Published in final edited form as:
Br J Nutr. 2012 August ; 108(3): 536–551. doi:10.1017/S0007114511006465.

PATTERNS AND TRENDS OF BEVERAGE CONSUMPTION AMONG CHILDREN AND ADULTS IN GREAT BRITAIN, 1986–2009

Shu Wen Ng,
University of North Carolina at Chapel Hill, 123 W. Franklin St., Chapel Hill, NC 27516-3997

Cliona Ni Mhurchu,
Clinical Trials Research Unit, The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand

Susan A. Jebb, and
MRC Human Nutrition Research, Elsie Widdowson Laboratory, Fulbourn Road, Cambridge, CB1 9NL, UK

Barry M. Popkin
University of North Carolina at Chapel Hill, 123 W. Franklin St., Chapel Hill, NC 27516-3997, Phone: (919) 966-1732, Fax: 919-966-9159 (backup: 6638), popkin@unc.edu

Abstract

Many dietary recommendations include reduction of excessive intake of sugar-sweetened beverages (SSBs) and other energy-rich beverages such as juices and alcohol. This study examines surveys of both individual dietary intake data and household food expenditures surveys to provide a picture of patterns and trends in beverage intake and purchases in Great Britain from 1986 to 2009, and estimates the potential for pricing policy to promote more healthful beverage purchase patterns. In 2008/09, beverages accounted for 21%, 14% and 18% of daily energy intake for children aged 1.5–18y, 4–18y, and adults (19–64y) respectively. Since the 1990s, the most important shifts are a reduction in consumption of high-fat dairy products and an increased consumption of fruit juices and reduced-fat milk among preschoolers, children and adolescents. Among adults consumption of high-fat milk beverages, sweetened tea and coffee and other energy-containing drinks fell, but reduced-fat milk, alcohol (particularly beer), and fruit juice rose. In testing taxation as an option for shifting beverage purchase patterns, we calculate that a 10% increase in the price of SSBs could potentially result in a decrease of 7.5 ml/capita/day. A similar 10% tax on high-fat milk is associated with a reduction of high-fat milk purchases by 5 ml/capita/day and increased reduced-fat milk purchase by 7 ml/capita/day. This analysis implies that taxation or other methods of shifting relative costs of these beverages could be a way to improve beverage choices in Great Britain.

Keywords

Caloric drinks; sugar sweetened beverages; price; Great Britain

Correspondence to: Barry M. Popkin.

CONFLICTS OF INTEREST
The authors have no conflicts of interest to report.

INTRODUCTION

Rates of overweight and obesity have increased sharply in Great Britain since the mid-1980s. In 2009, 61.3% of adults (aged 16 or over), and 28.3% of children (aged 2–10) in England were overweight or obese[(1)]. Improving the quality of the diet while also reducing per capita energy intake to achieve and maintain a healthy weight among the British represents a key policy objective[(2–4)]. The reduction of added sugar, specifically those from sugar-sweetened beverages (SSBs; namely all caloric soft drinks, fruit drinks and sugar-sweetened coffees and teas) and other high energy beverages such as juices and alcohol has been included in most documents concerned with obesity not only in the Great Britain, but also globally[(5, 6)]. In order to establish the likely impact of such changes it is necessary to consider beverage intake patterns.

The biological basis for a policy to decrease sugar-sweetened beverages to prevent obesity is the relationship between beverage intake and food intake. There appears to be little reduction in food intake when caloric beverages are substituted for water and other low-nutritive sweetened or "diet" beverages[(7–9)]. In addition, there is some evidence that the fructose component of sugars such as sucrose and high fructose corn syrup might lead to additional cardio-metabolic risks[(10–14)]. Individual studies are often inconsistent; however meta-analyses of clinical and epidemiological research show a significant linkage of SSBs with weight gain and a range of cardio-metabolic risks[(15–17)]. Emerging data suggests that the effect of fruit juice consumption on weight gain and risk of diabetes and other cardio-metabolic outcomes are consistent with the SSB studies[(18–22)]. There are only a small number of studies comparing water as a substitute for these caloric beverages; however they consistently suggest that water intake may help to reduce energy intake[(23, 24)].

There are few systematic analyses of overall beverage patterns and trends at the national level. For the United States, a number of studies have examined overall patterns and found a large secular increase in both total energy intake from beverages and also the total volume of beverage intake other than water[(25, 26)]. Both the United States and Mexico (a country that almost doubled its intake of energy from beverages between 1999 and 2006) obtain over 20% of their daily energy intake from beverages, with significant proportions from high sugar beverages including SSBs and juices[(27, 28)]. Elsewhere, there is a lack of systematic research on overall trends in beverage consumption at the national level.

An important question for researchers is to identify how changes in beverage intake may be stimulated. One approach seen as being potentially effective is taxation based on the amount of added sugar used [(29, 30)]. In Great Britain, there is a growing literature on fat taxes, which concludes that well-designed and targeted taxes could be useful in reducing the burden of nutrition-related diseases[(31–33)] but there are limited studies looking at pricing policies on SSBs.

This study examines surveys of both individual dietary intake data and purchasing data in the context of household income and expenditures to provide a picture of patterns and trends in beverage intake and purchases in Great Britain over the 1986–2009 period. In addition, it examines the potential for pricing policy to promote more healthful beverage purchase (and thus consumption) patterns.

2. DATA & METHODS

2.1 Data Sources

2.1.1 Dietary intake data—There have been five nationally representative surveys of dietary intake among selected age groups in Great Britain. They are the Dietary and

Nutritional Survey of British Adults, 1986/87; the 2000/01 National Diet and Nutrition Survey (NDNS) of Adults aged 19 to 64y; a 1997 NDNS of Young People aged 4 to 18y; and the 1992 National Diet, Nutrition and Dental Survey of Children Aged 1.5 to 4.5y. Beginning in 2008, the British government began the NDNS Rolling Programme, which collects nutrient intakes and nutritional status of people aged 1.5y and older living in private households in Great Britain. Except for the 1986 survey, each survey used a multistage random probability sample with postal sectors as the primary sampling unit, thus sample weights were available for all the surveys to allow estimation of nationally representative measures.

However, there are critical differences in the data collection periods across the surveys that require complex statistical adjustments to provide statistically representative trends between surveys. The 1992 survey among children (1.5 to 4.5y) and the 2008/09 survey used a four-day food records to quantify food and nutrient intakes, while the previous NDNS of adults (19 to 64y) and young people (4 to 18y) were conducted over seven days. This is pertinent because day-to-day variability for each individual means that diary duration may have an impact on survey estimates. Hence, to allow for all the analyses and comparisons to be done on a four-day basis, we applied the methods outlined in the NDNS 2008/09 report[(34)] on the 1986/87 and 2000/01 adult, and the 1997 young people surveys to derive the means and standard errors by bootstrap sampling with replacement.

We also standardized the measurement of beverages across all the surveys. For energy from beverages, added milk and sugar for tea, coffee and other drinks were provided separately in the earlier food intake survey, but we could systematically link the results so we are able to examine sweetened and unsweetened tea and coffee separately. Water consumption from both tap and bottle data was utilized from all surveys when possible, however there is minimal understanding of the quality of the water measurement in most surveys conducted in Europe and the US on this topic[(24)]. Table 1 below provides the beverage groups used, and their definitions, with examples.

2.1.2 Food purchase data—For 1975–2000, we utilized five-year increments of the British National Food Survey (NFS), the longest-running continuous (annual) survey of household food purchases and expenditure in the world. The NFS was originally set up in 1940 by the then Ministry of Food to monitor the adequacy of the diet of urban 'working class' households in wartime, but it was extended in 1950 to become representative of households throughout Great Britain. In 1996, the survey was extended to cover the entire United Kingdom (UK) to be presented for the first time. The household member who did most of the food shopping was asked questions about the household and its food purchasing, and kept a diary for seven days, recording food coming into the household, including quantities, expenditure, food prices, and some detail of the household meals (including snacks and picnics prepared from household supplies). We only used five-year increments of the data due to the immensity of working with 25 years of raw data.

From 2001, the NFS was completely replaced by the Expenditure and Food Survey (EFS), which combined and superseded both the previous Family Expenditure Survey (FES) and the NFS. The EFS sample for UK is a multi-stage stratified random sample with clustering. The survey is continuous, interviews being spread evenly over the year to ensure that seasonal effects are covered. Further information on sampling can be found in the user guide volume of the EFS documentation[(35)]. The basic unit of the survey is the household, with each individual (≥16y) in the household keeping diary records of daily expenditure for two weeks. Information about regular expenditure, such as rent and mortgage payments, is obtained from a household interview along with retrospective information on certain large, infrequent expenditures such as those on vehicles. The results have also included information from simplified diaries kept by children aged 7–15y.

In most years, surveys reported dried milk in its reconstituted liquid equivalent volume. All other dry or concentrated beverages (chocolate drinks, coffee beans and tea leaves, powders or essences) were reported as purchased. We adjusted these systematically across the surveys so the reconstituted liquid equivalents are reported for all beverages for the prices paid. This included Ribena and other beverage concentrates that require different reconstitution formulas. Appendix 1 shows which beverages belong to each group, and Appendix 2 shows the ratios of diluent to powder used to adjust non-liquid beverages to their liquid equivalents. The main difference between analysis of beverages in the dietary intake and food expenditure surveys is that we were able to create a separate categories for sweetened and unsweetened tea and coffee for the dietary intake data.

There were some significant differences in how beverage data were recorded for the most recent surveys. Takeout coffee and tea were added in 2007 as was the separation of vegetable purees into juices and purees; water purchases were not collected until 1985, and alcohol purchases were not added until 1992. Similarly, sugar-sweetened milk was only added in 2008.

For studying the associations between changes in the prices households faced on their beverage purchases, we needed to have a beverage price for all the beverages studied for each household at the relevant time period of the diary collection. However, prices are reported only for the households which purchase the items, and there were too many differences between the NFS and the EFS that affected expenditure and our ability to create of price measures in a consistent manner. In addition, the EFS had less than 1% missing measures for the demographic measures used: household size and numbers of adult males and females and children, employment status and education levels for adults in the household, family income per week, and recipient of income support, while the NFS had up to 39% missing values for some of these measures for certain years. Consequently, we only use the EFS data for imputing prices to conduct price-related analyses given that they would be more reflective of current beverage purchase trends and behaviors and thus more appropriate for simulating response to potential price shifts. To imputed prices for the EFS, we divided expenditure over volume purchased for each beverage type among those who reported purchasing that beverage within a geographical area. We then assumed that this average price was the price that all respondents within the same geographical area were exposed to. This way all respondents had measures of an average prices for each beverage, regardless of whether they purchased beverages or not. This is the standard method economists have used for decades as the most valid method for deriving prices when utilizing expenditures data for price studies[36].

2.2 Statistical Procedures

To describe nationally representative beverage dietary intake and purchases (grams or ml and energy) using the various national dietary intake data and food expenditures surveys, survey weighted means were calculated. Energy from non-beverage sources were also calculated from each survey. We conducted t-test to analyze differences on energy consumed and volume purchased from beverages and the various types of beverages over time. A p-value <0.01 was considered significant.

For the analysis of income and price elasticities, we selected the most recent as well as the earliest food purchase survey data for which we had reliable price and income data (i.e., EFS 2001 and 2007). Separate estimations were done for two separate but related decisions: the decision to purchase, and the conditional decision of the amount to purchase. This follows standard statistical procedures of eliminating biases when examining outcomes such as purchase of milk or soft drinks where there are large proportions of zero purchasers[37] by using a survey-weighted two-part model. Purchase distribution can be skewed because some people do not purchase certain foods. Thus, researchers recommend using two-part models to analyze either food purchase or dietary intake behaviors[37]. Two-part models are also useful in predicting actual outcomes based on observed data.

The analysis examined separately two cross-sections to estimate the price effects at specific years. The assumption is that with two nationally representative samples, the mean statistics based on the pooled sample of households represents the ‘average’ household in each of the cross-sections. It would have been preferable to conduct time-series analyses, which would have allowed for error correlations over time across the same households. However, given the cross-sectional nature of the data available, this was not possible. The two-part model included a survey-weighted probit model using maximum-likelihood estimation in the first part to estimate the probability of purchasing any of the particular beverage of interest. The second part is a log-linear survey-weighted ordinary least squares (OLS) regression model on only the sub-sample of those who did purchase a particular beverage of interest. The two parts have the same specifications. These two-parts were estimated separately before we derived the unconditional elasticities and bootstrapped standard errors.

Own-price and cross-price effects on volume (ml) of purchase of each beverage were calculated. The former is defined as the change in quantity in demand that occurs in response to a percentage change in price. This should be negative. Cross-price effect of demand is the change in quantity demanded for the first good that occurs in response to a percentage change in the price of a second good. Goods with positive cross-price effects are considered substitutes and those with negative cross-price effects are considered complements. Examples of substitutes are coffee and tea, while coffee and milk can be complements. Stata version 11.0 was used in all analyses[38]. Ideally, it would be useful to study the effects of taxation based on added sugar content in beverages. However, this would require knowing the *added sugar* of all beverages purchased or consumed, which does not exist even if one were to use commercial databases linked with nutrition facts panel data since only total sugar is reported. Therefore, we rely on a simplistic approach of looking at price effects on a certain sets of beverages that are known to have high or low added sugar content. For ease of interpretation, we derived simulations on the changes in the amount of beverages bought that is associated with a 10% and 20% increase in the price of each beverage. Our estimates are point-estimates based on current purchase levels and assume linearity.

3 RESULTS

3.1 Beverage Intake Patterns and Trends

In the most recent (2008/09) National Diet and Nutrition Survey Rolling Programme, we can observe the different beverage consumption patterns by age groups. Figure 1a shows that preschoolers (2–6y) had 68% of their beverage energy coming from dairy sources (reduced fat milk, high fat milk and sweetened dairy). The proportion gets progressively lower with the older age groups, and or adults (19–64y) only 10% of energy from beverages are from dairy sources. Figure 1b shows that sugar-sweetened beverage (soda, fruit drinks and sweetened coffee and tea) intake is the highest both in absolute and relative terms (548 kJ or 41% of energy from beverages among adolescents (13–18y), is also large for adults (431 kJ) but much lower among children and preschoolers. In addition, energy from alcohol contributes to 16% of energy intake from beverages among adolescents, and 43% of energy from beverages among adults.

There have been limited surveys on dietary intake for all age groups prior to the new 2008/9 survey. For the years of data available for select age groups, we present the per capita energy consumption from dairy and non-dairy beverages. Additional details are available in Appendix 3 Tables A1 and A2, which present the per capita consumption, the proportion of individuals who consume a particular beverage (over a four-day basis), and the average daily amount consumed among consumers. These are in terms of energy contribution (panel A) and total volume consumed (panel B). We also present the sample sizes for each of surveys by age groups.

3.1.1 Young children ages 1.5 to 4.5—For the purposes of comparison across the available data in 1992 and 2008/09, we looked at 1.5–4.5 year old children. We found that the proportion of young children consuming high fat milk, sweetened dairy, sodas/fruit drinks and sweetened tea fell significantly, but the percentage that consumed fruit juices rose significantly (from 39% to 58%). However, from a per capita energy consumption standpoint, only energy from soda/fruit drinks, sweetened tea and other caloric drinks fell significantly. This means that even though fewer young children are consuming any high fat milk and sweetened dairy, those who are consuming these beverages are getting more energy from these sources, indicative of increasing disparities in intake (see Appendix 3 Table A1).

3.1.2 Children and adolescents ages 4 to 18—Milk (high fat plus low fat) intake overall declined slightly from 1997and 2008/09 for preschoolers, children and adolescents, due to the decline of high fat milk concurrent with a much smaller increase in reduced fat milk (see Figure 2a). Sweetened dairy however, has emerged to almost equal reduced fat milk in per capita consumption levels across all these age groups.

In 2008/9, energy from beverages represented about 14% of energy intake for all British children aged 4–18 with the bulk of energy coming now from sugary beverages such as soda, fruit drinks, juices and sweetened dairy (See Appendix 3 Table A1). The most commonly consumed beverage or this age group continues to be sugar-sweetened beverages, with sugar-sweetened beverage intake in the 2008/9 period being especially high among adolescents. The proportions consuming any juices rose significantly from 44% to 53%, and sweetened dairy is now consumed by nearly a third of children 4–18y (Figure 2b).

3.1.3 Adults aged 19 and older—In 2008/9, energy intake from beverages represented about 18% of energy intake for all British adults aged 19–64y with the bulk of energy coming now from alcohol and sugar-sweetened beverages such as soda, fruit drinks, sweetened coffee, tea and juices. Since 1986 there were three points to measure dietary intake of beverages by adults. During this period, British adults' overall proportion of energy from beverages has changed very little, but there are some shifts in the sources of energy from beverages. Figure 3a describes changes in consumption of dairy beverages, which while continue contributing to 10–11% of energy from beverages, has significantly shifted away from high fat milk towards reduced fat milk. Energy from sweetened dairy has also declined, particularly between 1986/87 and 2000/01.

For the average adult, SSBs increased gradually from 113 kJ/day in 1986/87 to 209 kJ/day in 2008/09, as did alcohol, which by 2008/09 accounted for nearly half of the energy from beverages. Wine increased slightly but beer remains the single largest source of energy from beverages and represents about two-thirds of energy from alcohol (see Appendix 3 Table A2). Meanwhile, sweetened tea and coffee and other energy-containing drinks declined markedly (Figure 3b). Much of these noted changes may be due to the fact that since 1986/87, the percentage of British adults consuming high fat milk, sweetened tea and coffee fell significantly, while the percentage that consumed reduced fat milk, low-nutritive (diet)

NIH-PA Author Manuscript

NIH-PA Author Manuscript

sweetened drinks and juices rose. In addition, we note that the increase in energy from juice was due to both increases in the percentage of consumers and the amount consumed per person. Adults, in particular, had a large increase in consumption of low-nutritive (diet) sweetened beverages from 17 ml/day in 1986/87 to 102 ml/day in 2008–9 (see Appendix 3 Table A2.)

3.1.4 Water's role in British beverage patterns—The volume of total water intake per capita across all age groups has increased over time. These differences are large and statistically significant (Figure 4). From these cross-sectional years of data, about 23–32 % of water intake comes from food sources, and the remainder comes from beverages. Water as a beverage increased across all age groups in the most recent survey, which may be due to greater efforts to measure water consumption in the more recent surveys. Still, it is important to note that the surveys may not provide reliable data on tap or unbottled water intake [23, 24].

3.2 Long-term trends in Household per capita purchases

The household expenditure data collected from British families demonstrate changes in purchases over the 1975 to 2007 period.Figure 5 highlights major shifts while Appendix 3 Table A3 provides detailed information. The major trends over these three decades include a reduction in purchase of tea, no change in coffee, a decline in overall purchases of milk with a shift toward more reduced-fat milk, and a slight decline in sweetened dairy (e.g., yogurt drinks, hot chocolate), a large increase in SSBs (soda and fruit drinks), low-nutritive (diet) sweetened beverages, and fruit juice.

These results are provided only in ml of weekly purchase after adjusting for the number of people in each household. These data represent purchases during a limited time period and do not account for wastage. Our inability to separate coffee and tea purchases into unsweetened and sweetened categories does not allow any understanding of the health effects of shifts in tea and coffee purchases. However, the total increase in the purchases of beverages containing sugar—SSBs (soda and fruit drinks) and fruit juices, is clear.

3.3 Price effects

Water, chocolate drinks, and vegetable juice purchases were made by about 20%, 10% and 1% of the households respectively, and we do not report the effects of prices on these outcomes (unreported results). We also exclude alcohol though over 50% of households purchased this. For all the other beverages the proportion of household that purchased the items ranged from 30–75%.

Analyses of the two cross-sectional datasets from 2001 and 2007 provide the estimated own-price effects, defined as the ml change in amount purchased per capita per week, related to a 10% and 20% increase in price (Table 2). These are the estimates of the effect of changes in the price of SSB from a tax or removal of a subsidy on SSBs on beverage purchases. SSBs are fairly price responsive with a 10% increase in the price of SSBs being associated with a 50 to 53 ml/capita/week (or around 7.5 ml/capita/day) lower purchase. Increasing elasticities for juice and reduced-fat milk over time suggest a shift toward reduced-fat milk as the commodity of choice and also greater availability of different varieties of milks (e.g., soy, rice, almond) and juice such that households have become more price sensitive to these beverages. Also, consumers are consistently price responsive to increases in the prices of tea, although less so over time.

Using the 2007 EFS data, we estimated the associations between a 10% and a 20% increase in the price of some of these beverages and the weekly purchase (in ml) of other beverages

(Table 3). The values along the diagonals are the own-price effects, which are the same as reported in Table 2B for the weekly purchase in ml for the average household member on a per capita basis. The figures in the off-diagonals are the cross-price effects. We find that raising the price of SSBs had no significant effect on the consumption of other beverages, and the demand for low-nutritive (diet) sweetened beverages is separate from that for SSBs (i.e., they are not substitutes). In contrast, there is strong substitutions among the high and reduced-fat milks as we find that a 10% increase in the price of high-fat milk is associated with an increase in the purchase of reduced-fat milk by 48 ml/capita/week (7 ml/capita/day) and a decrease in high fat milk purchases by 35 ml/capita/week (5 ml/capita/day).

4 DISCUSSION

In 2008/09, beverages accounted for 21%, 14% and 18% of energy per day for children aged 1.5–18y, 4–18y, and adults (19–64y) respectively. Since the 1990s, the most important shifts are a reduction of consumption of high-fat milk, particularly among preschoolers, children and adolescents with a shift towards sodas, fruit drinks, juices, and sweetened dairy. Among adults, consumption of dairy, sweetened tea and coffee and other energy-containing drinks fell, but alcohol (particularly beer) and juice rose. Furthermore, the total volume of water consumed increased.

Data is limited but patterns of beverage consumption in British adolescents appears to mirror those of adolescents across other European countries{Duffey, 2011 #13871}. In comparison with the United States, Mexico and other countries with published beverage consumption data, the British beverage consumption pattern has not changed as markedly[27, 40, 41]. While energy from beverages has not shifted markedly overall during the past decade in Britain, energy intake from beverages, especially SSBs, remains a significant contributor to total energy intake. Given that the population level energy imbalance in the UK over the last 10 years, estimated very recently by a Department of Health Expert Group was just 67 kJ/day or 100 kJ/day for the 90th percentile of weight gain (unpublished data), encouraging replacing SSBs and high-fat milk with less energy-dense beverages is one potential public health target.

To understand the implications of taxation as an option for shifting beverage consumption patterns, this paper explored taxation of SSBs and high-fat milk, among other products. The findings from of a 10% price increase were quite comparable to the effect found in the US and Mexico{Barquera, 2008 #12361; Duffey, 2011 #13390; Andreyeva, 2009 #13718; Finkelstein, 2010 #112}. Increasing the price of SSBs by just 10% is associated with a reduction of 7.5 ml/capita/day based on 2007 data. Interesting, there is a clear substitution between high-fat and reduced-fat milk whereby a 10% price increase of high-fat milk is associated with a decline in purchase by 5 ml/capita/day and an increase in purchase of reduced-fat milk by 7 ml/capita/day. We consider the potential implications on beverage purchases of these price changes. In 2007, the British population was around 60,769,000. Data from the British soft drink industry[45] indicate total annual soft drink (including bottled water, sports and energy drinks, fruit juices, smoothies, and SSBs) volume sales of 14,060 million liters, or 231 liters/capita, of which only 65% (or 151 liters/capita/year) apply to our categorization of SSB. Our estimates of 7.5 ml/capita/day reduction in SSB purchase is equivalent to 2.8 liters/capita/year, or about 1.9% of the total British SSB (based on our definition) volume. Given that change in SSB volume sales over the last 5 years has ranged from −1.1% to +3.3% per year[45], this is not an insignificant finding. Meanwhile, a 10% increase in the price of high-fat milk is associated with in a decrease of about 6% of the total British high-fat milk sales, and an increase of nearly 4% of the total British reduce-fat milk sales (based on applying the estimates from the ESF 2007 data). We do not extend our findings to estimate potential changes in beverage intake or health outcomes since there are difference between what is purchased and consumed (e.g., people might be consuming fruit juices that are freshly squeezed rather than packaged from the store; people may be buying milk and adding it to their coffee or tea, or using it for cooking/baking). However, this analysis suggests the potential for taxation or other methods of shifting relative costs of these beverages as a way to change beverage choices in Great Britain, which may support public health goals.

Of course, this paper focuses only on beverages, so there are other important foods that might be affected by beverage prices that we cannot address here. In addition, we do not address the role of price changes in alcohol(46), a beverage whose role in obesity and cardio-metabolic health is quite complex(47, 48). Ideally, we would have liked to study how taxation based on added sugar content or fat content would affect beverage purchase and/or intake. However, that would require detailed measurements of each beverage purchased/consumed along with the added sugar content of each beverage product, which currently is not even reported on nutrition facts panels and do not exist in any country. Therefore, we have simply looked at SSBs as a beverage category that is known to have significant added sugar content, and milks by fat content.

In considering taxation based on added sugar, it is not clear what proportion of this tax might be absorbed by producers. However, it is likely as it was with alcohol and tobacco taxation that all (or a large proportion of) taxes are passed on through higher prices and reduced purchase as we show (49–51). Interestingly, in the agricultural area, recent subsidies on food are often not passed on either to producers or consumers but rather absorbed by agribusiness middlemen(52, 53). Another consideration that we have not studied here is the potential of using revenue from taxation of less healthy foods and beverages to support direct point-of-purchase subsidies on healthier foods like fruits and vegetables, which has been shown to influence consumption in an intervention study(54). The debate around taxing certain foods or beverages can be contentious, particularly in countries such as the US(55), making price simulation exercises like what we have done here critical in providing the scientific basis for any arguments on either side of the issue.

This is not to say that there are no limitations to this study. One limitation is the basic issue of under-measurement and limitations in the collection of accurate 24-hour recall data, in particular less desirable foods high in fat or sugar(56). Comparison of self-reported intakes in NDNS with measured energy expenditure provides clear evidence of under-reporting of energy intake, highlighted in past papers suggested that there is a secular trend towards greater under-reporting(57, 58). A similar analysis has not been performed on the present NDNS data as it represents only the first year in a rolling programme. Further measures of energy expenditure using doubly-labelled water have been conducted in year 3, but have yet been reported. However, preliminary suggestions are that under-reporting is of similar magnitude in the recent survey as that reported in an earlier paper(58). This would mean that our measurement of trends for SSB intake and other sugary or high caloric beverages might actually be understated(58–62).

In addition, there are gaps in measurement of selected beverages—an issue that also exists in US diet and expenditure data. We compared the patterns with the British Soft Drinks Association (BSDA) data. Sports and energy drinks do not appear to be captured in these surveys. In a related report by the BSDA, they show a marked increase in consumption of energy drinks to about 8.3 liters/person/year(45). We also could not find any category for flavored waters, many of which are sweetened. Moreover, the NSF and ESF are based on one-week and two-week food and beverage expenditure diaries, which do not fully capture the consumption patterns of households over the course of the year and are simply snap-shots. As such, consumption of some of these beverages may seem lower that estimates from propriety data (e.g., The Nielson Company, IRI) that track household purchases over longer periods of time and across seasons. The same is true, of course, for the dietary intake measures. There would be great potential for UK scholars to utilize the TNS Kantar sales and purchase data or the Nielsen data for the UK to study tax issues as has been done in the US [44]. As with the publicly available dietary intake data, these data provide benefits in sample size and precise prices but lack representativeness, and suffer from other data collection issues [63–65].

In summary, this is a comprehensive study of trends in overall beverage intake patterns in Britain. We utilize sophisticated methods to ensure comparability of trends between all surveys. A marked decline in intake of dairy beverages with a shift toward sweetened milk is one major finding. A second is the increase in consumption of all sugar-sweetened beverages across all age groups along with high alcohol intake among British adults. Modeling suggests that higher prices for high-fat milk and SSBs are associated with reduction in their purchase while increasing purchases of healthier beverages (e.g., reduced fat milk).

Acknowledgments

Funding for this research is from the University of North Carolina and the Medical Research Council, UK. Our thanks to Ms. Ashley Olson from MRC-Human Nutrition Research for her help in guiding our efforts to create a bootstrapped sample for comparisons of the dietary data over the various years. Also, thanks to Phil Bardsley and Rick O'Hara for programming assistance, Tom Swasey for graphic assistance, and France Dancy for administrative assistance. B.M.P., S.A.J. and C.N.M. provided the idea for the analysis; S.W.N., conducted the analysis; and S.W.N., S.A.J., C.N.M. and B.M.P wrote the paper. All authors were responsible for reviews and approval of the manuscript.

REFERENCES

1. NHSI Center. , editor. NHS. Health Survey for England - 2009 trend tables. Joint Health Surveys Unit; 2010.
2. WHO. Obesity: Preventing and Managing the Global Epidemic. Geneva: World Health Organization; 2000.
3. WHO/FAO. Expert Consultation on Diet, Nutrition and the Prevention of Chronic DiseasesReport of the joint WHO/FAO expert consultation. Geneva: World Health Organization; 2003.
4. Kopelman P. Symposium 1: Overnutrition: consequences and solutions Foresight Report: the obesity challenge ahead. Proc Nutr Soc. 2009:1–6.
5. World Health Organization. Diet, nutrition, and the prevention of chronic diseases. WHO Technical Report Series. Geneva: World Health Organization; 2003. 2003.
6. World Health Organization. World Health Organization. Resolution WHA57.17. Global strategy on diet, physical activity and health. Geneva: World Health Organization; 2003. 22 May 2004.
7. Mattes R. Dietary compensation by humans for supplemental energy provided as ethanol or carbohydrate in fluids. Physiology & Behavior. 1996; 59:179–187. [PubMed: 8848479]
8. DiMeglio DP, Mattes RD. Liquid versus solid carbohydrate: effects on food intake and body weight. Int J Obes Relat Metab Disord. 2000; 24:794–800. [PubMed: 10878689]
9. Mourao D, Bressan J, Campbell W. Effects of food form on appetite and energy intake in lean and obese young adults. Int J Obes (Lond). 2007; 31:1688–1695. [PubMed: 17579632]
10. Bray GA. How bad is fructose? Am J Clin Nutr. 2007; 86:895–896. [PubMed: 17921361]
11. Brown CM, Dulloo AG, Yepuri G. Fructose ingestion acutely elevates blood pressure in healthy young humans. Am J Physiol Regul Integr Comp Physiol. 2008; 294:R730–R737. [PubMed: 18199590]
12. Choi HK, Curhan G. Soft drinks, fructose consumption, and the risk of gout in men: prospective cohort study. Bmj. 2008; 336:309–312. [PubMed: 18244959]

13. Stanhope KL, Havel PJ. Endocrine and metabolic effects of consuming beverages sweetened with fructose, glucose, sucrose, or high-fructose corn syrup. Am J Clin Nutr. 2008; 88:1733S–1737S. [PubMed: 19064538]
14. Stanhope KL, Schwarz JM, Keim NL. Consuming fructose-sweetened, not glucose-sweetened, beverages increases visceral adiposity and lipids and decreases insulin sensitivity in overweight/obese humans. J Clin Invest. 2009; 119:1322–1334. [PubMed: 19381015]
15. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. Am J Clin Nutr. 2006; 84:274–288. [PubMed: 16895873]
16. Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. Am J Public Health. 2007; 97:667–675. [PubMed: 17329656]
17. Johnson L, Mander AP, Jones LR. Is sugar-sweetened beverage consumption associated with increased fatness in children? Nutrition. 2007; 23:557–563. [PubMed: 17616342]
18. Mueller NT, Odegaard A, Anderson K. Soft Drink and Juice Consumption and Risk of Pancreatic Cancer: The Singapore Chinese Health Study. Cancer Epidemiology Biomarkers & Prevention. 2010; 19:447–455.
19. Sanigorski AM, Bell AC, Swinburn BA. Association of key foods and beverages with obesity in Australian schoolchildren. Public Health Nutr. 2007; 10:152–157. [PubMed: 17261224]
20. Bazzano LA, Li TY, Joshipura KJ. Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. Diabetes Care. 2008; 31:1311–1317. [PubMed: 18390796]
21. Flood-Obbagy JE, Rolls BJ. The effect of fruit in different forms on energy intake and satiety at a meal. Appetite. 2009; 52:416–422. [PubMed: 19110020]
22. Odegaard AO, Koh W-P, Arakawa K. Soft Drink and Juice Consumption and Risk of Physician-diagnosed Incident Type 2 Diabetes. American Journal of Epidemiology. 2010; 171:701–708. [PubMed: 20160170]
23. Daniels MC, Popkin BM. Impact of water intake on energy intake and weight status: a systematic review. Nutrition Reviews. 2010; 68:505–521. [PubMed: 20796216]
24. Popkin BM, D'Anci KE, Rosenberg IH. Water, hydration, and health. Nutrition Reviews. 2010; 68:439–458. [PubMed: 20646222]
25. Popkin BM. Patterns of beverage use across the lifecycle. Physiology & Behavior. 2010; 100:4–9. [PubMed: 20045423]
26. Duffey K, Gordon-Larsen P, Jacobs DR. 20-year beverage intake, obesity & diabetes: The CARDIA Study. NAASO Obesity Society Annual Meeting. Obesity. 2007; 15:A 36.
27. Barquera S, Campirano F, Bonvecchio A. Caloric beverage consumption patterns in Mexican children. Nutrition Journal. 2010; 9:47. [PubMed: 20964842]
28. Rivera JA, Muñoz-Hernández O, Rosas-Peralta M. Consumo de bebidas para una vida saludable: recomendaciones para la población (Beverage consumption for a healthy life: recommendations for the Mexican population). Salud Publica Mexico. 2008; 50:173–195.
29. Brownell KD, Farley T, Willett WC. The Public Health and Economic Benefits of Taxing Sugar-Sweetened Beverages. New England Journal of Medicine. 2009; 361:1599–1605. [PubMed: 19759377]
30. Brownell KD, Frieden TR. Ounces of Prevention - The Public Policy Case for Taxes on Sugared Beverages. New England Journal of Medicine. 2009; 360:1805–1808. [PubMed: 19357400]
31. Tiffin R, Arnoult M. The public health impacts of a fat tax. Eur J Clin Nutr. 2011
32. Mytton O, Gray A, Rayner M. Could targeted food taxes improve health? Journal of Epidemiology and Community Health. 2007; 61:689–694. [PubMed: 17630367]
33. Nnoaham KE, Sacks G, Rayner M. Modelling income group differences in the health and economic impacts of targeted food taxes and subsidies. International Journal of Epidemiology. 2009; 38:1324–1333. [PubMed: 19483200]
34. Food Standards Agency, Department of Health. National Diet and Nutrition Survey: Headline results from Year 1 of the Rolling Programme (2008/2009). London: 2010.
35. Office of National Statistics Living Costs and Food Survey. online [cited; Available from: http://www.statistics.gov.uk/ssd/surveys/expenditure_food_survey.asp

36. Timmer, CP.; Falcon, WP.; Pearson, SR. Food policy analysis. Baltimore: The Johns Hopkins University Press for the World Bank; 1984. pp. editor^editors].
37. Haines P, Guilkey D, Popkin B. Modelling food group decisions as a two-step process. J Agri Econ. 1988; 70:543–552.
38. Stata Corporation. Stata, Release 11. College Station: Stata Corporation; 2009.
39. Duffey, K.; Huybrecht, I.; Mouratidou, T.; Kersting, M.; DeVriendt, T.; Gottrand, F.; Widhalm, K.; Dallongeville, J.; Hallström, L.; González-Gross, MM.; DeHenauw, S. Moreno, Luis, Popkin, Barry on behalf of the HELENA Study group(2010). Beverage consumption among European adolescents in the HELENA Study. Beverage consumption among European adolescents in the HELENA Study; 2010.
40. Popkin BM. Patterns of beverage use across the lifecycle. Physiol Behav. 2010; 100:4–9. [PubMed: 20045423]
41. Barquera S, Hernández L, Tolentino ML. Energy from beverages is on the rise among Mexican adolescents and adults. J Nutr. 2008; 138:2454–2461. [PubMed: 19022972]
42. Duffey KJ, Gordon-Larsen P, Shikany JM. Food Price and Diet and Health Outcomes: 20 Years of the CARDIA Study. Arch Intern Med. 2010; 170:420–426. [PubMed: 20212177]
43. Andreyeva T, Long MW, Brownell KD. The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food. Am J Public Health. 2009; 100:216–222. [PubMed: 20019319]
44. Finkelstein EA, Zhen C, Nonnemaker J. Impact of Targeted Beverage Taxes on Higher- and Lower-Income Households. Arch Intern Med. 2010; 170:2028–2034. [PubMed: 21149762]
45. British Soft Drink Association. Trusted Innovation: The 2009 UK Soft Drinks Report. London: BSDA; 2009.
46. Gallet CA. The demand for alcohol: a meta-analysis of elasticities*. Australian Journal of Agricultural and Resource Economics. 2007; 51:121–135.
47. Marinos, Gibney Michael JE.; Ljunggvist, Olle; Dowsett, Julie, editors. Clinical Nutrition (The Nutrition Society Textbook). London: Wiley-Blackwell; 2005.
48. Purshouse RC, Meier PS, Brennan A. Estimated effect of alcohol pricing policies on health and health economic outcomes in England: an epidemiological model. The Lancet. 2010; 375:1355–1364.
49. Liang L, Chaloupka F, Nichter M. Prices, policies and youth smoking, May 2001. Addiction. 2003; 98:105–122. [PubMed: 12752364]
50. Ranson MK, Jha P, Chaloupka FJ. Global and regional estimates of the effectiveness and cost-effectiveness of price increases and other tobacco control policies. Nicotine Tob Res. 2002; 4:311–319. [PubMed: 12215240]
51. Warner, KE. Tobacco Policy in the United States: Lessons for the Obesity Epidemic. In: Mechani, D.; Rogut, LB.; Colby, DC., editors. Policy Challenges in Modern Health Care. New Brunswick, NJ: Rutgers University Press; 2005. p. 99-114.
52. Popkin BM. Agricultural policies, food and public health. EMBO Rep. 2011; 12:11–18. [PubMed: 21151043]
53. Muller, M.; Schoonover, H.; Wallinga, D. Considering the Contribution of US Food and Agricultural Policy to the Obesity Epidemic: Overview and Opportunities. Minneapolis, Minnesota: 2007.
54. Herman DR, Harrison GG, Afifi AA. Effect of a targeted subsidy on intake of fruits and vegetables among low-income women in the special supplemental nutrition program for women, infants, and children. American Journal of Public Health. 2008; 98:98–105. [PubMed: 18048803]
55. Kamerow D. Yankee Doodling The case of the sugar sweetened beverage tax. British Medical Journal. 2010; 341 -.
56. Heitmann BL, Lissner L, Osler M. Do we eat less fat, or just report so? Int J Obes Relat Metab Disord. 2000; 24:435–442. [PubMed: 10805500]
57. Rennie KL, Coward A, Jebb SA. Estimating under-reporting of energy intake in dietary surveys using an individualised method. British Journal of Nutrition. 2007; 97:1169–1176. [PubMed: 17433123]

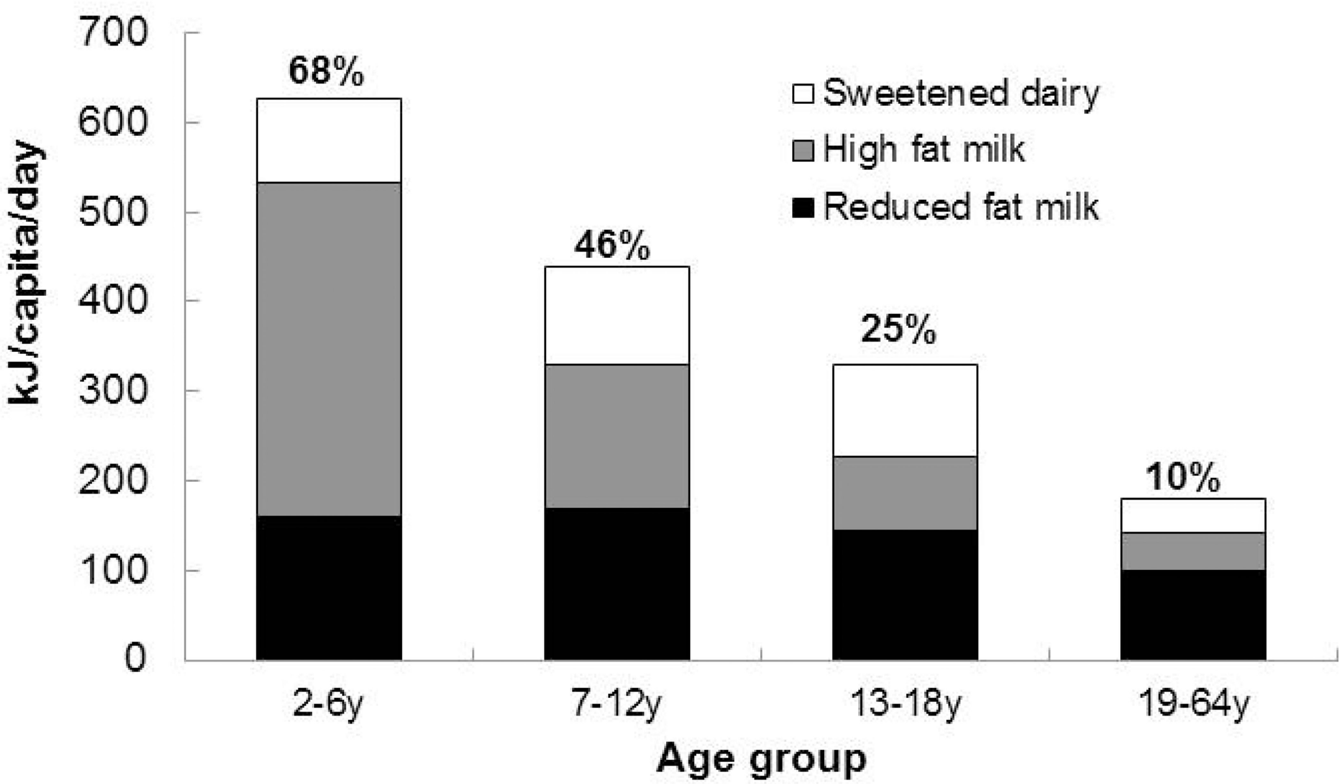
NIH-PA Author Manuscript

NIH-PA Author Manuscript

58. Rennie KL, Jebb SA, Wright A. Secular trends in under-reporting in young people. British Journal of Nutrition. 2005; 93:241–247. [PubMed: 15788117]
59. Black AE, Goldberg GR, Jebb SA. Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. Eur J Clin Nutr. 1991; 45:583–599. [PubMed: 1810720]
60. Erinosho TO, Thompson OM, Moser RP. Fruit and Vegetable Intake of US Adults: Comparing Intake by Mode of Survey Administration. Journal of the American Dietetic Association. 2011; 111:408–413. [PubMed: 21338740]
61. Wilks DC, Mander AP, Jebb SA. Dietary energy density and adiposity: employing bias adjustments in a meta-analysis of prospective studies. BMC Public Health. 2011; 11:48. [PubMed: 21255448]
62. Lissner L, Heitmann BL, Lindroos AK. Measuring intake in free-living human subjects: a question of bias. Proceedings of the Nutrition Society. 1998; 57:333–339. [PubMed: 9656337]
63. Einav, L.; Leibtag, E.; Nevo, A. On the Accuracy of Nielsen Homescan Data. Washington, DC: USDA; 2008.
64. Einav L, Leibtag E, Nevo A. Recording discrepancies in Nielsen Homescan data: Are they present and do they matter? Quantitative Marketing and Economics. 2010; 8:207–239.
65. Zhen C, Taylor JL, Muth MK. Understanding Differences in Self-Reported Expenditures between Household Scanner Data and Diary Survey Data: A Comparison of Homescan and Consumer Expenditure Survey. Review of Agricultural Economics. 2009; 31:470–492.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

1a



Note: Nationally weighted to be representative; Percentage reflect the contributing source of calories from all beverages

Source: National Diet and Nutrition Survey Rolling Programme, 2008-2009 (N=995), 4-day diet recall

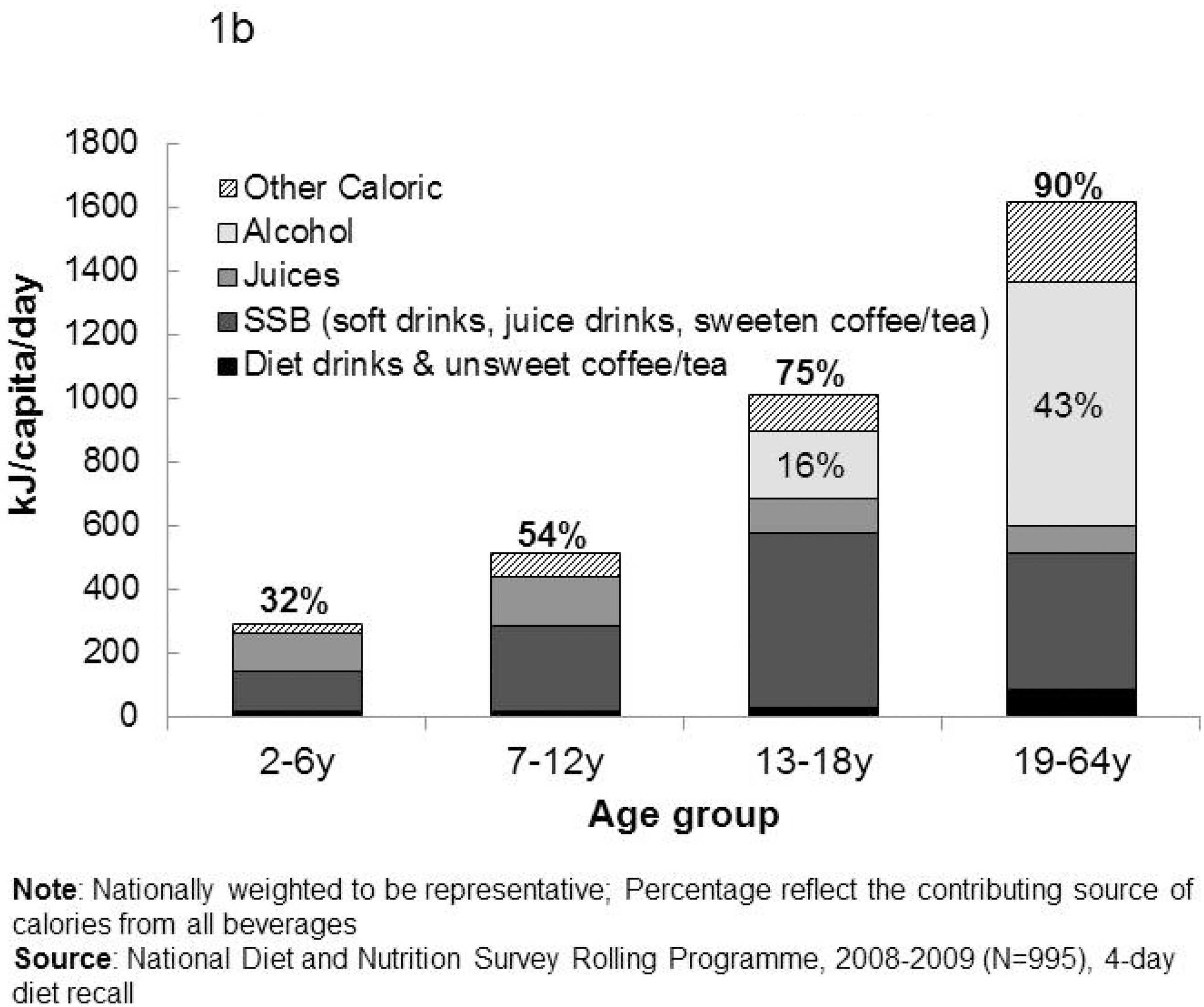
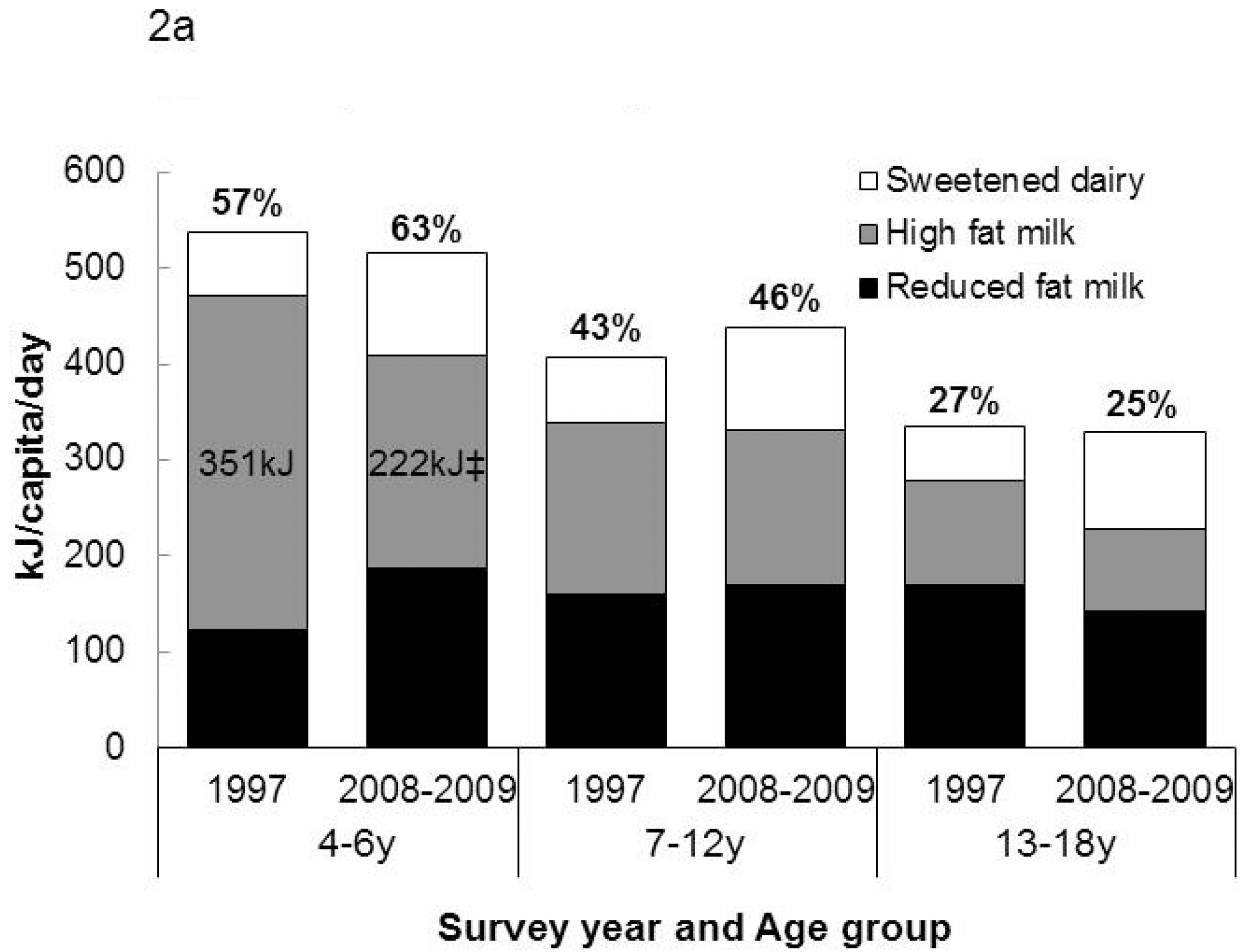


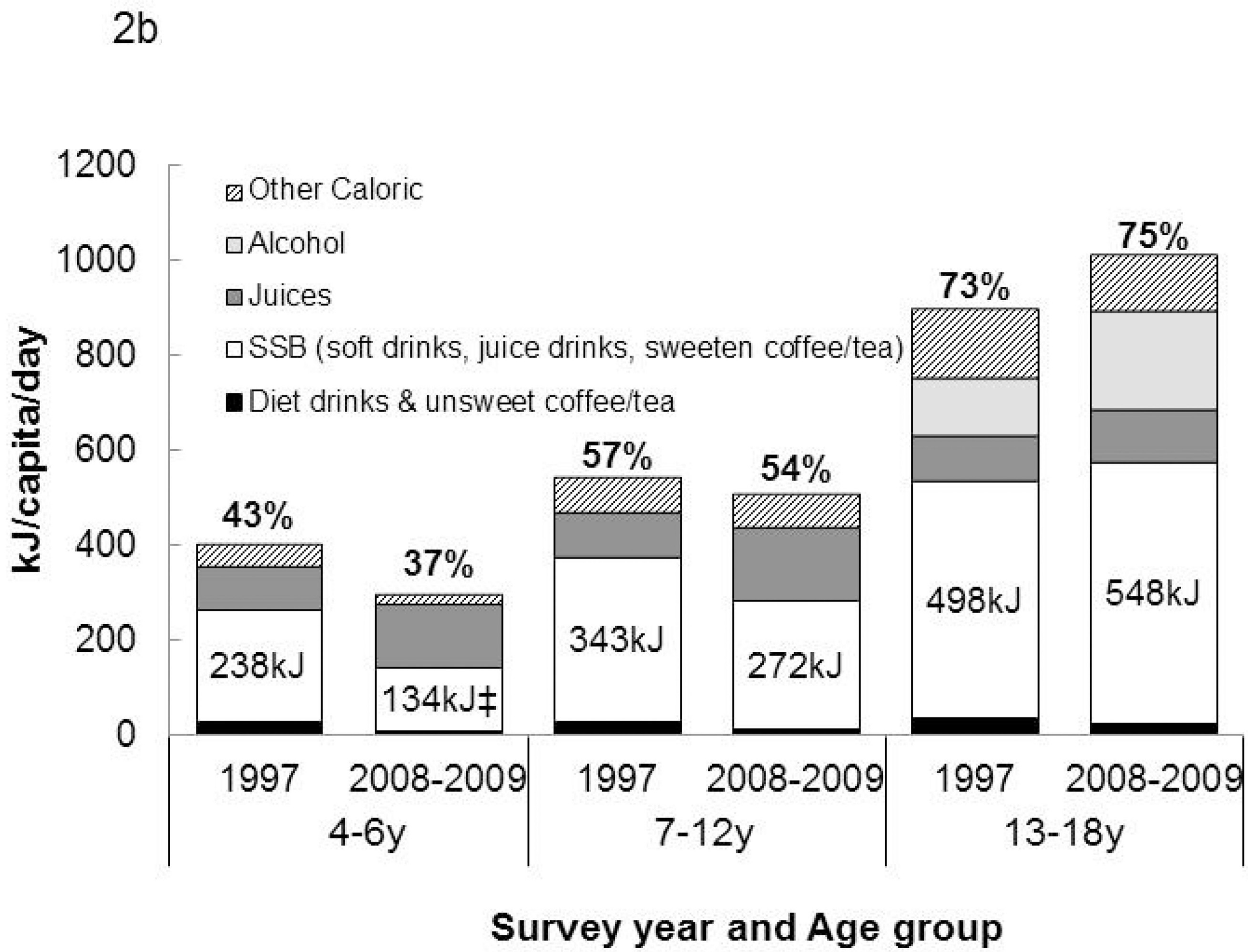
Figure 1.

a. Daily per Capita Dairy Beverage Consumption in the UK in 2008–2009, by Age Groups

b. Daily per Capita Non-Dairy Caloric Beverage Consumption in the UK in 2008–2009, by Age Groups



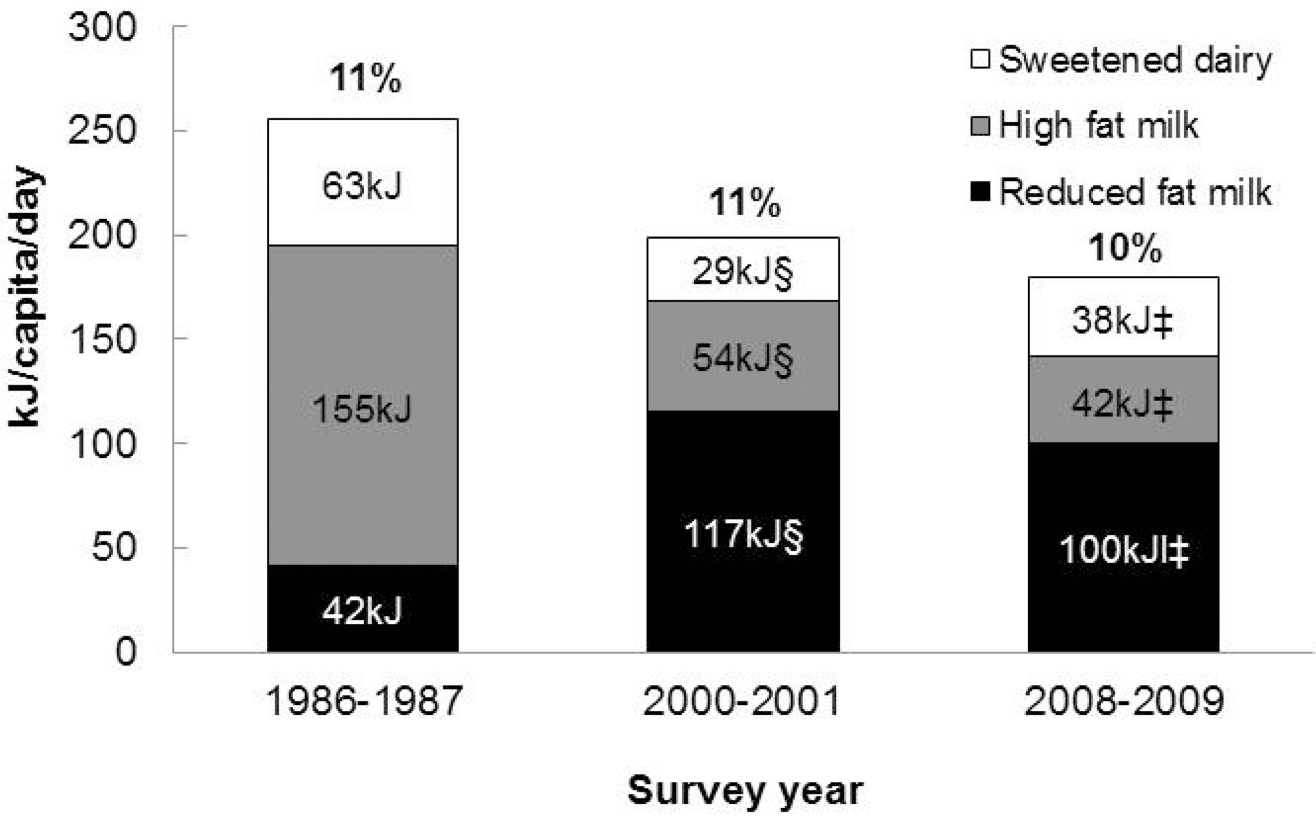
Note: Nationally weighted to be representative where weights were available;
‡ statistically significant difference between 1997 and 2008-2009 ($p<0.01$)
Sources: National Diet and Nutrition Survey of Young People (4-18y), 1997 (N=1798), 7-day recall bootstrap sampled to 4-day diet recall National Diet and Nutrition Survey Rolling Programme, 2008-2009 (N=462), 4-day diet recall



Note: Nationally weighted to be representative where weights were available;
‡ Statistically significant difference between 1997 and 2008-2009 (P<0.01)
Sources: National Diet and Nutrition Survey of Young People (4-18y), 1997 (N=1798), 7-day recall bootstrap sampled to 4-day diet recall National Diet and Nutrition Survey Rolling Programme, 2008-2009 (N=462), 4-day diet recall

Figure 2.
a. Daily per Capita Dairy Beverage Consumption in the UK Among Children 4–18y, 1997 vs. 2008–2009
b. Daily per Capita Dairy Beverage Consumption in the UK Among Children 4–18y, 1997 vs. 2008–2009

3a



Note: Nationally weighted to be representative where weights were available; Percentage reflect the contributing source of calories from all beverages.

‡ statistically significant difference between 1986-1987 and 2008-2009 (p<0.01);

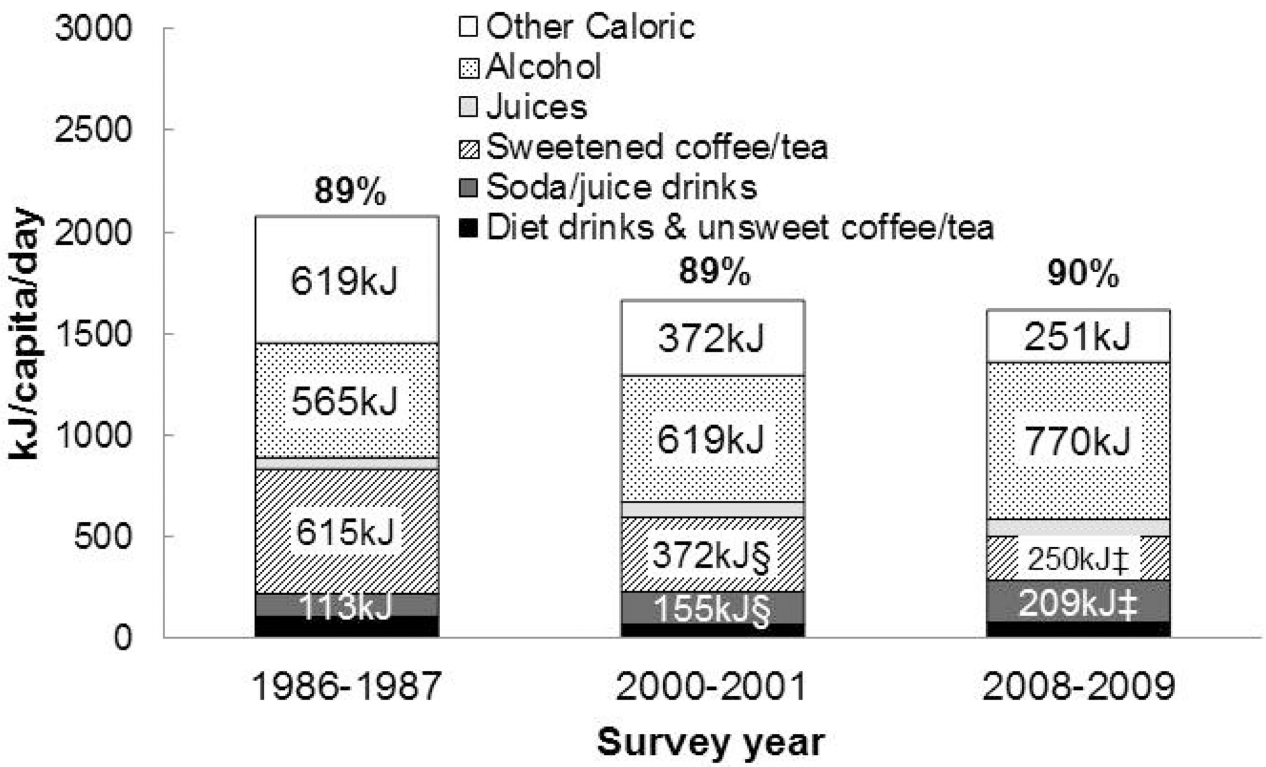
§ statistically significant difference between 2000-2001 and 2008-2009 (p<0.01)

Sources: Dietary and Nutritional Survey of British Adults, 1986-1987 (N=2030), 7-day diet recall bootstrap sampled to only use 4-day diet recall

National Diet and Nutrition Survey, 2000-2001 (N=1724), 7-day diet recall bootstrap sampled to only use 4-day diet recall

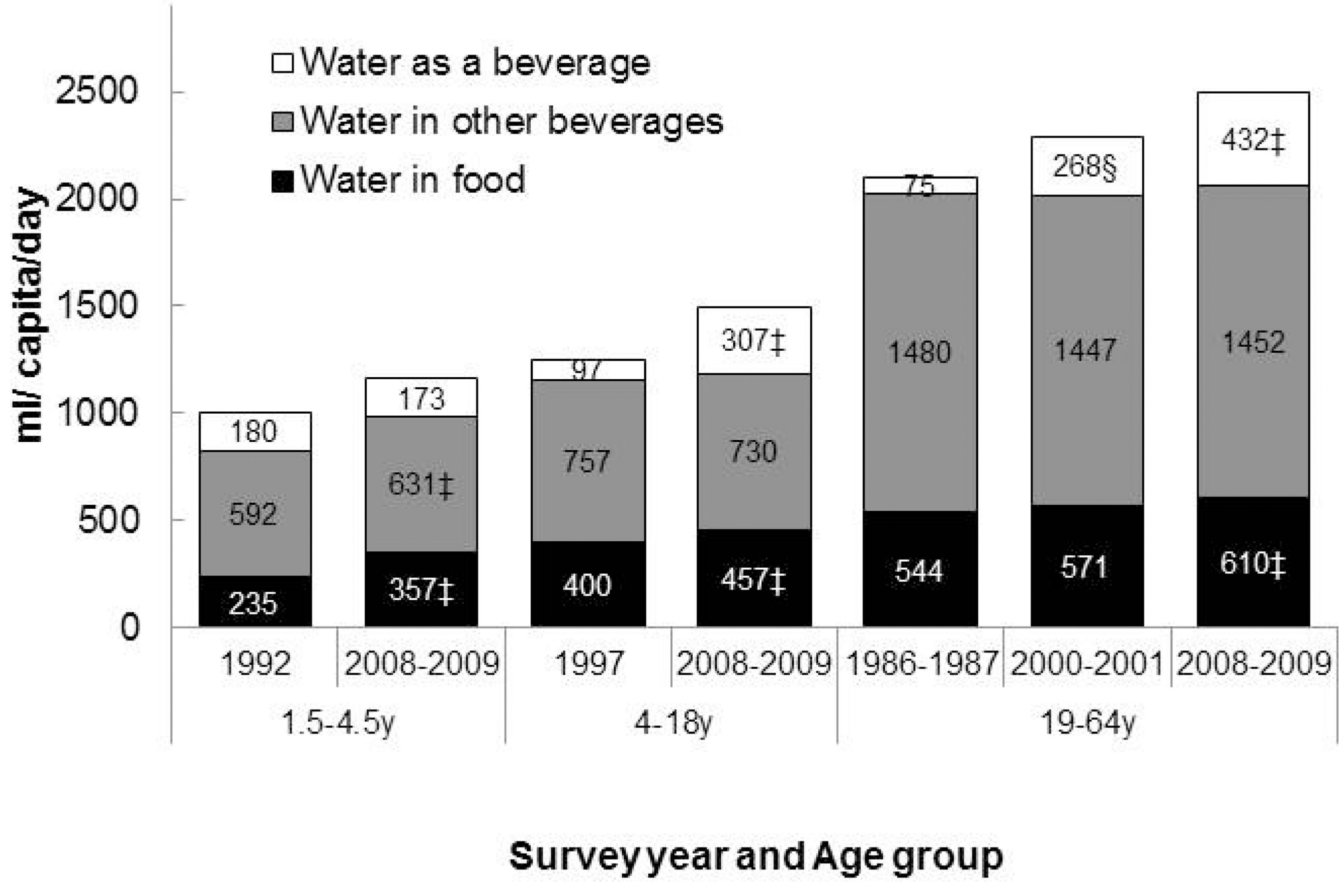
National Diet and Nutrition Survey Rolling Programme, 2008-2009 (N=434), 4-day diet recall

3b



Note: Nationally weighted to be representative where weights were available; Percentage reflect the contributing source of calories from all beverages
‡ statistically significant difference between 1986-1987 and 2008-2009 ($p<0.01$);
§ statistically significant difference between 2000-2001 and 2008-2009 ($p<0.01$)
Sources: Dietary and Nutritional Survey of British Adults, 1986-1987 (N=2030), 7-day diet recall bootstrap sampled to only use 4-day diet recall
National Diet and Nutrition Survey, 2000-2001 (N=1724), 7-day diet recall bootstrap sampled to only use 4-day diet recall
National Diet and Nutrition Survey Rolling Programme, 2008-2009 (N=434), 4-day diet recall

Figure 3.
a. Trends In Daily per Capita Dairy Beverage Consumption Among Adults (19–64y) in the UK, 1986–1987, 2000–2001, 2008–2009
b. Trends In Daily per Capita Non-Dairy Caloric Beverage Consumption Among Adults (19–64y) in The UK, 1986–1987, 2000–2001, 2008–2009



Note: Nationally weighted to be representative where weights were available.

‡ Statistically significant difference between earliest year and 2008-2009 ($p<0.01$)

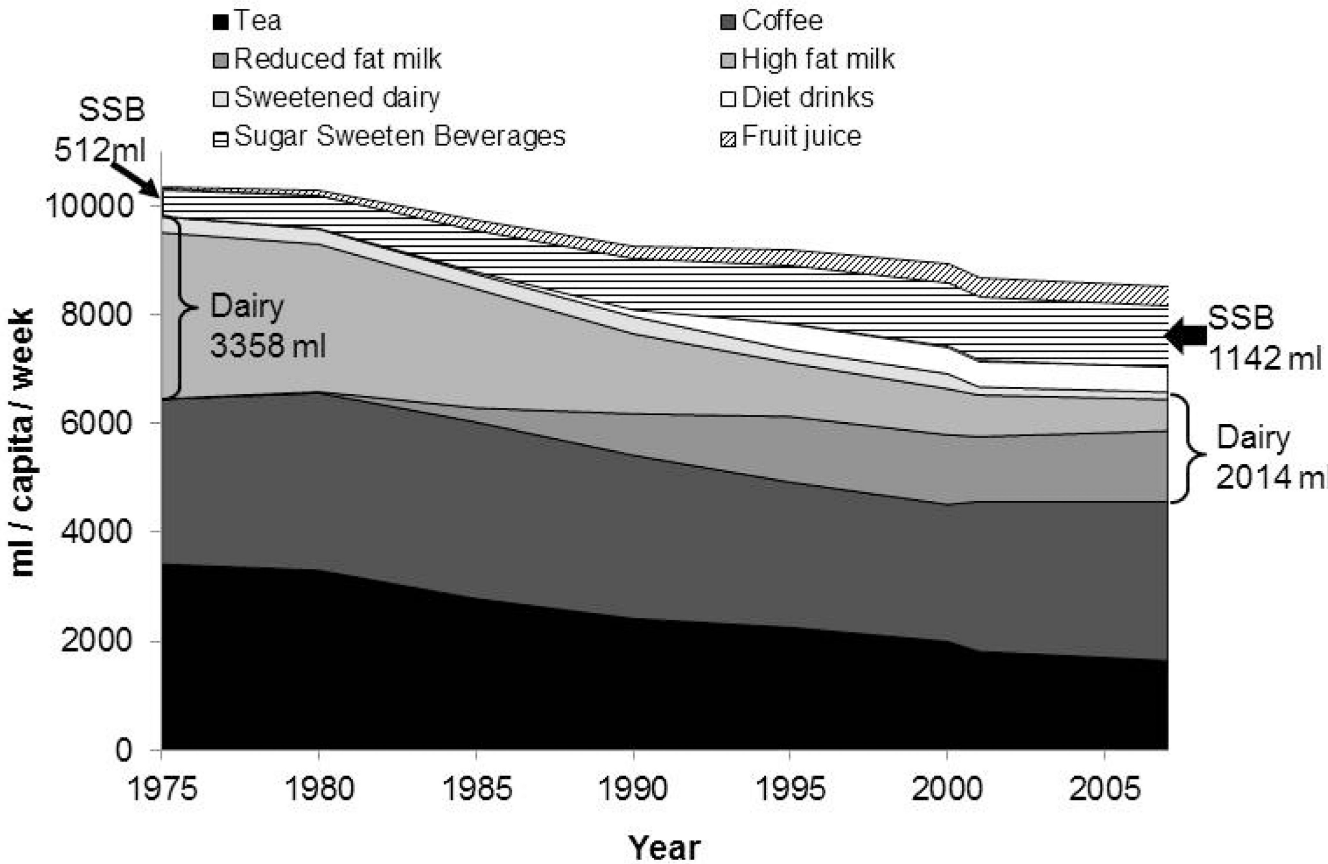
§ Statistically significant difference between 1986-1987 and 2000-2001 ($p<0.01$)

Sources: National Diet and Nutrition Survey of Young People (4-18y), 1997 (N=1798), 7-day recall bootstrap sampled to 4-day diet recall

National Diet and Nutrition Survey Rolling Programme, 2008-2009 (N=462), 4-day diet recall

Figure 4.

Daily per Capita Water Consumption in the UK in 2008–2009, by Age Groups



Source: UK household expenditures and consumption from the 1975-2000 Family Expenditures Survey and the 2001-7 Expenditure and Food Survey

Figure 5.

UK Beverage Groups Trends (milliliter purchased per person per week), 1975–2007

Table 1

Beverage categories from Great Britain dietary intake data sources

Beverage group used	Definition used and examples
High-fat milk	> 2% milk fat Whole milk, "UHT" or sterilized liquid milk, Condensed milk, evaporated milk, infant milks, powdered milks, non-skimmed milks, cream
Reduced-fat milk	≤ 2% milk fat Skimmed milk, fully skimmed milk, semi and other skimmed milk, almond, soy, rice, hemp and other milks
Sweetened Dairy	Dairy beverages with added sugars Yogurt drinks, pro-biotics, milkshakes, cocoa with milk, Horlicks, Ovaltine
Alcohol	Any alcoholic content
Spirits/Liquers	Spirits, Liqueurs
Wines	Wine, Fortified wines
Beer/cider/alcopop	Low alcohol beers, lagers and ciders, Beers, Lager and continental beers, Ciders and perries, Alco-Pops
Soda & Fruit Drinks w/ sugar	Sugar sweetened soft drinks and fruit drinks (<100% juice) Regular soft drinks, fruit flavored drinks, nectars, Ribena
Low-nutritive "diet" sweetened drinks	Diet or low-calorie substitute sweetened drinks Low calorie soft drinks, low calorie fruit drinks, diet-sweetened tea/coffee drinks
Juices	100% juice Fruit juice, vegetable juice
Unsweetened coffee/tea	Coffee or tea consumed without any added sweeteners or dairy
Sweetened coffee	Coffee consumed with added sweeteners (low-caloric, diet, artificial or regular) or dairy
Sweetened tea	Tea consumed with added sweeteners (low-caloric, diet, artificial or regular) or dairy
Other caloric	Other caloric drinks not included above Cacao power, drinking chocolate and instant chocolate drinks consumed without dairy
Water as a beverage	0 calorie waters Tap water (filtered or unfiltered), bottled water, mineral water

Dietary data used: Dietary and Nutritional Survey of British Adults, 1986–1987
1992 National, Diet, Nutrition and Dental Survey of Children (1.5–4.5y)
1997 NDNS of Young People (4–18y)
2000/01 National Diet and Nutrition Survey (NDNS) of Adults (19–64y)
2008/09 NDNS Rolling Programme of adults and children (≥1.5y)

Table 2

The effects of a 10% and 20% price increase on the number of ml of weekly purchases of beverages per capita

2A. 2001 (7,411 households)	**10% price increase**			**20% price increase**		
	With Income Support	**Without Income Support**	**Average UK Household**	**With Income Support**	**Without Income Support**	**Average UK Household**
Coffee	−54*	−42*	−43*	−107*	−86*	−89*
Tea	−241*	−61*	−84*	−458*	−121*	−162*
Reduced-fat milk	−53*	−43*	−45*	−106*	−84*	−88*
High-fat milk	−80*	−41*	−46*	−151*	−79*	−89*
Low-nutritive “diet” sweetened beverages	−46	−26	−28	−86	−50	−53
Sugar-sweetened beverages	−72*	−47*	−50*	−137*	−92*	−98*
Fruit juice	−24	−13	−14	−46	−25	−28
% of 2001 households	12%	88%	100%	12%	88%	100%

2B. 2007 † (6,071 households)	**10% price increase**			**20% price increase**		
	With Income Support	Without Income Support	Average UK Household	With Income Support	Without Income Support	Average UK Household
Coffee	−33	−30	−30	−65	−59	−60
Tea	−61*	−48*	−49*	−121*	−94*	−95*
Reduced-fat milk	−68*	−72*	−72*	−132*	−140*	−140*
High-fat milk	−41*	−35*	−35*	−78*	−68*	−69*
Low-nutritive “diet” sweetened beverages	−22	−23	−22	−42	−44	−44
Sugar-sweetened beverages	−62*	−53*	−53*	−121*	−103*	−104*
Fruit juice	−12	−19*	−19*	−23*	−37*	−36*
% of 2007 households	6%	94%	100%	6%	94%	100%

Source: The UKDA National Food Surveys 2001 and 2007.

Note: Results are weighted to be nationally representative and are in terms of ml/capita/week.
These point elasticities are based on a two-part model that first estimates the effects of prices while controlling for key socio-demographic measures. These include: family income, whether a person in the household has full-time employment, the highest education of members of the household, the total household size, the number of adult males and females and children in the household, the price per 100 grams of each beverage. Prices of other beverages are included in each model. The sample is stratified by whether the household had income support or not.

* denote statistical significance at the 5% level ($p<0.05$);

NIH-PA Author Manuscript
NIH-PA Author Manuscript

† In 2007, the sample of households with income support was very small (< 6%).

Table 3

The effects of a 10% and 20% price increase of select beverages on the per capita weekly purchases of other beverages for 2007†

	Change in per capita weekly purchases (in ml)				
	Reduced-fat milk	**High-fat milk**	**Low-nutritive "diet" sweetened**	**SSBs**	**Fruit juice**
10% increase in price of					
Reduced-fat milk	− 72*	15*	− 25*	−2	5
High-fat milk	48*	−35*	7	−5	5
Low-nutritive "diet" sweetened drinks	− 9	−1	− 22	11	−1
Sugar-sweetened beverages	−4	0	3	−53*	0
Fruit juice	−1	1	− 4*	−7	− 19*
20% increase in price of					
Reduced-fat milk	−140*	31*	−49*	−4	10
High-fat milk	96*	−69*	15	−10	11
Low-nutritive "diet" sweetened drinks	−18	−1	−44	23	−2
Sugar-sweetened beverages	−9	0	6	−104*	1
Fruit juice	−2	2	−9*	−14	−36*

Source: The UKDA National Food Survey 2007.

Note: Results are weighted to be nationally representative.
These point elasticities are based on a two-part model that first estimates the effects of prices while controlling for key socio-demographic measures. These include: family income, whether a person in the household has full-time employment, the highest education of members of the household, the total household size, the number of adult males and females and children in the household, the price per 100 grams of each beverage. Prices of other beverages are included in each model.

*denote statistical significance at the 5% level ($p<0.05$).

†In 2007, the sample of households with income support was very small (< 6%).

Appendix 1

Beverage Group Categories for UKDA National Food Survey—food expenditures data

Name	Food Description	Unit
Water	Mineral Water	floz.
Coffee (unsweet or sweet)	Coffee, bean and grounded Coffee, instant Coffee, essences	oz. oz. floz.
Tea (unsweet or sweet)	Tea[1]	oz.
Milk, low-fat & skimmed (Low/Reduced-fat)	Skimmed milk Fully skimmed milk Semi and others skimmed milk Other milk, including skimmed	Impt.
Milk, high-fat & infant (Whole/High-fat)	Milk, liquid “UHT” liquid milk Sterilized milk, full price Other liquid milk Milk, condensed Milk, dried, national Infant milks Milk, instant Other milk, not skimmed Other milks Cream	Impt.
Chocolate, Horl micks, Ovaltine (Sweetened dairy)	Cocoa, drinking chocolate and instant chocolate Branded food drinks	oz. oz.
Low-nutritive/calorie (Diet sweetened)	Soft drinks, low calorie Soft drinks, low calorie, concentrated Soft drinks, low calorie, unconcentrated	floz.
Soda & Fruit Drinks w/ sugar (Sugar sweetened)	Soft drinks, concentrated Soft drinks, unconcentrated	floz.
Fruit Juice	Fruit juices[2]	floz.
Vegetable Juice	Vegetable juices	floz.
Alcohol	Low alcohol beers, lagers and ciders Beers Lager and continental beers Ciders and perry Wine Wine (not full strength) spirits with additions Fortified wines Spirits Liqueurs Alco-Pops	cl. cl. cl. cl. cl. cl. cl. cl. cl. ml.

[1]The lone “tea” code in the NFS data did not include instant tea or herbal tea, which were part of a “miscellaneous” code.

[2]The “fruit juices” code in the NFS data did not include juice concentrate, which was part of the “dried fruit” code.

Appendix 2

Mean "Diluent to Powder" Ratios from the 2000 UKDA Food Intake & Expenditures Data

This table shows basic descriptive statistics for diluent to powder ratios, which were calculated for various powders and concentrates using the 2000 UK Food Intake & Expenditure data. The median ratio was used to reconstitute the corresponding powder or concentrate in the National Food Survey (NFS) and the Expenditure and Food Survey where the dry weight of the powder or concentrate was reported.

NFS Data Powder/ Concentrate	Diluent	Powder/Concentrate	Diluent to Powder Ratio Med	Mean	Std	Min	Max
Instant Coffee[a]	Water and/or Milk	Instant coffee, Instant cappuccino, whitener, no sugar. Instant cappuccino, whitener, sugar, Instant coffee, decaffeinated	169	173	78	3	620
Tea[b]	Water	Instant tea, freeze dried, lemon. Instant tea, milk powder added	45	71	73	10	383
Diet Soft Drinks	Water	Fruit drink, etc., cont. blackcurrant, Barley water, diet, no blackcurrant, High juice drink, low sugar, Ribena light, low sugar, Ribena, no added sugar Fruit drink, etc., no blackcurrant Barley water, diet, cont. blackcurrant	5	6	5	0.3	42
Regular Soft Drinks	Water	Lime juice cordial, Fruit drink, squash, no blackcurrant, Super-concentrated crush, Ribena original, Cordial High juice drink, no blackcurrant High juice drink, cont. blackcurrant, Fruit drink, squash, cont. blackcurrant, Barley water High juice, red. sugar, no blackcurrant, Fruit drink, cont. blackcurrant	5[d]	6	7	0.3	155
Dairy & Chocolate Drinks	Water and/or Milk	Cocoa powder, Milk shake powder, Drinking chocolate, instant, Cadbury highlights, chocolate instant, Instant malted drinks	17	23	22	2	266
Branded Drinks	Water and/or Milk	Horlicks malted food drink, Ovaltine not ovaltine instant, Horlicks powder instant, Ovaltine instant low fat, Horlicks low fat instant, chocolate, Horlicks chocolate malted food drink, Bournvita not instant	12	18	27	3	287

[a]The ratios for both coffee beans and coffee essences could not be calculated, since their weights were reported in reconstituted form in the Food & Expenditure data. We used our own calculations: coffee beans =42 and coffee essences =4.

[b] The NFS code for tea only included tea bags. Since tea bags were reported in reconstituted form in the Food & Expenditure data, we calculated the ratios for instant tea= 45 and instant herbal tea=16. After consideration, we decided that the instant tea ratio was more comparable to tea bags.

[c] Milk as a diluent codes include: 602, 603, 604, 608, 610, 613, 616, 622, 694, 8543, 8544, 9132.

[d] We changed the ratio for soft drinks from 4 to 5 to match the 2008 "Family Food" report, table 1.1, footnote c.

Appendix 3

Descriptive statistics on beverage consumption in the Britain

Table A1. Daily Per Capita and Per Consumer Beverage consumption (kJ/day and ml/day) among children in Britain[*]

	Ages 1.5–4.5y[¤]						Ages 4–18y[¥]					
	1992			2008–2009			1997			2008–2009		
	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer
A. Energy Contribution (kJ/day)												
High fat milk	510	82%	623	565	69%[¤]	828	192	44%	439	138 [¥]	30% [¥]	464
Reduced fat milk	100	33%	301	138	42%	331	155	52%	301	159	58%	276
Sweetened dairy	130	90%	146	88	21%[¤]	406	63	21%	297	105 [¥]	30% [¥]	356
Alcohol	0	1%	21	0	0%	0	42	8%	544	92	8%	1100
Spirits/liqueurs	0	0%	0	0	0%	0	4	2%	247	25	3%	808
Wine	0	1%	21	0	0%	0	4	2%	192	4	3%	163
Beer/cider/alcopop	0	0%	21	0	0%	0	33	6%	611	63	6%	1038
Sodas/fruit drinks	280	86%	326	88[¤]	52%[¤]	172	285	81%	351	318	79%	402
Low-nutritive “diet” sweetened drinks	13	49%	25	13	61%	17	21	72%	33	13[¥]	59% [¥]	21
Juices	67	39%	176	109	58%[¤]	188	92	44%	213	130 [¥]	53%	247
Unsweetened coffee/tea	4	18%	29	4	17%	21	8	17%	54	4	15%	38
Sweetened coffee	8	6%	163	0	0%	172	25	11%	218	13	7%	172
Sweetened tea	79	30%	264	21[¤]	16%[¤]	121	67	31%	218	38	24%	159
Other Caloric	88	33%	268	38[¤]	21%	172	92	38%	247	79	39%	209
Total energy from beverages		285			249			228			250	
Total energy from all sources		1137			1173			1725			1759	
% of total energy from beverages		25%			21%[¤]			13%			14%	
B. Volume Consumed (ml/day)												
B1. Water intake												
Water in food		235			357[¤]			400			457	
Water in beverages		771			804[¤]			854			1037	

Table A1. Daily Per Capita and Per Consumer Beverage consumption (kJ/day and ml/day) among children in Britain*

	Ages 1.5–4.5y[¤]						Ages 4–18y[¥]					
	1992			2008–2009			1997			2008–2009		
	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer
Water total from all sources		1007			1161			1254			1494	
B2. Beverage Pattern												
No Calories												
Water as a beverage	180	77%	235	173	74%	234	97	51%	189	307 [¥]	80% [¥]	383
Unsweetened coffee & tea	9	18%	51	12	17%	71	33	17%	198	26	15%	169
High Caloric												
High fat milk	180	82%	220	208	69%	303	69	44%	158	51	30% [¥]	171
Reduced fat milk	52	33%	157	79	42%	186	81	52%	158	87	58%	149
Sweetened dairy	42	90%	47	30[¤]	21%[¤]	140	20	21%	92	31	30% [¥]	104
Alcohol	0	1%	8	0	0%	0	28	8%	358	44	8%	522
Soda/fruit drinks	181	86%	211	79	52%[¤]	153	212	81%	264	230	79%	290
Low-Caloric												
Low-nutritive “diet” sweetened drinks	81	49%	165	185[¤]	61%	304	220	72%	307	170 [¥]	59% [¥]	289
Juices	48	39%	122	69	58%[¤]	118	63	44%	145	81	53% [¥]	154
Other caloric	62	33%	186	26	21%	124	86	38%	227	73	39%	187
Total ml of beverages	100%	835		100%	860[¤]		100%	909		100%	1099	
Number of obs		1689			141			1798			462	
Days of Intake[†]		7 adjusted to 4			4			7 adjusted to 4			4	

Table A2. Daily Per Capita and Per Consumer Beverage consumption (kJ/day and ml/day) among adults (19–64y) in the Britain*

	1986–1987			2000–2001[§]			2008–2009[‡, ◊]		
	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer
A. Energy Contribution (kJ/day)									
High fat milk	155	49%	314	54[§]	15%[§]	351	42[‡]	13%[‡]	331
Reduced fat milk	42	24%	172	117[§]	50%[§]	234	100[‡]	54%[‡]	184

Table A2. Daily Per Capita and Per Consumer Beverage consumption (kJ/day and ml/day) among adults (19–64y) in the Britain*

	1986–1987			2000–2001§			2008–2009$^{\ddagger,\diamond}$		
	Per capita	**% consume**	**Per consumer**	**Per capita**	**% consume**	**Per consumer**	**Per capita**	**% consume**	**Per consumer**
Sweetened dairy	63	16%	368	29§	12%	255	38	12%	310
Alcohol	565	62%	916	619	65%	925	770‡	64%	1205
Spirits/liqueurs	54	19%	272	59	17%	314	100	17%	573
Wine	121	32%	385	163	35%	456	205	36%	565
Beer/cider/alcopop	389	40%	975	397	42%	916	469	40%	1159
Sodas/fruit drinks	113	49%	226	155§	46%	335	209‡	54%$^{\diamond}$	381
Low-nutritive “diet” sweetened drinks	0	12%	8	8	36%§	25	8	35% ‡	17
Juices	54	34%	163	79	40%	192	84‡	41%	205
Unsweetened coffee/tea	109	69%	159	71§	59%§	121	7‡	68%$^{\diamond}$	109
Sweetened coffee	276	63%	435	209§	64%	326	105$^{\ddagger,\diamond}$	37%r$^{\ddagger,\diamond}$	289
Sweetened tea	339	60%	569	163§	39%§	414	117‡	40%‡	293
Other Caloric	619	84%	741	372§	81%	464	251$^{\ddagger,\diamond}$	65%$^{\ddagger,\diamond}$	385
Total energy from beverages		411			359			376	
Total energy from all sources		2064			1978			1950	
% of total energy from beverages		19%			18%			18%	
B. Volume Consumed (ml/day)									
B1. Water intake									
Water in food		544			571			610‡	
Water in beverages		1555			1715§			1884‡	
Water total from all sources		2099			2286§			2494‡	
B2. Beverage Pattern									
No Calories									
Water as a beverage	75	44%	169	268§	66%§	408	432 $^{\ddagger,\diamond}$	78% $^{\ddagger,\diamond}$	556
Unsweetened coffee & tea	440	69%	635	326§	59%	555	451 $^{\diamond}$	68%	664
High Caloric									
High fat milk	56	49%	116	20§	15%§	131	16 ‡	13% ‡	124

Table A2. Daily Per Capita and Per Consumer Beverage consumption (kJ/day and ml/day) among adults (19–64y) in the Britain[*]

	1986–1987			2000–2001[§]			2008–2009[‡, ◊]		
	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer	Per capita	% consume	Per consumer
Reduced fat milk	23	24%	98	65[§]	50%[§]	131	55 [‡]	54% [‡]	103
Sweetened dairy	24	16%	145	11[§]	12%	93	13 [‡]	12%	102
Alcohol	316	62%	511	336	66%	511	405	64%	635
Soda/fruit drinks	76	49%	154	108[§]	46%	236	139 [‡]	54%	256
Low-Caloric									
Low-nutritive “diet” sweetened drinks	17	12%	144	99[§]	36%[§]	272	102 [‡]	35% [‡]	290
Juices	37	34%	108	59[§]	40%	147	55	41%	133
Other caloric	572	84%	683	509	80%	633	301 [‡, ◊]	65% [‡, ◊]	460
Total ml of beverages	1637	100%	1637	1801[§]	100%	1801	1970 [‡]	100%	1970
Number of obs	2030			1724			434		
Days of Intake[†]	7 adjusted to 4			7 adjusted to 4			4		

Table A3. Great Britain Beverage Group Trends: ml purchased per household per week

	Beverage purchases by British households per week (ml)							
Beverage Category	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2001**	**2007**
High fat milk	3056	2711	2190	1469	982	847[‡,◊]	764	579[§,¥,¤]
Reduced fat milk	8	23	258	763	1207	1278[‡,◊]	1191	1301[§,¥,¤]
Sweetened dairy	294	279	271	316	246	275	149	134[¥,¤]
Alcohol	NA	NA	NA	NA	700	817	770	833
Sugar Sweetened (Soda/fruit drinks)	512	607	771	940	1082	1189[‡]	1195	1142[¥]
Low-nutritive “diet” sweetened drinks	5	12	40	134	468	483[‡,◊]	464	472[¥,¤]
Juices	47	105	177	231	284	342[‡,◊]	342	347[¥,¤]
100% fruit juice	46	104	175	229	282	340[‡]	337	340[¥,¤]
Vegetable juice	1	1	2	2	2	2	5	7[¥,¤]
Coffee	3029	3260	3247	3003	2669	2522	2758	2920
Tea	3417	3302	2782	2415	2253	1993[‡,◊]	1811	1644[¥,¤]

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table A3. Great Britain Beverage Group Trends: ml purchased per household per week

	Beverage purchases by British households per week (ml)							
Beverage Category	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2001**	**2007**
Water, Bottled	NA	NA	21	93	174	246[◊]	215	267[¤]
Sample size, No. of Households	7405	7914	7102	7174	8011	6590	7450	6102

[*] Nationally weighted to be representative where weights were available (weights applied to 1997 and 2008–2009 data).

[¤] 2008–2009 is statistically different (p<0.01) from 1992

[¥] 2008–2009 is statistically different (p<0.01) from 1997

Unable to determine statistical difference between years for per consumer consumption since the sample population that consume the beverage varies from beverage to beverage.

[†] 1992 and 1997 surveys have 7-day recalls, but adjusted by bootstrap sampling to allow comparisons with 2008–2009 on a 4-day basis

[*] Nationally weighted to be representative where weights were available (weights applied to adults 2000–2001 and 2008–2009).

[§] 2000–2001 is statistically different (p<0.01) from 1986–1987

[‡] 2008–2009 is statistically different (p<0.01) from 1986–1987

[◊] 2008–2009 is statistically different (p<0.01) from 2000–2001

Unable to determine statistical difference between years for per consumer consumption since the sample population that consume the beverage varies from beverage to beverage.

[†] 1986–1987 and 2000–2001 surveys have 7-day recalls, but adjusted by bootstrap sampling to allow comparisons with 2008–2009 on a 4-day basis

NA: not available. All results are weighted to be nationally representative.

[§] 2007 is statistically different (p<0.01) from 2001;

[¥] 2007 is statistically different (p<0.01) from 1975;

[¤] 2007 is statistically different (p<0.01) from 1990

[‡] 2000 is statistically different (p<0.01) from 1975;

[◊] 2000 is statistically different (p<0.01) from 1990

Source: British household expenditures and consumption from the 1975–2000 Family Expenditures Survey and the 2001–7 Expenditure and Food Survey.