	Self-employed	20	0·98	0·86, 1·11	7	0·85	0·70, 1·02
Total combined annual household income	<£20 000	23	1·00	Ref.	8	1·00	ref.
	£20 000–£40 000	22	0·82	0·69, 0·96	10	1·30	1·01, 1·67
	>£40 000	19	0·76	0·63, 0·91	9	1·53	1·16, 2·00
Marital status	Single	19	1·00	Ref.	6	1·00	Ref.
	Married	20	0·98	0·76, 1·25	9	1·05	0·71, 1·53
	Other	18	0·97	0·73, 1·30	8	1·13	0·74, 1·73
Number of people living in the household	One person	15	1·00	Ref.	7	1·00	Ref.
	2 people	17	1·26	0·99, 1·61	9	1·06	0·75, 1·50
	3 people	24	1·67	1·30, 2·14	9	1·08	0·75, 1·54
	≥4 people	23	1·44	1·12, 1·85	9	1·04	0·73, 1·49
Car ownership	Yes	16	1·00	Ref.	5	1·00	Ref.
	No	21	1·13	0·89, 1·42	9	1·45	0·99, 2·11
Home ownership	Yes	18	1·00	Ref.	7	1·00	Ref.
	No	20	1·43	1·08, 1·86	9	1·09	0·73, 1·64

Ref., reference category.
*A category listed at the top of each variable was used as a reference in logistic regression models for daily *v.* non-daily consumers of SSB and ASB. A category for missing information was included in each model, but not presented. Adjustment for missing data had little influence on the results.
†Adjusted for age, sex, site (Cambridge, Ely, Wisbech) and all sociodemographic variables shown at the first column.

After adjustment for sociodemographic factors, ASB consumption and SSB consumption were modestly correlated ($r = 0{\cdot}13$). In additional analyses including SSB or ASB consumption as a covariate, results changed little. Results were not altered materially after adjustment for total energy intake, calendar year or date of baseline visit, or medications for hypertension or dyslipidaemia.

Having missing information (i.e. at least one exposure variable missing) was not significantly associated with daily consumption of SSB ($\chi^2 = 0{\cdot}02$; $P = 0{\cdot}88$) or ASB ($\chi^2 = 3{\cdot}32$; $P = 0{\cdot}07$). Not adjusting for the missing variable indicator had little influence on the main results. Evaluating ≥3 servings/d as a cut-point for SSB and ASB consumption or excluding fruit squash/cordial from SSB definition, estimates became imprecise, but were generally similar to those in the primary analysis (see online supplementary material, Supplemental Tables 1 and 2). As exceptions, by contrast to the primary findings, ≥3 servings ASB/d was significantly associated with former smoking history, lower alcohol drinking and lower diet quality (Mediterranean diet score; $P < 0{\cdot}05$). Evaluating ≥1 servings/d of both SSB and ASB as an outcome (*n* 307, 3·1 %), one-third of daily consumers of ASB (*n* 893) reported daily SSB consumption, while approximately 15 % of SSB consumers reported daily ASB consumption, and trends of associations were generally similar to the findings for ASB with wide confidence intervals (Supplemental Tables 1 and 2).

Discussion

In the current study of 9991 adults in Cambridgeshire, UK, one in five adults reported daily consumption of SSB and one in ten adults reported daily consumption of ASB. Although daily consumers of SSB and ASB shared many sociodemographic characteristics, a key difference between groups was the finding that having a lower

Table 4 Associations of lifestyle characteristics with daily consumption of sugar-sweetened beverages (SSB) and artificially sweetened beverages (ASB) among adults (*n* 9991) aged 30–64 years in the Fenland Study, Cambridgeshire, UK, 2005–2013

		SSB†			ASB†		
Variable	Categories or scale*	% daily consumers	OR	95 % CI	% daily consumers	OR	95 % CI
BMI group (kg/m^2)	<25·0	17	1·00	Ref.	5	1·00	Ref.
	≥25·0 and <30·0	21	1·17	1·04, 1·33	9	1·92	1·58, 2·34
	≥30·0 and <35·0	26	1·58	1·35, 1·85	15	3·09	2·47, 3·86
	≥35·0	27	1·62	1·30, 2·02	22	4·51	3·44, 5·92
			P trend <0·001‖			*P* trend <0·001‖	
Smoking status	Never	21	1·00	Ref.	8	1·00	Ref.
	Former smoker	20	0·97	0·87, 1·09	10	1·06	0·90, 1·24
	Current smoker	21	0·79	0·66, 0·93	10	0·98	0·77, 1·24
Sedentary time	per 2 hours	20	0·96	0·91, 1·02	9	0·93	0·86, 1·01
Moderate/vigorous PA‡	per 2 hours	20	1·13	1·02, 1·26	9	1·01	0·86, 1·18
Alcoholic beverage	per serving	20	0·92	0·87, 0·97	9	1·02	0·95, 1·09
Mediterranean diet score§	per 2 points	20	1·01	0·96, 1·07	9	0·99	0·92, 1·06
Weight-reducing diet	No	20	1·00	Ref.	8	1·00	Ref.
	Yes	23	1·07	0·86, 1·33	24	2·58	2·05, 3·24

PA, physical activity; Ref., reference category.
*For categorical variables, levels are shown. For continuous variables, scale for interpretation of OR is shown.
†Adjusted for age, sex, test site, and sociodemographic and lifestyle/behavioural variables together. See Tables 1 and 2 for the variables. The associations of eating behaviours are shown in Figs 1 and 2.
‡Intensity of PA was modelled isotemporarily; with time estimates denoting substitution from light PA into either sedentary or moderate/vigorous PA.
§Mediterranean diet score was an 18-point scale representing adherence to the Mediterranean diet, used as a marker of diet quality.
‖ *P* values for trend are presented, for which an ordinal variable was included as a continuous term in a logistic regression model.

household income was associated with higher SSB consumption, but with lower ASB consumption. In addition to sociodemographic factors such as age and education, modifiable factors were significantly associated with higher consumption of both SSB and ASB, including being overweight or obese, eating meals or snack foods while watching television, and skipping breakfast.

Sugar-sweetened beverage consumption

Some of our findings relating to SSB consumption were consistent with existing studies which reported positive associations with younger age, male sex, a lower level of education and a lower household income[3,34,35,37–40]. Our study was consistent with previous studies that reported positive associations of frequent SSB consumption with higher BMI[4–6,41], less frequent alcohol consumption[35], and eating meals or snack foods in front of the television[26,36,42,43]. Habitual SSB consumption exerts adverse health effects and its association with lower household income may therefore worsen health outcomes for disadvantaged groups.

Some of the current findings were not consistent with the existing literature, which might reflect differences in population and methodology. We did not observe a significant association of SSB consumption with socio-economic classes after adjustment for other demographic variables, whereas other European studies reported higher SSB consumption among those of lower socio-economic groups[44–46]. This could be partly explained by the differences in the definitions of socio-economic class that were used across studies[45,46], or it may be because the current study controlled for more covariates. We identified home ownership and the number of household members as significant determinants of SSB consumption in our study, independent of socio-economic class. Home ownership may act as a proxy for relative affluence and has not been explored as an independent covariate in similar studies. The positive association with household size suggests that adults living with children may be more frequent consumers of SSB. Since children consume more SSB than any other age group in the UK[47], parents living with children may purchase and consume more SSB than those who are not living with children, as supported by a UK national survey[39] and previous American studies[48,49]. This finding highlights the potential benefit of considering family-based interventions to reduce SSB consumption.

Previous evidence suggests that SSB consumers tend to have generally unhealthy lifestyles[35,37,50,51]. This was not observed in our study, where daily SSB consumption was associated with greater physical activity and lesser alcohol consumption. The finding for physical activity might reflect that physically active adults consume more sports/energy drinks, which are SSB. The lower consumption of alcoholic beverages may be due to a substitution effect. This might be influenced by the type of alcoholic beverages consumed, as some people who consume spirits may also consume SSB as mixers. Further research on the details of such substitution effects will be valuable.

Our finding of an inverse association between current smoking and daily SSB consumption also contrasts with previous studies[34,35,51–53]. Our study supports that smokers have less appetite to consume caloric beverages and foods[54] and may avoid consuming SSB and other perceived unhealthy products to 'compensate' for their smoking. Although such mechanisms are not proven, our findings indicate the need for population-specific monitoring and intervention to reduce SSB consumption

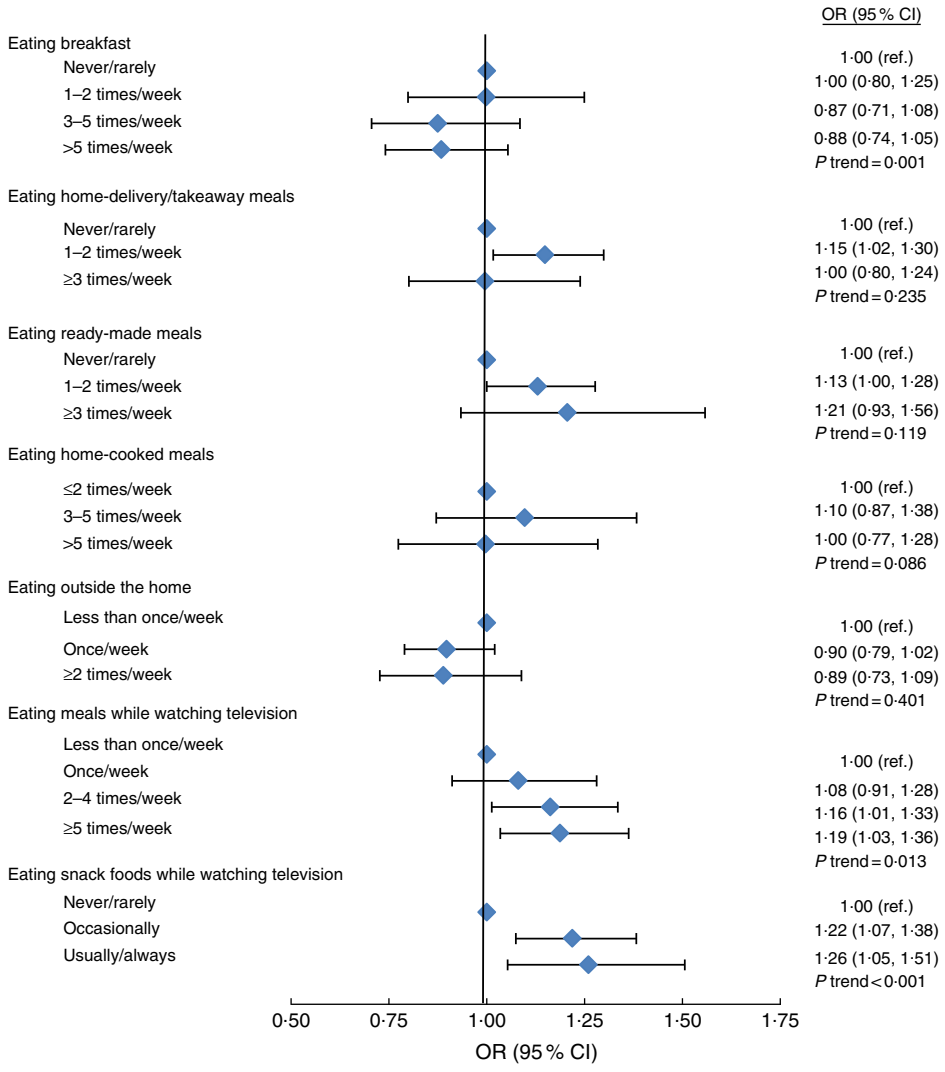

Fig. 1 Associations of dietary habits with daily consumption of sugar-sweetened beverages among adults (*n* 9991) aged 30–64 years in the Fenland Study, Cambridgeshire, UK, 2005–2013. OR (◆) and 95 % CI (represented by horizontal bars) were adjusted for demographic and socio-economic factors and mutually adjusted for different dietary habits presented here (ref., reference category)

among adults, particularly when they are trying to make other lifestyle changes such as quitting smoking or starting an exercise programme.

Eating meals or snacking while watching television was each related to SSB consumption, while eating takeaway meals or eating outside the home was not significantly related, inconsistent with previous studies[26,55–58]. As discussed above, the inconsistency may reflect differences in available variables for statistical adjustment and population demographics. Additional research is warranted in different populations, evaluating socio-economic and behavioural variables that were previously understudied, but identified in our study to be important as potential determinants of SSB consumption.

Artificially sweetened beverage consumption

There have been fewer studies on determinants of ASB consumption than SSB consumption, but despite limited literature, our study and previous work consistently found that ASB consumption was higher among women and younger adults[21,34,38–40,59], those of white ethnicity and higher household income[21,60], and was more common among adults with higher BMI and those on weight-loss diets[3,34,60].

Lower educational attainment (younger age of finishing education) was associated with higher ASB consumption in the present study, similar to SSB consumption. This finding was opposite to two previous studies in Belgium and the UK[34,39], possibly reflecting the difference in education attainment between the study populations. Whereas our study population had longer duration of education than the national average[61], the prior UK study, the Low Income Diet and Nutrition Survey (LIDNS), examined the nation's most socially deprived households[39] and the Belgian study recruited men who were less educated than the Belgian average[62]. We found no significant association of ASB

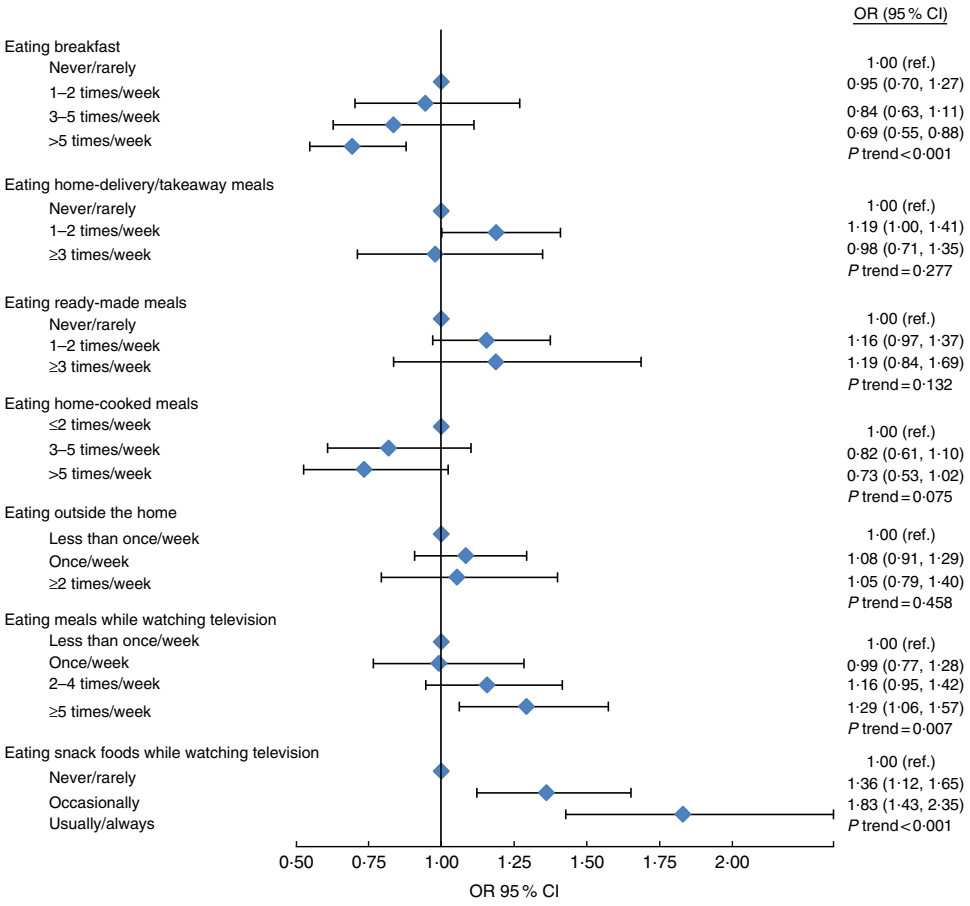

Fig. 2 Associations of dietary habits with daily consumption of artificially sweetened beverages among adults (*n* 9991) aged 30–64 years in the Fenland Study, Cambridgeshire, UK, 2005–2013. OR (◆) and 95 % CI (represented by horizontal bars) were adjusted for demographic and socio-economic factors and mutually adjusted for different dietary habits presented here (ref., reference category)

consumption with household size. This was inconsistent with the finding from the LIDNS of high ASB consumption in households without children[39]. These observations indicate heterogeneity in determinants of beverage consumption across sociodemographic characteristics and indicate the challenges in designing potential interventions which account for this heterogeneity.

ASB consumption was strongly associated with overweight or obesity, skipping breakfast and being on a weight-loss diet, but not associated with physical activity levels, consistent with findings previously reported in non-UK settings[34,60]. Consumption of ≥3 servings ASB/d was associated with former smoking and lower diet quality; and one-third of ASB consumers reported daily SSB consumption. This suggests that individuals may habitually consume ASB for weight management or general health after quitting smoking, but without regard for improvement in diet quality and physical activity levels. While confirmation of this finding in a general population is needed, this has potential implications for dietary or weight-loss programmes which aim to improve health outcomes through delivery of information and health promotion interventions.

Eating behaviours such as consuming meals or snacks while watching television were related to ASB consumption, in line with a previous US-based study which reported that persons who purchased the most ASB also purchased the largest amount of snack foods[63]. Another American study reported that about 20 % of total energy intake among ASB consumers was from snack foods[60]. This supports that, independent of any direct health effects, ASB consumers may need to be recognised as those with clustering of potentially unhealthy dietary behaviours.

Strengths and limitations

The large size of the current study provided adequate precision in our estimates. The study included a larger number of potential confounders than previous similar studies[34–36]. This allowed a more thorough statistical adjustment and provided detailed insight into the characteristics of SSB and ASB consumers, including important behavioural factors in addition to sociodemographic factors. No previous literature was identified for some of the associations in the present study, particularly relating to ASB consumption. For these and other characteristics, the study helps to fill a gap in the existing evidence.

There are a number of limitations to our study. As it was cross-sectional, causality is limited in our findings of associations. Therefore, we cannot rule out that current social factors (e.g. income), for example, were driven by habitual, long-term dietary habit with high SSB consumption and obesity. Moreover, appreciable changes in the pattern of sweetened beverage consumption over time may not have been discerned. Although statistical adjustment might partly reduce measurement errors of dietary exposure, there might be errors in measurements of beverage consumption due to participants' interpretation of a serving size and habitual consumption, including possible underestimation. Participants may not have thought to report their consumption of some sweetened beverages (e.g. sports drinks) as the FFQ might have prompted respondents to mostly consider carbonated soft drinks and fruit cordials. Pure fruit juices were not included in the study and it is possible that respondents misclassified some SSB as fruit juice. We could not rule out bias due to missing data, but the use of modelled indicator variables did not suggest discernible differences in characteristics. Seasonality of beverage consumption, as well as of lifestyle and dietary behaviours, was not interrogated in the study. Although the FFQ was intended to reflect average habitual dietary consumption over a year, the accuracy of responses is limited by participants' memory and may be influenced by recall of recent beverage intake, which may in turn be affected by recent weather. This may have led to additional variability in measurements. The differences in SSB consumption across sites in the study may reflect unmeasured societal factors, including area-level characteristics. Wisbech has a higher area-specific Index of Multiple Deprivation score compared with Ely and Cambridge[64]. All sociodemographic variables evaluated in the present study were at the individual level and this may have led to residual confounding in our findings.

Generalisability may be limited as the participation rate was low (27 %). The study population did not include people younger than 30 years old where the consumption of sweetened beverages is higher, people with diabetes were excluded, and overall the recruited study participants might be healthier than the general population, being less likely to be current smokers (12·9 %) and overweight/obese (60·8 %) than the general population in Cambridgeshire (16·4 and 63·6 %, respectively)[64]. Although the study population might be healthier than the general population, unhealthy behaviours were nevertheless detected. For example, more than two-thirds of participants reported eating meals or snacks while watching television at least once weekly, and more than 30 % skipped breakfast at least twice weekly. Given the relatively high prevalence of sweetened beverage consumption observed, our study is unlikely to overstate needs for future interventions on such eating behaviours related to beverage consumption in the general population.

Implications

Our findings may help to inform strategies aiming to reduce consumption of sweetened beverages among adults. Population-based interventions, such as nutrition labelling, menu labelling and health warnings, need to allow for the lower level of education of frequent consumers of SSB and ASB. Labelling needs to be intelligible to all consumers, as those with lower education may have lesser comprehension of nutrition labels[65]. Restricting television advertising of sweetened beverages may help to reduce consumption in the home, particularly given the higher levels of consumption among those who eat in front of the television.

Our findings support that while SSB taxation may be regressive, disproportionately affecting lower-income groups, the health benefits would be progressive in these groups given their higher levels of consumption and given that these groups were more likely to be obese in our study. However, taxation may not influence the other unhealthy eating behaviours observed among frequent sweetened beverage consumers.

Conclusions

The present study provides the first detailed insight into social and behavioural determinants of SSB and ASB consumption in a UK population. The findings help to clarify those who stand to benefit most from further public health interventions and support that future efforts to reduce sweetened beverage consumption warrant targeting of individuals' behaviours as well as environmental influences.

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final manuscript. *Ethics of human subject participation:* This study was approved by the Cambridge Local Ethics Committee.

Supplementary material

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