Abstract

Objective: We aimed to identify socio-demographic, lifestyle and behavioural determinants of consumption of sugar-sweetened beverages (SSBs) and artificially-sweetened beverages (ASBs) in adults in Cambridgeshire, UK.

Design: Cross-sectional data were obtained from a cohort of 9,991 adults born between 1950 and 1975. A food frequency questionnaire was used to assess consumption of beverages and other dietary factors. Multivariable logistic regression was used to examine potential determinants of consuming SSBs and ASBs (≥1 serving/day).

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

Subjects: Adults (n=9,991) aged 30-64 years from three areas of Cambridgeshire, UK.

Results: Prevalence estimates for daily SSB and ASB consumption were 20.4% (n=2,041) and 8.9% (n=893), respectively. SSB consumption was more common in men than women (OR 1.33; 95% CI 1.17, 1.50), and among those reporting lower income (<£20,000/year) than those reporting higher income (>£40,000/year) (OR 1.31; 95% CI 1.09, 1.58). In contrast, daily ASB consumption was more common among women than men (OR 1.62; 95% CI 1.34, 1.96), those on weight-loss diets than those who were not (OR 2.58; 95% CI 2.05, 3.24), and those reporting higher income than lower income (OR 1.53; 95% CI 1.16, 2.00). Factors associated with higher consumption of each of SSBs and ASBs 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 SSBs and ASBs differ by several socio-demographic characteristics. However, increased BMI, younger age, and unhealthy eating behaviours are common to both groups.

Keywords: Sugar-sweetened beverages, artificially-sweetened beverages, carbonated beverages, socio-demographic, lifestyle, feeding behaviour

Socio-demographic, lifestyle and behavioural factors associated with consumption of sweetened beverages among adults in Cambridgeshire, UK –the Fenland Study.

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Shortened version of the title: **Sweetened beverage consumption in UK adults.**

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Introduction

Consumption of sugar-sweetened beverages (SSBs) has increased both internationally, and in the UK, in recent decades (1-3). SSBs are a major source of added sugars, and 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, SSBs 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 SSBs 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 pledge by government to introduce taxation of SSBs.

The consumption of artificially-sweetened beverages (ASBs) has also increased in recent years in the UK and elsewhere (1, 21, 22). Although ASBs are unlikely to offer any nutritional benefit they are promoted as a substitute for SSBs for weight control (23). ASBs are considered to be a less harmful alternative to SSBs, 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 the existing research on social and behavioural correlates with sweetened beverage consumption has been conducted in North America and has focused on consumption of SSBs 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 socio-demographic and behavioural factors associated with consumption of SSBs and ASBs 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 one year, psychotic illness, or being pregnant, lactating, or unable to walk unaided. Participants gave written informed consent.

The current study sample included data on 9,991 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 a food-frequency questionnaires (FFQ) (N=100). Implausible responses were defined by <0.5th percentile or ≥99.5th percentiles of a ratio of total energy intake to basal metabolic rate (29).

Assessment of dietary intake

Data on consumption of SSBs and ASBs 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 a week, 2-4/week, 5-6/week, once a day, 2-3/day, 4-5/day, and 6 or more a day. 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/take-away meals, ready-made meals, home-cooked meals, meals outside of 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. whiskey, vodka) and other alcoholic beverages (e.g. port, sherry) was collected using the FFQ, and responses were summed to calculate total servings/day of alcoholic beverages.

Assessment of socio-demographic 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 of white (97.6%) and non-white ethnicity. Education level, income, and other social factors were evaluated as indicators of socioeconomic conditions which relate to dietary habits, including daily consumption of SSBs or ASBs. These included age finishing education, current work status (full-time, part-time, keeping house, not currently working), employment type (employee, self-employed), 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 we computed body mass index (BMI) as weight/height^2 (kg/m^2). Physical activity was objectively measured for six days 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 (METs) and summarised as average hours/day spent in sedentary or resting time (<1.5 METs), light physical activity (≥1.5 and <3.0 METs) or moderate/vigorous physical activity (≥3.0 METs) (33).

Statistical analysis

All analyses were undertaken using Stata 13.1 (Stata Corp, College Station, TX, USA) (α two-sided=0.05). For each of SSB and ASB, participants were classified to daily consumers (≥1 drink/day) and non-daily consumers (<1 drink/day, including non-consumers) based on their responses to frequency of consumption. The association between socio-demographic factors and lifestyle/behavioural factors and daily or non-daily consumption of each of SSBs and ASBs was evaluated using logistic regression, in line with previous approaches (34-36). Odds ratio (OR) and 95% confidence intervals (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 socio-demographic factors as independent variables, the model included other socio-demographic 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 socio-demographic 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, socio-demographic 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. Chi-squared tests were 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 ≥3 servings/day of SSB and of ASB, respectively; and by defining only fizzy drinks as SSBs, 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/day for both beverage types) to characterise adults who did not consider how soft drinks were sweetened.

Results

Of 9,991 participants, 54.0% were women. The mean and standard deviation of age was 47.8±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 were skewed to the right (Supplementary Figure 1) and mean±sd servings/day of SSBs and ASBs. Daily consumption of SSBs and ASBs was reported by 20.4% and 8.9% of participants, respectively. Among daily consumers, SSB consumption and ASB consumption were 2.2±1.4 servings/day and 2.0±1.3 servings/day on average, respectively.

In unadjusted analysis, daily SSB consumption was positively associated with being male, whereas daily ASB consumption was positively associated with being female ($p<0.001$) (Table 1 and 2). SSB and ASB consumption were similarly associated with younger age, white ethnicity, and all eating behaviours ($p<0.001$ each), apart from eating outside of the home ($p>0.1$). Mean BMI was higher among daily SSB consumers than SSB non-consumers (27.6±5.0 and 26.6±4.7 kg/m^2, respectively) and daily ASB consumers than ASB non-consumers (29.5±5.6 and 26.6±4.6 kg/m^2).

In multivariable-adjusted analysis, daily SSB consumers were significantly more likely to be men, of lower socio-economic class, and have younger age of finishing education (Table 3). 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 ASBs showed significant associations with age 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 to those with lower income, OR for daily consumers of SSB and of ASB were 0.76 (95% CI 0.63, 0.91) and 1.53 (95% CI 1.16, 2.00), respectively.

Results for lifestyle characteristics are presented in Table 4. Obese or overweight adults were more likely to consume SSBs and ASBs, than normal weight adults. Current smoking was associated with lesser likelihood of consuming SSBs daily, with OR 0.79 (95% CI 0.66, 0.93) compared to non-smokers. Those on weight-loss diet were more likely to consume ASBs daily, with OR 2.58 (95% CI 2.05, 3.24), compared to those not on a weight-loss diet. Among eating behaviours (Figure 1), skipping breakfast and having meals or snacks while watching television were associated with daily consumption of SSBs or ASBs ($p<0.02$).

After adjustment for socio-demographic factors, ASB consumption and SSB consumption were modestly correlated ($r=0.13$). 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 SSBs ($\chi^2=0.02$; $p=0.88$) or ASBs ($\chi^2=3.32$; $p=0.07$). Not adjusting for the missing variable indicator had little influence on the main results. Evaluating ≥3 servings/day 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 (Supplementary Table 1 and 2). As exception, by contrast to the primary findings, ≥3 servings/day of ASBs was significantly associated with former smoking history, lower alcohol drinking and lower diet quality (Mediterranean diet score) ($p<0.05$). Evaluating ≥1 servings/day of both SSB and ASB as an outcome (n=307, 3.1%), one third of daily consumers of ASBs (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 ASBs with wide confidence intervals (Supplementary Table 1 and 2).

Discussion

In this study of 9,991 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 SSBs and ASBs shared many socio-demographic characteristics, a key difference between groups was the finding that having a lower household income was associated with higher SSB consumption, but with lower ASB consumption. In addition to socio-demographic factors such as age and education, modifiable factors were significantly associated with higher consumption of both SSBs and ASBs, including being overweight or obese, eating meals or snack foods while watching television, and skipping breakfast.

SSB consumption

Some of our findings relating to SSB consumption were consistent with existing studies which reported positive associations with younger age, men, 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 this 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 SSBs. Since children consume more SSBs than any other age group in the UK (47), parents living with children may purchase and consume more SSBs 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 SSBs. 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 SSBs 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 SSBs 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 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 were related to SSB consumption, while eating takeaway meals or eating outside the home were 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 socioeconomic and behavioural variables that were previously under-studied, but identified in our study to be important as potential determinants of SSB consumption.

ASB 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 finishing education) was associated with higher ASB consumption in this 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 consumption with household size. This was inconsistent with LIDNS' finding of high ASB consumption in households without children (39). These observations indicate heterogeneity in determinants of beverage consumption across socio-demographic 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/day of ASBs 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 ASBs for weight

299 management or general health after quitting smoking, but without regard for improvement in diet
300 quality and physical activity levels. While confirmation of this finding in a general population is
301 needed, this has potential implications for dietary or weight loss programmes which aim to improve
302 health outcomes through delivery of information and health promotion interventions.
303
304 Eating behaviours such as consuming meals or snacks while watching television were related to ASB
305 consumption, in line with a previous US-based study which reported that persons who purchased the
306 most ASBs also purchased the largest amount of snack foods (63). Another American study reported
307 that about 20% of total caloric intake among ASB consumers was from snack foods (60). This
308 supports that, independent of any direct health effects, ASB consumers may need to be recognised as
309 those with clustering of potentially unhealthy dietary behaviours.
310
311 *Strengths and limitations*
312 The large size of this study provided adequate precision in our estimates. The study included a larger
313 number of potential confounders than previous similar studies (34-36). This allowed a more thorough
314 statistical adjustment, and provided detailed insight into the characteristics of SSB and ASB
315 consumers, including important behavioural factors in addition to socio-demographic factors. No
316 previous literature was identified for some of the associations in this study, particularly relating to
317 ASB consumption. For these and other characteristics the study helps to fill a gap in the existing
318 evidence.
319
320 There are a number of limitations to our study. As this study was cross-sectional, causality is limited
321 in our findings of associations. Therefore, we cannot rule out that current social factors (e.g. income),
322 for example, were driven by habitual, long-term dietary habit with high SSB consumption and
323 obesity. Moreover, appreciable changes in the pattern of sweetened beverage consumption over time
324 may not have been discerned. Although statistical adjustment might partly reduce measurement errors
325 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 under-estimation. 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 SSBs 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 this 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 this 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 socio-demographic variables evaluated in this 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 nonetheless detected. For example, more than two thirds of participants reported eating meals or snacks while watching television at least once a week, and more than 30% skipped breakfast at least twice a week. Given the relatively high prevalence of sweetened beverage consumption observed, our study is unlikely to over-state 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 SSBs and ASBs. 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

This 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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533

534 **Figure Legend**

535 Figure 1. Associations of dietary habits with daily consumption of sugar sweetened beverages in the
536 Fenland Study. Odds ratios were adjusted for demographic and socioeconomic factors and mutually
537 adjusted for different dietary habits presented here.

538 Figure 2. Associations of dietary habits with daily consumption of artificially sweetened beverages in
539 the Fenland Study. Odds ratios were adjusted for demographic and socioeconomic factors and
540 mutually adjusted for different dietary habits presented here.

541 **Table 1**. Socio-demographic characteristics of participants stratified by daily consumption of sugar-
542 sweetened beverages and artificially-sweetened beverages: The Fenland Study (n=9,991)

	Sugar-sweetened beverages*			Artificially-sweetened beverages*		
	Daily	Less than daily	*p*	Daily	Less than daily	*p*
	n=2,041	n=7,950		n=893	n=9,098	
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
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.we did not

550 **Table 2**. Lifestyle/behavioural characteristics of participants by daily consumption of sugar-
551 sweetened beverages and artificially-sweetened beverages: The Fenland Study (n=9,991)

	Sugar-sweetened beverages*			Artificially-sweetened beverages*		
	Daily n=2,041	Less than daily n=7,950	*p*	Daily n=893	Less than daily n=9,098	*p*
Body mass index group, %						
<25 kg/m^2	33.3	40.8		20.5	41.1	
≥25 and <30 kg/m^2	39.8	39.6		39.8	39.6	
≥30 and <35 kg/m^2	19.2	14.2		25.1	14.3	
≥35 kg/m^2	7.7	5.4	<0.001	14.7	5.0	<0.001
Physical activity (PA), hours/day						
Sedentary time	16.1 (2.5)	16.6 (2.4)	<0.001	16.4 (2.4)	16.5 (2.4)	0.17
Light PA	6.0 (1.9)	5.7 (1.8)	<0.001	6.0 (1.9)	5.8 (1.8)	<0.001
Moderate or vigorous PA	1.9 (1.5)	1.7 (1.3)	<0.001	1.6 (1.3)	1.7 (1.3)	0.004
Alcoholic beverages, servings/day	0.7 (1.0)	0.8 (1.1)	<0.001	0.7 (1.1)	0.8 (1.1)	0.017
Mediterranean diet score†	6.4 (2.2)	6.7 (2.2)	<0.001	6.4 (2.2)	6.7 (2.2)	<0.001
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	66.03	
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 of 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 (standard deviation) for continuous variables and proportions for categorical variables. P values were computed by crude logistic regression analysis relating daily consumption of sugar-sweetened beverages or artificially sweetened beverages (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.

561 **Table 3.** Associations of socio-demographic characteristics with daily consumption of sugar-
562 sweetened and artificially-sweetened beverages: The Fenland Study (n=9,991).

Variable	Categories†	Sugar-sweetened beverages			Artificially-sweetened beverages		
		% 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	1.0	ref.	10	1.0	ref
	Men	22	1.33	(1.17, 1.50)	7	0.66	(0.56, 0.79)
Test site	Cambridge	15	1.0	ref.	5	1.0	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	Whites	21	1.0	ref.	9	1.0	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	1.0	ref.	11	1.0	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 or older	12	0.52	(0.41, 0.64)	4	0.43	(0.31, 0.61)
Socio-economic class	Higher	18	1.0	ref.	8	1.0	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	1.0	ref.	9	1.0	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	1.0	ref.	9	1.0	ref.
	Self-employed	20	0.98	(0.86, 1.11)	7	0.85	(0.70, 1.02)
Total combined household income	<£20,000	23	1.0	ref.	8	1.0	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	1.0	ref.	6	1.0	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	1.0	ref.	7	1.0	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	1.0	ref.	5	1.0	ref.
	No	21	1.13	(0.89, 1.42)	9	1.45	(0.99, 2.11)
Home ownership	Yes	18	1.0	ref.	7	1.0	ref.
	No	20	1.43	(1.08, 1.86)	9	1.09	(0.73, 1.64)

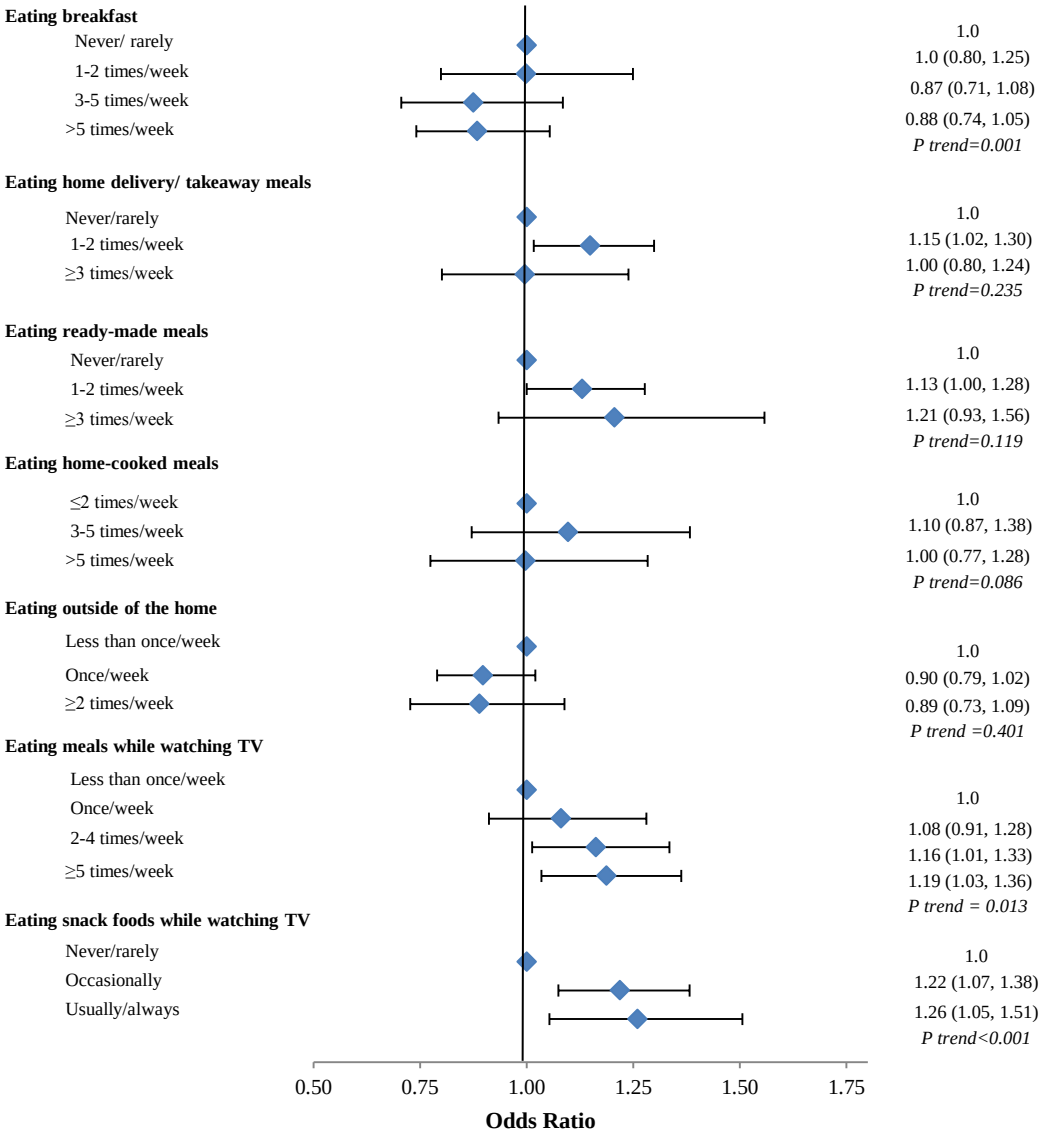
563 *Adjusted for age, sex, site (Cambridge, Ely, Wisbech), and all of the socio-demographic variables
564 shown at the first column.
565 † A category listed at the top of each variable was used as a reference (ref.) in logistic regression
566 models for daily vs. non-daily consumers of sugar-sweetened beverages and artificially-sweetened

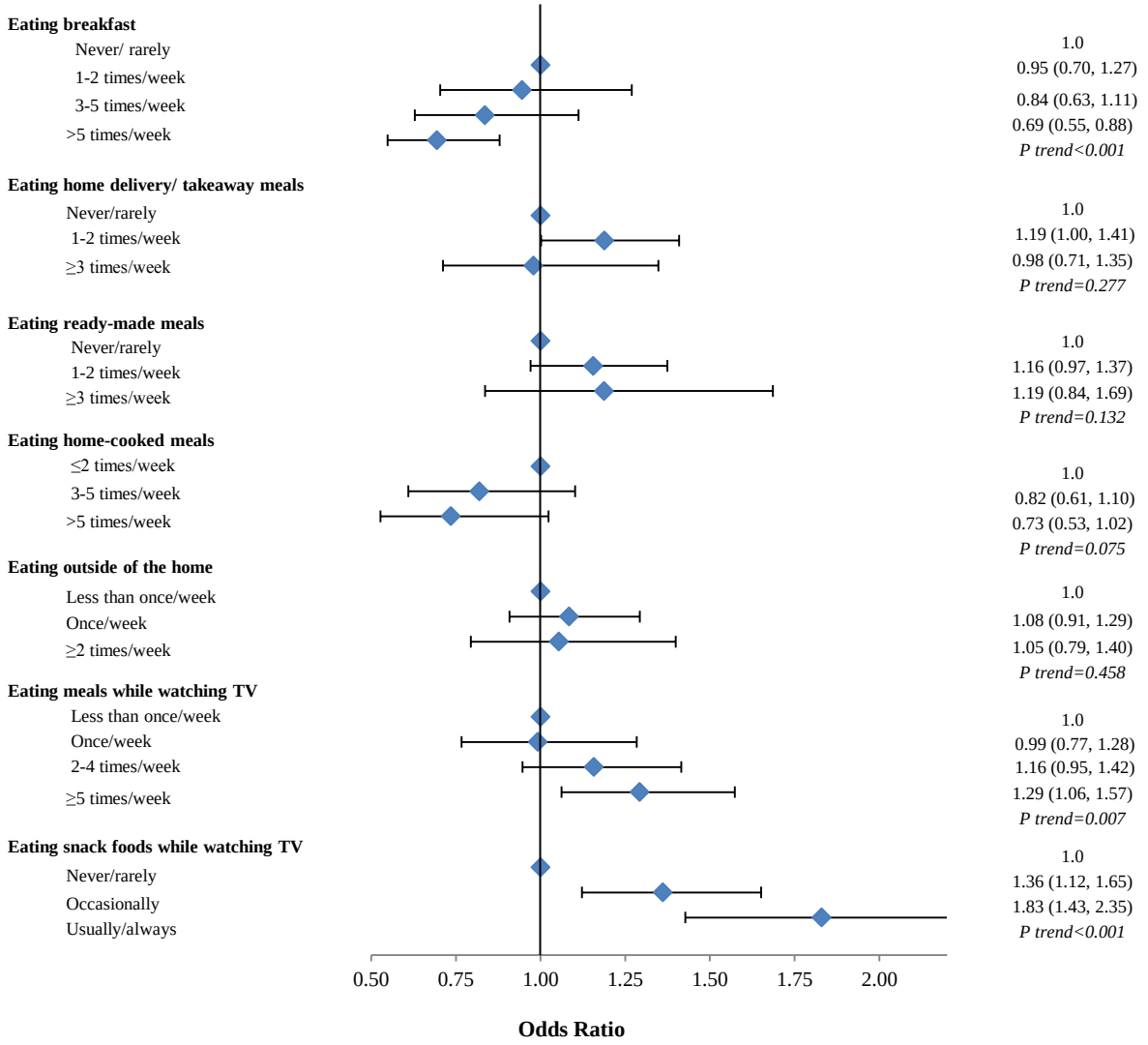
beverages. A category for missing information was included in each model, but not presented. Adjustment for missing data had little influence on the results.

Table 4. Associations of lifestyle characteristics with daily consumption of sugar-sweetened and artificially-sweetened beverages: The Fenland Study (n=9,991).

Variable	Categories or scale*	Sugar-sweetened beverages†			Artificially-sweetened beverages†		
		% daily consumers	OR	95% CI	% daily consumers	OR	95% CI
Body mass index group, kg/m^2	<25	17	1.0	ref	5	1.0	ref.
	≥25 and <30	21	1.17	(1.04, 1.33)	9	1.92	(1.58, 2.34)
	≥30 and <35	26	1.58	(1.35, 1.85)	15	3.09	(2.47, 3.86)
	≥35	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	1.0	ref.	8	1.0	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 physical activity	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	1.0	ref.	8	1.0	ref.
	Yes	23	1.07	(0.86, 1.33)	24	2.58	(2.05, 3.24)

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


Eating breakfast
Never/ rarely
1-2 times/week
3-5 times/week
>5 times/week
1.0
1.0 (0.80, 1.25)
0.87 (0.71, 1.08)
0.88 (0.74, 1.05)
P trend=0.001
Eating home delivery/ takeaway meals
Never/rarely
1-2 times/week
≥3 times/week
1.0
1.15 (1.02, 1.30)
1.00 (0.80, 1.24)
P trend=0.235
Eating ready-made meals
Never/rarely
1-2 times/week
≥3 times/week
1.0
1.13 (1.00, 1.28)
1.21 (0.93, 1.56)
P trend=0.119
Eating home-cooked meals
≤2 times/week
3-5 times/week
>5 times/week
1.0
1.10 (0.87, 1.38)
1.00 (0.77, 1.28)
P trend=0.086
Eating outside of the home
Less than once/week
Once/week
≥2 times/week
1.0
0.90 (0.79, 1.02)
0.89 (0.73, 1.09)
P trend =0.401
Eating meals while watching TV
Less than once/week
Once/week
2-4 times/week
≥5 times/week
1.0
1.08 (0.91, 1.28)
1.16 (1.01, 1.33)
1.19 (1.03, 1.36)
P trend = 0.013
Eating snack foods while watching TV
Never/rarely
Occasionally
Usually/always
1.0
1.22 (1.07, 1.38)
1.26 (1.05, 1.51)
P trend<0.001
0.50
0.75
1.00
1.25
1.50
1.75
Odds Ratio


Eating breakfast
Never/ rarely
1-2 times/week
3-5 times/week
>5 times/week
1.0
0.95 (0.70, 1.27)
0.84 (0.63, 1.11)
0.69 (0.55, 0.88)
P trend<0.001
Eating home delivery/ takeaway meals
Never/rarely
1-2 times/week
≥3 times/week
1.0
1.19 (1.00, 1.41)
0.98 (0.71, 1.35)
P trend=0.277
Eating ready-made meals
Never/rarely
1-2 times/week
≥3 times/week
1.0
1.16 (0.97, 1.37)
1.19 (0.84, 1.69)
P trend=0.132
Eating home-cooked meals
≤2 times/week
3-5 times/week
>5 times/week
1.0
0.82 (0.61, 1.10)
0.73 (0.53, 1.02)
P trend=0.075
Eating outside of the home
Less than once/week
Once/week
≥2 times/week
1.0
1.08 (0.91, 1.29)
1.05 (0.79, 1.40)
P trend=0.458
Eating meals while watching TV
Less than once/week
Once/week
2-4 times/week
≥5 times/week
1.0
0.99 (0.77, 1.28)
1.16 (0.95, 1.42)
1.29 (1.06, 1.57)
P trend=0.007
Eating snack foods while watching TV
Never/rarely
Occasionally
Usually/always
1.0
1.36 (1.12, 1.65)
1.83 (1.43, 2.35)
P trend<0.001
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Odds Ratio