Assessing how commercial data on food retail sales can be used to monitor industry-led changes in the food supply in the UK

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Abstract

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Introduction: A poor diet is one of the leading causes of morbidity and premature mortality around the world. National and international policymakers recognise that changing the food supply is a crucial part in changing the diets of a population, yet there are few established methods to monitor the actions of food manufacturers and retailers.

Aim: The overarching aim of this thesis was to develop and apply a new method pairing food sales data and nutrition composition data to allow the nature of the food supply to be quantified and monitored over time.

Method: A systematic review identified potential sources of food sales data. A cross-comparison data study, led to the selection of Euromonitor as the most appropriate source for food sales data with nutrition composition data collected from supermarket websites by commercial company Brand View. The sales data and nutrition information were paired based on product name, brand name and category. This unique method was then applied in two ways: first, by analysing the changes in the sugar content of selected food and drinks in the UK between 2015 and 2018 in the context of the UK Government's 20% sugar reduction targets and soft drinks industry levy (SDIL); and second by applying a nutrient profiling model to the top 10 UK companies' product portfolios, to develop a benchmarking tool based on the healthiness of companies' products.

Results: Analysis showed that the sales-weighted mean sugar content of soft drinks fell by 34% between 2015 and 2018, from 4.4g/100ml to 2.9g/100ml. The total volume of sugars sold from soft drinks decreased by 30%, from 15.5g per capita per day to 10.8g, a reduction of 4.7g. There was a much smaller decrease in the mean sugar content or sugar sales from food products included in the sugar reduction strategy. The total volume sales of sugar from the included categories fell by 8%, equating to 1.7g per capita per day with marked differences across food categories. However, there has been no significant change between 2015 and 2018 in the overall nutrient profiling score for the top 10 food and drink companies in the UK. In 2018, the sales-weighted mean score of all food and drinks was 65, below the score of 70 which can be considered 'healthy'. No individual company had an overall score of above 70. There was little change in the number of individual products classified as healthy, although the proportion of total sales classified as healthy increased from 38% to 46%.

Discussion: This thesis provides novel insights into how companies have responded to Government public health policies, including the sugar reduction programme. A new method has been developed in this thesis that has the potential to be used continually to monitor the nutritional composition of the food supply, to evaluate which companies are making efforts to improve public health nutrition and to monitor the pace of change.

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Table of Contents

List of tables and figures

List of abbreviations

ATNI: Access to Nutrition Initiative

BMI: Body mass index

BSDA: British Soft Drink Association

CHD: Coronary heart disease

CoFID: Composition of Food Integrated Dataset

CPNP: Centre on Population Approaches for NCD Prevention

FNV: Fruit, nuts and vegetables

FSA: Food Standards Agency

g: grams

HFSS: high fat, sugar and salt

HSE: Health Survey England

kcal: kilocalorie

LCF: Cost of Living and Food Survey

ml: millilitres

NCD: Non-communicable disease

NDNS: National Diet and Nutrition Survey

NGO: Non-governmental organisation

Ofcom: Office for Communication

PHE: Public Health England

PHRD: Public Health Responsibility Deal

RCT: Randomised Control Trial

SDIL: Soft Drink Industry Levy

SSB: Sugar-sweetened beverage

UK: United Kingdom

UN: United Nations

WHO: World Health Organization

Chapter 1: Introduction

A poor diet is one of the leading causes of morbidity and premature mortality around the world. National and international policymakers recognise that changing the food supply is a crucial step in changing the diets of the nation. However, most research to date has focussed on gross food production or on individual consumption, and there are few established methods to monitor the actions of food manufacturers and retailers who are crucial to the availability and promotion of foods. The aim of this thesis is to develop and apply a new method using food sales data combined with the nutritional composition of food and drinks to allow an individual company's contribution to the food supply in a country to be quantified and monitored.

This introductory chapter provides an overview of the burden of diet-related disease in the UK, the role the food industry plays in the food system, outlines the current policy tools available and the evolution of obesity policy, before introducing the main aims of this thesis.

Diet related disease globally and in the UK

More than 1.9 billion adults are overweight and obese, approximately two billion suffer from micronutrient deficiencies (including vitamins A, D and 12, iron, folate, calcium and zinc), while 462 million suffer from undernutrition (1). These three burdens often co-exist in the same household, affecting communities and populations globally. Malnutrition in all its forms can have serious consequences, including increased risk of disease and premature death. Diet-related diseases, including heart disease, diabetes, cancer and osteoporosis are the leading cause of mortality and morbidity globally, with a poor diet resulting in one in five of all deaths in 2016 and contributing to 255 million disability adjusted life years (2)(3).

In the UK, the majority of adults (64%) are overweight. The proportion of the UK adult population who are obese has risen by 80% in the last 24 years, from 16% in 1993 to 29% in 2017 (4). One third of children aged 10-11 are overweight or obese, with the prevalence twice as high in the most deprived areas compared to the least deprived (4). Obesity is multi-factorial and genetic and environmental factors both play a part. That said, changes in our genetic make-up over the past 30 years cannot account for such a rapidly rising rate in obesity prevalence (5). Instead, recent rises are largely attributed to changes in behaviour. Our lives have become more sedentary, including reductions in active transport and increased screen time. There has also been a steady rise in energy intakes, driven by major shifts in the global food system. Since the end of World War II, agricultural output has focussed on starchy staples, animal feed and cash crops, increasing production in an attempt to address global hunger (6). Political and economic change over recent decades means that governments have increasingly ceded control of the food system to the private sector (6).

This intense focus on production means that on average, estimated worldwide per capita food consumption has increased from 2358 kcal/day in the 1960s to 2940 kcal/day in 2015 (7). Households have seen a shift away from at-home food preparation using fresh ingredients to foods prepared outside the home. These foods are heavily marketed through various means such as advertising, and price promotion and many are high in sugar, fat and salt. In the UK, it is estimated that 50% of calories purchased are from ready-to-consume processed foods, including confectionery, breakfast cereals, biscuits, pastries, cakes, ice cream, packaged bread, ready meals, yoghurts and soft drinks (8).

The high energy density of foods undermine the human appetite control system, leading to excess energy consumption (9). A higher consumption of processed foods (>4 servings/day) has been shown to increase energy intakes and increase risk of all-cause mortality by 62% (10). The dominance of processed foods in people's diets means that a large proportion of the UK population now exceed the Government's guideline intakes for macronutrients of concern. **Table 1** below outlines guideline amounts (11) compared to self-reported intakes from the National Diet and Nutrition Survey (NDNS) (12). The NDNS data, based on a dietary survey, is thought to be subject to underreporting, something that is fully explored later in this chapter.

Table 1: Government dietary recommendations for energy and macronutrients, adults aged 19-64 years (11), compared to self-reported intakes from the NDNS (12)

	Females			**Males**		
	Guideline amount	NDNS	% reported intake	Guideline amount	NDNS	% reported intake
Energy (kcal/day)	2000	1632	82%	2500	2019	81%
Protein (g/day)	45	66.6	148%	56	87.4	156%
Fat (g/day) [less than]	78	62.4	80%	97	76.7	79%
Saturated fat (g/day) [less than]	24	22.8	95%	31	27.5	89%
Carbohydrate (g/day) [at least]	267	199	75%	333	249	75%
Free sugars (g/day) [less than]	27	50	185%	33	64.3	195%
Sodium (mg/day) [less than]	2400	2120	88%	2499	2120	88%
Dietary fibre (g/day) [at least]	30	17.4	58%	30	20.7	69%

Official dietary guidelines were first introduced in the UK in 1979 in an effort to offer clearer guidance to the public on what a healthy diet consists of. That said, the publication and promotion of dietary guidelines alone seems to have had little effect on improving diet.

Population-level interventions to improve dietary behaviours

Broadly speaking, interventions to improve diet-related disease can be classified into individual and population-based approaches. Individual approaches are delivered to a group of individuals who have been identified as high-risk of developing a disease and generally tackle the proximal risk factors. Examples of individual approaches to reducing obesity of diet-related disease include nutrition counselling, prescription of weight-loss drugs and bariatric surgery. Individual interventions are often effective, but can be expensive to administer and do nothing to reduce the underlying causes of a risk factor.

Population-based interventions aim to shift the distribution of risk factors in a sub-group of the population, or the population as a whole, often irrespective of individuals' risk of developing, or having, the targeted risk factor or disease. Examples include nation-wide health promotion campaigns, age-restrictions on the purchasing of tobacco and alcohol and the enforcement of wearing seat-belts. Population interventions tend to focus on the more distal causes of disease, such as societal and environmental factors.

To achieve the World Health Organization (WHO) target to halt the rise in obesity and diabetes, dramatic changes to food environments are needed to motivate and sustain healthier diets, worldwide and in the UK (13). Action needs to be taken by the three main actors that can instigate change in the food system: Governments, industry and the public themselves. At the UN General Assembly High Level Meeting on the Prevention and Control of Non-communicable Diseases in 2011, Heads of States and Governments were asked to call upon the private sector to consider promoting and producing foods that are more consistent with a healthy diet, including through reformulation (14).

The role of the food industry in the UK food system

As designers, producers, manufacturers and distributors of food, the food industry is a key actor that shapes our food environment. The role the industry plays in the UK food system can be analysed through the lens of the marketing mix complex, or 'four Ps': product, place, price and promotion (15). By examining the traditional four Ps, we can see how the food industry has come to accumulate so much of a fifth P: Power.

Product: Manufacturing energy dense, processed foods is a profitable business

Of the food and drink products sold by retailers, it is the energy dense, processed foods that have seen the most marked increases in value sales in the UK. For example, the combined retail value sales of confectionery, ice cream, biscuits and cakes increased by 22% in the last 10 years after adjustment for inflation, from £17.2 billion in to £20.9 billion in 2018. These products mainly contain ingredients that are derived from subsidised crops and are cheap for manufacturers to procure: sugar and grains and oilseeds (16).

Place: The availability of foods influences dietary choices

Access to and the density of food retailers within the built environment have an important impact on dietary patterns and health. There has been a marked growth in the number of chain-owned retail stores in the UK over the past few decades, with large supermarkets in out-of-town locations and small, convenience stores in more urban areas (17). The retail market is dominated by four main companies: Tesco's, Sainsbury's, Asda and Morrisons, which represent nearly 60% of all grocery retail value sales (18). Observational evidence shows that large supermarkets are generally the most healthful food retail environment, compared to convenience, discounter and petrol station stores, which offer relatively more unhealthy products (19). Where products are placed in-store and how they are positioned on shelves also influences consumer behaviour.

The food service industry also has an impact on dietary behaviours. Based on data from local authorities in England there is an association between the density of fast food outlets (number of restaurants per 100,000 people) and area of deprivation (20), and a growing body of evidence that shows an association between fast food exposure and obesity (21)(22). Planning applications for food retail outlets, including fast food restaurants and convenience stores, rose continuously in the 2000s, bucking the general downward trend in the retail property market (23). Food service sales in the UK have increased by £9 billion in the past 10 years, and it is a more fragmented market than grocery food; in 2018, the top 20 companies, including McDonald's, Burger King, KFC, Subway and Pizza Hut, represented around 25% of food service sales, with 56% of sales coming from independent outlets alone (24).

Price: Healthy foods are more expensive than unhealthy foods

While healthful foods may protect against obesity due to their rich nutrient contents and satiating properties, they have low profit margins when compared to energy-dense, processed foods, i.e. products that have low manufacturing costs, made lower by agricultural subsidies (25). A systematic review and meta-analysis of 27 studies in 10 countries has shown that healthier diets cost on average $1.50 more per day than less healthy diets (26). There is evidence that processed foods are cheaper in the UK on a per serving basis, when compared to unprocessed fruits, vegetables and whole grains (27). It is argued that this fuels health inequalities. A lack of storage and cooking facilities and low levels of food preparation knowledge also mean that poor dietary habits and overweight and obesity are highest in households that are socially and economically deprived (28).

Promotion: Unhealthy products are more likely to be promoted

As well as promoting their products through price discounts, food and beverage companies spend large amounts of money on advertising and marketing. Analysis has shown that the top 18 food and soft drink brands in the UK spent £143 million on advertising in 2016, dwarfing the £5.2 million annual budget of the government's healthy eating campaign Change4 Life (29).

The UK has the highest level of spending on food and drink price promotions in Europe, at 40% of total grocery spend (30). While promotions make products cheaper, they also encourage people to buy more than normal, leading to increases in the total volume of food taken home (30). Evidence shows that a greater proportion of price-promoted products are for unhealthy compared to healthy foods (31) and people tend to be more responsive to price promotions on unhealthy products compared to healthier foods (32).

The fifth P: Power

The success of the food industry has led to the accumulation of a fifth P: power. According to the Food and Drink Federation (FDF), the food and drink industry is the biggest manufacturing sector in the UK, employing 450,000 people (33). It also makes an important contribution to GDP, giving it political leverage; in 2018, the combined retail value sales of processed food and soft drink products reached £74.9 billion, up from £55.1 billion in 2006 – an increase of 35% for packaged food and 41% for soft drinks (34).

A food or soft drink company's main priority is financial return on investment for shareholders; companies have quarterly targets to meet and are under pressure to increase profits in an environment where 50% people's energy intake already come from packaged foods (8). Demonstrating self-regulation and positive community action is one way that food and soft drink companies aim to avoid government legislation. Aware of growing criticism from governments, NGOs and crucially, the public, for contributing to poor diets, many food and soft drink companies now have entire teams dedicated to corporate social responsibility (CSR). Examples of CSR activities include the funding community sport projects by Coca-Cola (35), a responsible marketing code from Britvic (36) and a consumer guide to "snacking mindfully" from Mondelez (37).

Lobbying is also another strategy that companies employ to avoid stricter regulation. Stakeholder analysis of the EU's Platform on Diet, Physical Activity and Health in relation to soft drinks taxes showed that lobbying tactics by food companies are similar to those previously employed by the tobacco industry, and include questioning the effectiveness of policies, including by funding research, shifting blame to physical inactivity and establishing links with trade unions to promote economic and labour interests over health (38). Some argue that the food industry is an essential policy actor when it comes to improving health , while others say that their clear conflict of interest means collaboration between government and industry is flawed (25).

Policy options to improve dietary health

If the UK Government is to respond to calls by the WHO to halt the rise in obesity and to request the food industry to promote and produce foods that are more consistent with a healthy diet (13)(14), population-based interventions need to be supported by national and local policies. Population-interventions vary in the degree of agency individuals must exercise to benefit. There are multiple different frameworks that can be used to frame the policy options available, including the NOURISHING framework from the World Cancer Research Fund (39) and the two-continuum framework of population-based interventions set out by Adams et al. in 2016 (40).

The Nuffield Ladder of Intervention (Figure 1 below) can be used as a framework for conceptualising the different policy levers that are available to improve diet at a population level (41). This framework is not perfect – the ladder structurally embodies the assumption that autonomy is maximised by non-intervention (42) and implies that the preservation of personal freedoms should be prioritised. However, given the current political environment in which policies are formed in the UK, how individual choice is going to be impacted is an important consideration for policy makers. For this reason, the Nuffield Ladder of Intervention has been used to set out the potential policy approaches in terms of the evidence of their impact on diet and obesity, structuring them in terms of intrusiveness and acceptability, both publicly and politically.

Figure 1: Nuffield Intervention Ladder (framework (41), image (43))

1. Do nothing or simply monitor the situation

The UK has a strong set of surveillance data that has allowed policy makers to "simply" monitor dietary patterns, including the National Diet and Nutrition Survey (NDNS), which record individuals' dietary intake, and the Living Costs and Food Survey (LCF), which collects data on household spending. These surveys have allowed public health problems to be clearly defined, and as a result, governments in the UK have a long history of acting to improve diet or reduce obesity, albeit with limited success. Current surveys focus mainly on the individual or household. What is missing is a surveillance system that monitors how the other main actor of the food system – the food industry – is contributing to change from a public health perspective.

2. Provide information: inform and educate people

Evidence shows that mass media campaigns can directly and indirectly improve health behaviours, although they are most successful when applied alongside other interventions (44). The UK Government currently has two main information campaigns relating to healthy eating: the Eatwell Guide and Change4Life.

As well as the nutrient-based recommendations (see Table 1), the Government also recommends people consume five portions of fruit and vegetables per day (45) and limit red and processed meat intake to 70g per day (46). The Eatwell Guide is a pictorial version of the Government's food and nutrient recommendations and it is used to promote a healthy diet (47). Modelling evidence suggests that if the average diet was in line with the Eatwell Guide, then life expectancy would increase by 5.4 months for men and 4.0 months for women, averting 18 million disability adjusted life years (DALYs) over the lifetime of the current population (48).

Change4Life is a public education and social marketing campaign that aims to tackle the causes of obesity by promoting a healthy diet and increased physical activity, through information and interactive tools such as quizzes, games, videos and an app known as Smart Swaps that can be used to scan the barcodes of products, providing nutrition information and suggesting health swaps (49). A specific evaluation of the Smart Swaps programme, which began in 2014, found that using the Smart Swaps app led to users purchasing lower-fat dairy products and lower-sugar soft drinks compared to a control group after three weeks (50), although there is no evidence that this is effective at improving diet in the long run.

3. Enabling choice: enable people to change their behaviour

While back-of-pack nutrition labelling provides simple information, front-of-pack (FOP) nutrition labelling of energy, fat, saturated fat, sugars and salt per serving, provides a more accessible and interpretive guide for people to make healthier choices by using colours to interpret the nutritional content of products. Traffic-light labelling of pre-packaged foods in the UK is voluntary. A modelling study in Canada has shown that traffic light labels can reduce a population's intake of energy (-5%), total fat (-13%), saturated fat (-14%) and sodium (-16%) (51). An intervention study in New Zealand has also shown that products that were purchased after viewing traffic light labels led to significant healthier purchases (52).

Warning labels are a type of FOP label that are displayed on products when levels of key nutrients exceed recommended levels. They contain simple text and a recognisable 'stop' symbol in black, one for each nutrient in excess, and currently implemented in Chile, Uruguay, Peru and Israel and are currently under political discussion in Canada, Mexico, Brazil and India, among others (53). Evidence suggests that warning labels are more effective that traffic light labels at improving individuals' understanding of excess nutrient contents, improving their ability to identify unhealthy products and reduces the proportion of unhealthy purchases (54)(55).

A recent systematic review and meta-analysis has concluded that a small body of low-quality evidence suggests that labelling the energy content of menus may reduce the energy content of purchases in restaurants (56). In 2018 the Government ran a consultation on plans to make calorie labelling on menus mandatory for places that serve food and drink out of the home (57), although no recommendation or policy has yet been implemented.

The food industry produces a large range of products that enable consumers to choose healthier alternatives, including low-fat, low-salt and low-sugar versions of popular brands. Sales of low and no energy soft drinks now account for 64% of total volume sales, according to the British Soft Drinks Association (58).

4. Guide choice through changing the default: make 'healthier' choices the default option for people

The policy options that sit in this middle section of the ladder are mostly concerned with changing the micro-environment to "nudge" people into making healthier choices (known as choice architecture), often without requiring much agency from an individual (59)(60). Many nudges are interventions at the point of purchase – i.e. where people are making choices about what to eat or buy for themselves and their families (61). Examples of such intervention are given below.

Removing high fat, sugar and salt products from checkouts

Purchases of energy-dense foods are often made on impulse and are not necessarily planned as part of the family shop. Positioning foods at checkouts and other prominent locations encourages consumers to make impulse purchases. An in-store intervention and interrupted time series analysis has shown that removing confectionery and other unhealthy products from the checkout in UK supermarkets reduced the purchases of such products by 17% (62). In the UK, healthy checkout policies are currently implemented voluntarily by supermarkets, with policies varying between retailer and store-type.

Moving the positioning of products on the shelves

"Slotting fee" is the term given to the contract between a manufacturer and a grocery retailer that determines where on a shelf a manufacturer's product is placed. Higher slotting fees result in more prominent positioning, including the middle shelves which are at eye-level and easy to reach, and the end of the aisle, which receive higher footfall and often contain products on promotion (63). In-store interventions have shown that healthy-placement practices, whereby healthier products are positioned on these prime shelves, have been shown to significantly improve the healthiness of purchases (64) and reduce the number of calories purchased (65). Further research is needed around the long-term effects of these interventions, and on any substitution effects with regards to total calorie intake. There are currently no policies that relate to the positioning of products on shelves in the UK, although qualitative evidence from the US suggests that retailers are open to engage in healthy positioning practices, despite the fact that slotting fees are a key factor for retailers when sticking stores (66). The Royal Society of Public Health (RSPH) recommends that UK retailers adopt the key principles from its "Health on the Shelf" report, including allocating shelf space to products based on the Eat Well Guide, to introduce healthy rewards scheme and to providing more in-store cookery demonstrations and recipe cards (67).

Reducing portion or pack sizes

The portion sizes of many foods have increased significantly in recent years. For example, the average slice of bread has increased by 11% since 1993 and the average hamburger has trebled in size since the 1950s (68). Portion size is a modifiable determinant of energy intake - reducing the portion sizes and pack sizes of pre-packaged and fast food and restricting price practices whereby larger packets cost less in relative terms to smaller packets, may help to reduce total energy intakes (69). There is currently no policy intervention in the UK that limits portion sizes or price practices based on portion sizes of either pre-packaged or fast food.

Reformulating products to reduce sugar, fat and/or salt content

Reformulation can be defined as 'changing the nutrient content of a processed food product to either reduce the content of nutrients (typically salt, saturated fat, trans fat, sugar and energy) or to increase the content of others (such as dietary fibre, vitamins and fruit and vegetables)' (70). Manufacturers of packaged food and drinks may adjust the ingredients of their products and reformulate for technical or cost-saving purposes. There is a range of evidence to support reformulation as a public health strategy, which is outlined below.

Observational evidence

The main observational evidence we have that reformulation works is for salt and trans-fats. In 2006, the UK Food Standards Agency (FSA) implemented a salt reduction programme. It set a series of voluntary, category specific reduction targets that were underpinned by a public awareness campaign (71). Using data collected from 9000 adult participants of Health Survey England, observational evidence has shown that salt reduction led to a 15% reduction in salt intakes, from 9.5g per person per day in 2003, to 8.1g in 2011, leading to a reduction in blood pressure of the population (3.0 ± 0.33 mm Hg) (72)(73). While the salt content of foods was at its centre, the salt reduction programme was not only an exercise in reformulation. It had multiple, interweaving elements that made it successful: 1) an action group with strong leadership, 2) clear identification of the main sources of salt intake, 3) the setting of a target salt intake for the population, 4) the setting of progressively lower salt targets for specific foods as time went on, 5) constant engagement with the food industry, 6) recruitment of ministerial support and the potential threat of regulation by Department of Health, 7) clear nutrition labelling, 8) a clear consumer awareness campaign and 9) regular monitoring and reporting of progress in the media (72).

Voluntary reformulation by the food industry has also led to significant reductions in trans-fatty acid intake. A survey conducted by the Department of Health showed that the levels of artificial trans-fatty acids in foods fell by 75% between 2007 and 2013 (74). Results of the National Diet and Nutrition Survey (NDNS) from show that trans fats represented 1.1% of total energy intake in 2015-16, well below the recommended 2% (12).

To date, there is little observational evidence that reformulation, other than for salt and trans fats, has led to positive health outcomes. An observational study conducted by the Food and Drink trade association in Ireland showed that product reformulation by 14 of its member companies led to a reduction in the volume of sugar sold by 14% between 2002 and 2012 (75). While these findings are not peer-reviewed, they do suggest that industry-led reformulation can lead to reductions in sugar consumption.

Modelling studies

The results of modelling studies suggest that reformulation can be successful in reducing the consumption of specific nutrients, improve adherence to dietary guidelines and reduce obesity prevalence (76)(77)(78). A systematic review of studies that have modelled the impact of food reformulation of nutrient content and health showed that there is a consistent relationship between percentage reformulation and reductions in individual intakes, and in a few cases, between positive health outcomes (77). While the included models are important tools to evaluate reformulation interventions, the type of policy implemented and the time period covered varied significantly. For example, one study showed that industry-wide reformulation of all foods that did not meet nutrient profiling standards in the USA and France could lead to significant reductions in the consumption of energy, saturated fat, sugar, and sodium (76). Modelling evidence has also shown that reducing the sugar content of selected food groups by 20% could lead to calorie reductions equivalent to 19 kcal per person per day for adults, leading to a 5.5% reduction in obesity prevalence (79). In contrast, another study has shown that if manufacturers reduced the added sugar content of their foods by 1% a year for 20 years in the US, it would lead to a reduction in obesity prevalence of just 1.7% (78).

5. Guide choice through incentives: use financial and other incentives to guide people to pursue certain activities

There is now a wide range of reduced fat, sugar and salt products on the market, although uptake of some of these is limited. Promoting their consumption by reducing their price compared to standard versions may financially incentivise people to make healthier choices. A systematic review of studies that have subsidised and used price promotions for fruits, vegetables, nuts, legume and whole grains have shown that these price interventions significantly increase the purchase and consumption of such products (80). The included studies were conducted in a variety of settings, including supermarkets, cafeterias, markets and restaurants, although the intervention periods tended to be short with few including a long term follow up, with little evidence of the intervention having an impact on total diet or weight (80).The Healthy Start programme in the UK gives low-income families with young children vouchers for free fruit, vegetables and milk (81), although there is no such population-wide study. Analysis of the Health Start scheme has shown that it has increased spending on fruits and vegetables amongst recipients (82), but there is no such evidence that it has increased fruit and vegetable intake, or improved the healthiness of the diet overall.

6. Guide choice through disincentives: use financial and other disincentives to influence people to not pursue certain activities

The principle of using taxation as a public health intervention is to increase the price of unhealthy foods with the aim of reducing their consumption. Various countries and states have introduced different taxes on unhealthy foods, some of which are outlined below. The most widely implemented food-related tax is on soft drinks, which is a recommended policy intervention by the WHO (83). There is good evidence from randomised control trials (RCTs) that reducing sugar-sweetened soft drink consumption can have a positive impact on total energy intake (84), body weight (85)(86), insulin sensitivity (87) and gestational diabetes (85).

Taxes of soft drinks

Designing a randomised control trial (RCT) of soft drink taxes in a natural setting is difficult and most of the evidence supporting the effectiveness of sugary sweetened beverage (SSB) taxes is derived from observational studies. Over twenty countries have implemented taxes on soft drinks and there is now a wealth of studies that have evaluated these interventions. Observational literature generally shows that taxes on soft drinks lead to reductions in sales and consumption, although the subsequent impact on energy consumption, weight and other health outcomes is unknown. This does not necessarily mean that soft drink taxes do not have a positive effect on health, but that these outcomes are hard to measure at a population level where there is a high level of noise from other environmental influences and interventions.

In 2013, Mexico implemented a one peso per litre tax on sugar-sweetened soft drinks, equating to an average price rise of 10% (88). Between 2012 and 2014, consumption of sugary drinks fell by 7.6% (88), with adults who were aware of the tax reporting significantly lower consumption compared to those who were not (89). In France, a tax of €0.07 per litre of all sweetened beverages (including products that use low calorie sweeteners) has led to a reduction in the consumption of taxed drinks by 10 ml per capita a week (90). Hungary introduced a tax on soft drinks with more than 8g sugar per 100ml in 2011, with prices rising by 29% and consumption falling by 3.4% the year following implementation (91). Evaluations of excise taxes on soft drinks implemented in Berkeley, California and Philadelphia, Pennsylvania in the US show that they have led to increases in prices and reductions in sales, although there were variations in the rates of pass-on in different stores and areas (92)(93).

Taxes on other energy dense foods

Several other countries tax other energy dense foods, not just soft drinks. For example in Mexico, food products that contain more than 275kcal/100g have been subject to an 8% tax since 2013, leading to a 5% reduction in their purchases, although larger relative reductions were seen in urban areas (-7%) and among educated households (-10%) and households with children (-7%) (94). Hungary has had a 'junk food tax' implemented since 2011, including on soft drinks, snacks and confectionery, with an evaluation showing that prices of these products increased by 29% and their consumption fell by 3% (91). Norway has taxes on some sugar-sweetened foods, including beverages and ice cream, with tax rates as high as 83% for confectionery (95).

7. Restrict choice: regulate to restrict the options available to people

Interventions that restrict choice may have more positive health impacts, but are often considered paternalistic, and so are politically unfavourable. The Government is currently considering a statutory ban on the sales of energy drinks containing over 150mg of caffeine per serving to those under 16, and this restriction is already voluntarily implemented by some UK retailers (96). Healthy eating standards for schools in England mean that sugary drinks, crisps and confectionery cannot be sold in school canteens or vending machines, and food that has been battered, breaded and/or deep-fried cannot be served more than twice a week (97), restricting choice. There are healthy food recommendations for NHS hospitals (98) and prisons (99), but these are not enforced and unhealthy foods are still freely available in these settings.

8. Eliminate choice: regulate to eliminate choice entirely

Policies that eliminate choice, the Nuffield Council of Bioethics argues, need to be supported by the strongest evidence that shows causal links between consumption of a product and health outcomes. Even with tobacco, where cause and effect are supported by a wealth of evidence, smoking bans involving the complete elimination of choice are only in place in specific settings. A blanket ban on the production or sale of individual foods based on their nutrient content is unlikely in the UK. Unlike consuming tobacco or alcohol, eating is biologically essential. Despite the association between consumption of high fat, sugar and salt (HFSS) foods with diet-related disease, HFSS foods still contain macronutrients that are essential for humans. Even deciding which foods would be subject to such a ban would be a political and public minefield.

The evolution of diet and obesity policy in the UK

Broadly speaking, UK governments so far have responded to the challenge of improving unhealthy diets with strategies and policies that focus on guidance or encouraging or nudging individuals to adopt healthier behaviours (40).

In 1979, the National Advisory Committee for Nutrition Education (NACNE) was established, a working group set up to produce nutritional guidelines, which included the recommendation that fat should contribute to no more than 30% of total dietary energy, sugar intake should be halved to 10% of intake and increasing starches to account for 45% (100). In 1984, the Committee of Medical Aspects of Food and Nutrition Policy (COMA) published a report with a narrower remit than NACNE, with dietary recommendations to reduce cardiovascular disease. After acceptance of these guidelines by Government ministers, JACNE (Joint Action Committee on Nutrition Education) was set up to translate these targets into everyday language.

In 1992, the Government officially recognised obesity as a significant health problem that needed addressing and setting a target to reduce obesity in adults to below 7% (101). In 1999, a newly-elected Labour Government published ‘Saving Lives: Our Healthier Nation’, which claimed to be “the first comprehensive Government plan” to improve the health of the whole population (102). While it acknowledged that obesity and poor diet were drivers of disease, these two areas were largely ignored from specific actions and policies. In 2001, the National Audit Office declared that obesity had trebled in the past twenty years, outlining the enormous costs this had had on the economy and called for a cross-Governmental approach to tackle the problem (103).

As a result, the Government's approach become more focussed, placing an emphasis on childhood obesity. A public health strategy, including obesity and physical activity action plans, was published by the Department of Health between 2004-5 (104)(105)(106). These white papers set clear goals to improve diet, with their core principle being informed choice, i.e. helping people make their own decisions – a strategy that falls towards the bottom of the Nuffield ladder of intervention.

In 2006, restrictions on advertising unhealthy foods to children were introduced by the Office of Communications (Ofcom) (107) and voluntary, category specific salt reduction targets were set by the Food Standards Agency and underpinned by a public awareness campaign (108)(71).

The Foresight Report on Obesity was published in 2007 after being commissioned by the Government Office for Science (109). It is viewed by many as a landmark publication that developed a framework for action on obesity. It concluded that while individual responsibility is important, it is insufficient to tackle obesity on its own and a whole societal approach is needed. It also put the onus on the Government to deliver an integrated, multi-departmental political response to the obesity epidemic.

Healthy Weight, Healthy Lives followed – a cross-Government strategy published 2008. Most policy actions here were focussed on providing information, better support and incentives for the individual to make healthier choices (110). *Change4Life*, a national public health promotion campaign was launched in 2009 and is still being delivered today.
The election of a new Conservative-led Government in 2010 and the publication of its obesity strategy, *A Call to Action* in 2011, marked a political shift that put the responsibility of obesity back on the individual, and gave “partners – including the food and drink industry – the opportunity to play their part” in improving diet related disease (111).

The Public Health Responsibility Deal (PHRD), a policy that would be considered to lie in the middle of the Nuffield Ladder of Intervention, was initiated in 2010 and consisted of a series of voluntary pledges between the government, private industry and health organisations aimed at improving public health in England (112). Companies and organisations signed up and agreed to try and make changes to their products, policies and/or practices to meet these targets, self-reporting on progress each year. The Food Network of the PHRD consisted of 15 pledges, including the integration of the FSA salt reduction targets, calorie reduction targets, calorie labelling, the removal of ingredients containing trans fats and adopting the approved front of pack nutrition labelling scheme (112). Despite receiving 453 signatories across the 15 food pledges, the PHRD was criticised for its lack of quantitative monitoring and evaluation, and deflecting attention away from more objective public health goals (113)(114)(115).

In May 2015, a new government was elected, the PHRD was closed and responsibility for leading business in reformulation and healthy food policies was given to Public Health England (PHE) (116)(117).

Current obesity and diet-related policies in the UK

The current policy focus to tackle obesity is during childhood, with the theory that addressing childhood obesity will lead to long term health improvements and also affect the wider family, including adults. By framing policies as addressing a childhood issue, it makes tougher interventions more politically and publicly acceptable. Following on from the *Public Health Responsibility Deal*, many of the current policies given below are focussed on instigating changes by food manufacturers to improve the nutritional quality of the foods that they produce.

Childhood Obesity: A plan for action, chapters 1-3

In 2016, the first part of the government's obesity policy was published. *Childhood Obesity: A plan for action* outlined the impact obesity is having on the NHS (estimated costs of £5.1 billion a year) and recognised the inequalities fuelling the problem (118). It reaffirmed the Government's plans to introduce a *Soft Drinks Industry Levy* (SDIL) (announced by the Treasury in March 2016) and committed to a reformulation plan for nine foods that contribute the most to children's sugar intakes. However, it was criticised for failing to mention several key recommendations set out by the Health Select Committee in 2015, including controls on price promotions, tougher controls on marketing, teaspoon labelling for sugars, improved diet education and stronger powers for local authorities to make changes to the obesogenic environment (119).

Childhood Obesity: A plan for action, chapter 2 was published in 2018. It outlined a target for halving the rate of childhood obesity by 2020 and issued consultations on: banning sales of energy drinks to under 18s, banning buy one get one free promotions on HFSS foods, extending SDIL to include milk drinks, introducing a 9pm advertising watershed for HFSS products, and introducing calorie labelling in the out of home sector (120). Chapter 2 was again criticised for failing to include Health Select Committee recommendations, including new powers for local authorities to limit fast food outlets and HFSS billboards near schools, banning cartoon characters from packaging and setting updated breastfeeding targets (121).

The public health green paper *Advancing our health: prevention in the 2020s*, also contained "Chapter 3" of the current Government's childhood obesity strategy. Here the Government published its decision to ban the sale of energy drinks to under 16s, and set out its intentions to publish plans on infant feeding, labelling, reformulation (including of baby foods and salt reduction targets), improved weight management advice and a review of physical activity guidelines (122). These plans are yet to be published.

Salt reduction targets

The current salt reduction targets were originally set by the FSA in 2014, with average and maximum salt content targets for 76 specific food categories (representing an estimated 54% of salt intake), with the aim of them being met in 2017. In 2015 the responsibility for setting salt targets were integrated into the *Public Health Responsibility Deal*, before being moved to Public Health England (PHE). Analysis published in 2018 showed that just over half (52%) of average salt content reduction targets for foods eaten in-home were met, with retailers-own products making better progress (73%) than branded products (37%) (123). For the out of home sector, 75% of products in five out of 11 categories (including fried chicken, pizza, children's main meals and sandwiches) fell below the maximum salt content targets, although there was less progress in other categories (123).

Sugar reduction: Achieving the 20%

In 2015, the World Health Organisation and the UK Scientific Advisory Committee on Nutrition (SACN) recommended that the guideline intake on sugar should be revised from 10% to 5% of total dietary energy (124). Citing the success of the salt reduction targets and in an effort to reduce the population's consumption of sugars, Public Health England outlined a series of 20% voluntary sugar reduction targets for nine food categories in 2017. These nine food categories represent 54% of sugar consumed by children aged 4-10 years, and 34% for adults aged 19-65 (**Table 2**) (12).

Table 2: Percentage contribution of food groups covered by PHE's sugar reduction targets (excluding morning goods) to average daily free sugars intake in children and adults in 2016-17 (12)

	Percentage contribution (%)		
Category	**4-10 years**	**11-18 years**	**19-64 years**
Breakfast cereals	8	8	4
Biscuits	9	8	7
Cakes	8	7	7
Chocolate confectionery	7	7	7
Ice cream	5	3	2
Puddings	4	2	2
Sugar confectionery	7	4	2
Yoghurts	6	3	3
Total	**54**	**42**	**34**

During the development of these targets, PHE modelled the impact of reformulating the sugar content of each of these nine food groups by 50% using NDNS data. 50% was chosen as initial work suggested that reducing the consumption of sugar from soft drinks by 50% would lead to significant reductions in sugar intake for all age groups. PHE also assumed that the energy lost from reducing the sugar content of foods would not be replaced by energy from an increased intake of fat, protein or starch from these products. PHE's model estimated that reducing the average sugar content of soft drinks by 50% would lead to a 5g/day reduction for adults. Reducing the sugar content of all nine food categories plus table sugar, would lead to a reduction of 17g/day, bringing the proportion of sugars from total energy intake down to 9% for adults. This would still be above SACN's recommendation of 5%.

Using the average sugar content in 2015 as a baseline, PHE set out 5% and 20% sugar reduction targets for each category for 2018 and 2020 respectively. It also included portion guidelines on the calories per serving for each category. It highlighted that sugar reductions should be achieved without an increase in saturated fat and where possible, be accompanied by a reduction in calories. These voluntary targets are designed to encourage food manufacturers to reformulate their products and are dependent on a change in industry behaviour to have a positive impact.

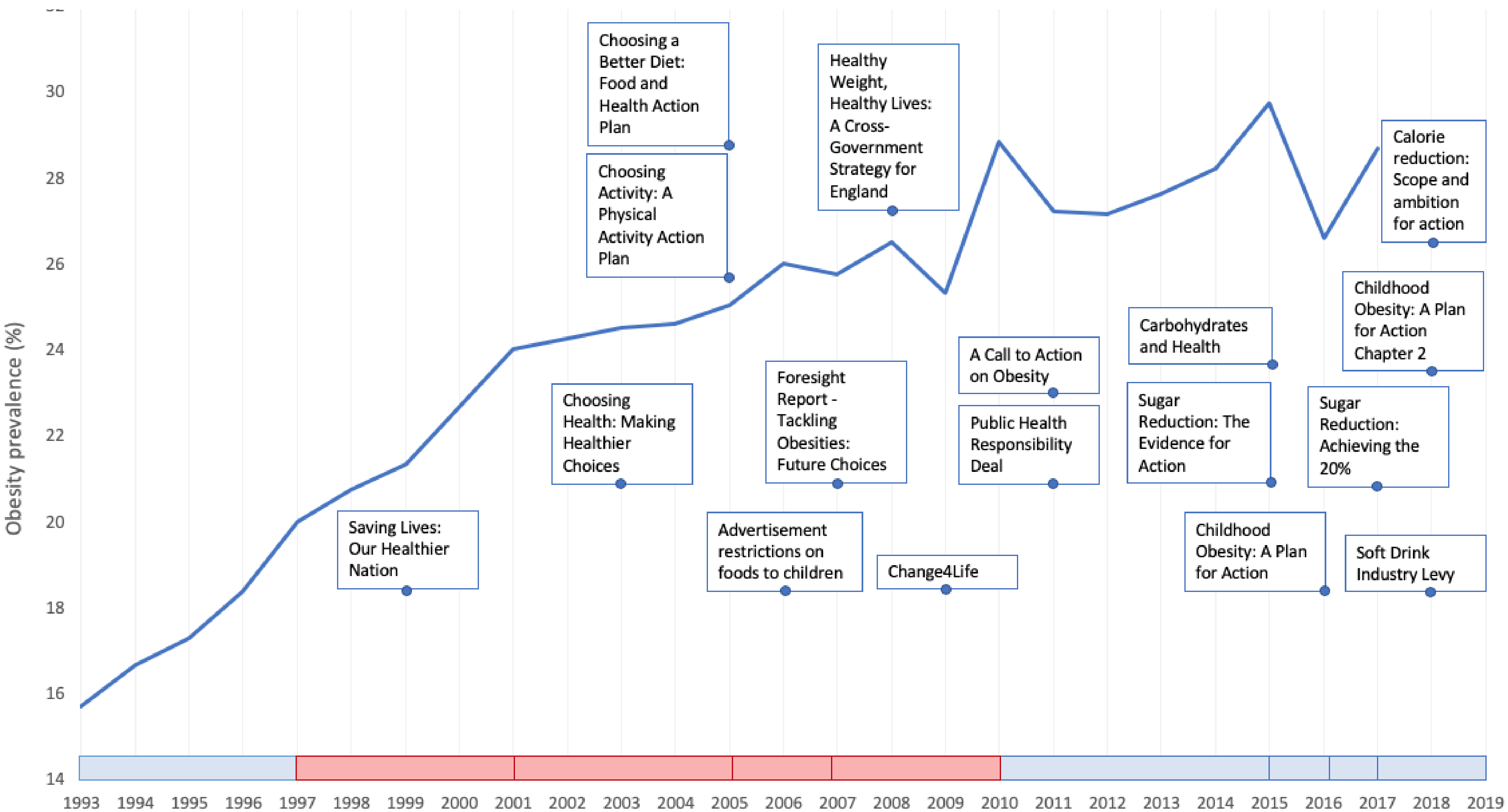
The Soft Drinks Industry Levy (SDIL)

In March 2016, the Treasury announced a three-tiered levy on sugar-sweetened soft drinks, which was implemented in April 2018 and is the first soft drink tax in the world to have multiple tiers designed to drive reformulation (125). Products that contain more than 8g sugar per 100ml are now taxed at 24 pence per litre and products that contain 5-8g/100ml are taxed at 18 pence per litre. Products with less than 5g sugar per 100ml are not subject to the tax (125). Pure, unsweetened fruit juice and flavoured milk drinks (amongst other smaller categories) are excluded from the levy. The introduction of the tax and the challenge to the industry to reformulate their products has been accompanied by a strong focus on soft drinks and sugar through the *Change4Life* programme (49) as well as increased attention on sugar in the mass media (126).

Calorie reduction: scope and ambition for action

Citing the success of the structured salt and sugar reduction targets, PHE issued a challenge to the food industry to achieve a 20% reduction in calories by 2024, with the publication of a calorie reduction programme in 2018. PHE estimate that these foods cover an additional 19% of children's energy intakes, taking the proportion of foods covered by the sugar reduction programme, calorie reduction programme and SDIL, to 50% of children's energy intakes (117). If met, these reduction targets are predicted to reduce the daily calorie intake of children by 82 kcal and adults by 68 kcal and prevent 35,000 premature deaths (117). How the obesity prevalence in adults has changed since 1992, and how this relates to the publication of key obesity-related policies discussed above, is outlined in Figure 2.

Figure 2: The evolution of key obesity policies mapped against the prevalence of adult obesity in England, 1993-2019



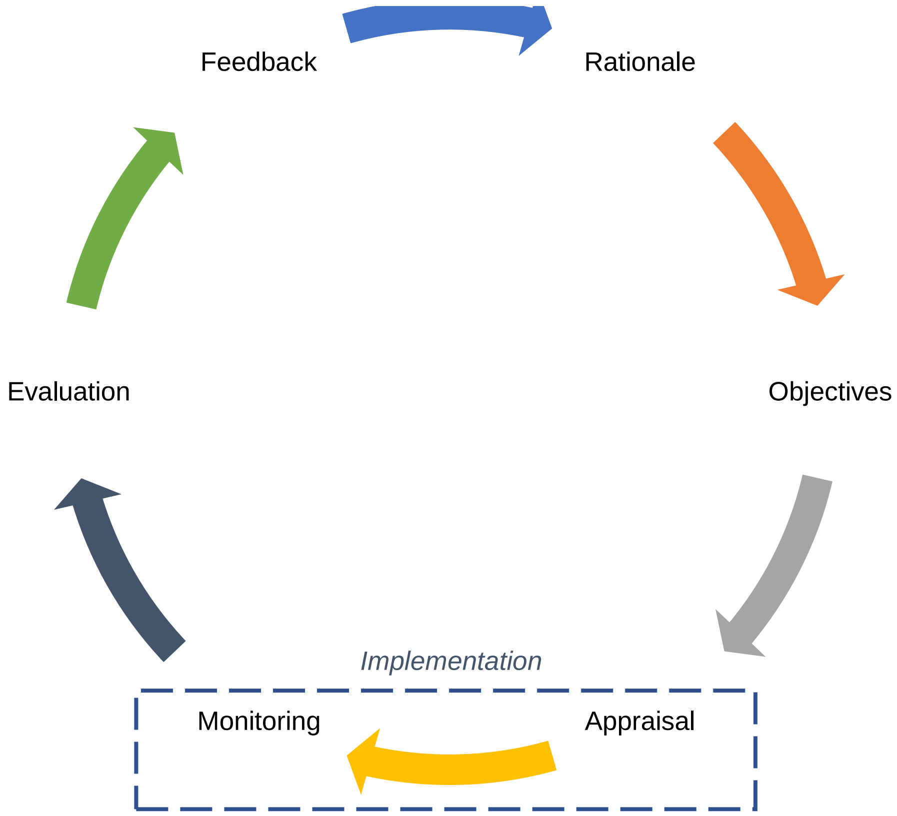
Adapted from (127). *National statistics on obesity taken from Health Survey England* (128). *The bars along the bottom refer to the leading party in government at the time, with blue for Conservative-led and red for Labour-led. Vertical lines in the bars refer to the start of a new government.*

Monitoring and evaluating public health policies

There has been a high rate of policy introduction in the previous five years, especially those dependent on industry-related changes, but there is a lack of evidence in how effective they have been in terms of their public health impact or whether they have instigated industry-led change. Monitoring can be used to appraise and assess the performance of policy activities (129). Evaluation as a formal and systematic activity where assessment is linked to an intervention's original intentions and the findings are fed back into the policy planning process (129). Both monitoring and evaluation are essential to ensure that policy making is informed by evidence on what works best to achieve its desired objectives.

The policy cycle is a way of demonstrating the different phases involved in policy development and can be a useful tool during planning and development of public health nutrition policies. According to the UK Central Government, monitoring and evaluating are essential activities that support evidence-based policy making (130). Where they sit in the 'ROAMEF policy cycle' (rationale, objectives, appraisal, monitoring, evaluation and feedback) is shown below (**Figure 3**).

Figure 3: ROAMEF policy cycle, adapted from (130)



Monitoring individual level behaviour

The tools that are currently used by health researchers and policy makers to monitor dietary patterns and intakes in the UK are based on individual-level data, or household data, which are interpreted into individual level data. Currently, the main source of information on dietary patterns and nutrient intakes in the UK is the National Diet and Nutrition Survey (NDNS). It is a continuously rolling cross-sectional survey involving approximately 1000 participants (500 adults and 500 children) using a four-day estimated diary (12)(131). Participants are asked to keep a record of everything that was eaten of drunk both inside and outside of the home, including the volumes of food and drink consumed.

However, misreporting in self-reported dietary surveys is common and well-documented (132). Underreporting may occur as a result of participants omitting – accidentally and intentionally – to record food and drinks consumed, particularly out of the home, from underestimating quantities, or changing dietary behaviours as a direct result of participating in the survey (132). Underreporting is particularly common in overweight individuals (133)(134), thus exacerbating the paradox of reported energy intakes falling below guideline intakes while obesity rates continue to rise.

The Living Costs and Food Survey (LCF) collects data on household spending, providing essential economic and social patterns, including food and drinks (135). The food data in particular is used by the Department for Environment, Food and Rural Affairs (DEFRA) in its annual report “Family Food” (136). Household expenditure is used to estimate the volume of food purchased inside and out of the home, and to estimate nutrient intakes, although no information is published on the brand of food or restaurant name visited. Reducing resources and a small and declining sample size (approximately 10,000 households in 2013) are limitations to this study (135).

As well as dietary patterns, health outcome indicators are also important for policy monitoring and evaluation. Health Survey England and the Scottish Health Survey provide trends on the nation’s health, including prevalence of overweight and obesity, diabetes, hypertension fruit and vegetable consumption and physical activity levels.

Monitoring industry behaviour

The Government’s policy focus on action by the food industry to improve the nutritional quality of the food supply, and the individual dietary data used to monitor these policies, are juxtaposed. Dietary intake data currently excludes information on the brand and food products consumed. Commercial sources of food sales data, including the value and volume of foods, and the bran and company market shares, offer a complementary source of information on dietary patterns. Although much happens between a food item being bought and it being consumed, including food preparation, distribution among household members and waste, food purchase data are a good indicator of diet. The value and volume sales of food and beverage products are available from private market research companies and are predominantly used by the food industry to track product performance, market shares, sales, brand loyalty and the success of advertisement campaigns and promotions (137). These data are usually presented as annual totals at the national level, or split by product category, company, brand and sociodemographic factors. Food sales data measures how much of a food product has been sold from the supplier side, where as food purchase data measures how much of a product has been purchased by consumers.

While neither sales nor purchase data measure exactly what individuals have consumed, they have the potential to be used by public health nutrition researchers, they have the potential to be used to monitor the nutrient content of foods and evaluate specific reformulation policies, as well monitoring the broader changes being made by the food industry when it comes to improving the nutritional content of their products.

Thesis aims

The aims of this research project are:

1. To conduct a systematic review to establish how commercial food sales data have already been used in public health nutrition research

2. To develop a method using food sales data and nutrition composition that allows an individual company's contribution to the food supply to be quantified and monitored

3. To apply this method in two ways:

a. To monitor companies' responses to sugar reduction in food and beverages in the UK

b. In combination with a nutrient profiling company, to rank the top 20 food and beverage companies in the UK in terms of the healthiness of their product portfolios.

Chapter 2

This chapter presents a systematic review that establishes how food sales data have already been used in public health nutrition research. It focuses mainly on the data sources, study design and methods and outcomes of the included studies. It identifies the different data sources that could be used for the main analysis of this thesis.

Chapter 3

This chapter narrows down the data sources identified in the systematic review by assessing them against selection criteria and by using an adapted quality assessment tool. A cross-validation study was then conducted to assess whether the choice of data source was likely to have any meaningful impact on analysis results.

Chapter 4

This fourth chapter uses food sales data and nutrition composition data in combination to develop a method that allows company-level changes in the sugar content of foods and drinks to be monitored over time. Using sales-weighted mean sugar content from 2015 as a benchmark, it shows how industry and consumer behaviour have changed since the introduction of the Government's sugar reduction programme through to 2018.

Chapter 5

This final analysis chapter uses the same data sources, plus the FSA/Ofcom nutrient profiling model, to monitor how the sales-weighted nutrient profiling score of the top 10 food companies in the UK has changed over time. Rather than focussing on a single nutrient, it tries to build a more holistic picture on how key manufacturers have responded to calls to improve the nutritional quality of their products.

Chapter 6

This discussion chapter summarises the main findings of this thesis and its key implications on research and policy.

Chapter 2: The use of commercial food purchase data for public health nutrition research: A systematic review

This chapter has been published as a peer-reviewed paper with the following citation:

Bandy L, Adhikari V, Jebb S, Rayner M (2019) The use of commercial food purchase data for public health nutrition research: A systematic review. PLOS ONE 14(1): e0210192

Chapter summary

The aim of this review is to establish how sales data on food and soft drink products from third-party companies have been used in public health nutrition research. A search of five electronic databases was conducted in February-March 2018 for studies published in peer-reviewed journals that had used food sales or purchase data from a commercial company to analyse trends and patterns in food purchases or in the nutritional composition of foods. Of 2919 papers identified in the search, 68 were included. The selected studies used sales or purchase data from four companies: Euromonitor, GfK, Kantar and Nielsen. Sales and purchase data have been used to evaluate interventions, including the impact of the saturated fat tax in Denmark, the soft drink and junk food taxes in Mexico and supplemental nutrition programmes in the USA. They have also been used to identify trends in the nutrient composition of foods over time and patterns in food purchasing, including socio-demographic variations in purchasing. This chapter identified six potential sources of foods sales data for use in this thesis. It concluded that food sales and purchase data are a valuable tool for public health nutrition researchers and their use has increased markedly in the last four years, despite the cost of access, the lack of transparency on data-collection

methods and restrictions on publication. The availability of product and brand-level sales data means they are particularly useful for assessing how changes by individual food companies can impact on diet and public health.

Introduction

As discussed in chapter 1, measuring the effectiveness of policies to change the food environment is difficult as research methods to monitor the nutritional quality of the food supply or the impact of the changes being made by individual manufacturers are not well developed. Researchers have typically relied on food balance sheets and agricultural and economic data to monitor the food supply or dietary surveys to monitor consumption, but these have their limitations. They look at the production, import, export and stocks of commodities and their domestic utilisation, but provide no details on specific products or on the sub-populations who consume them (138). Dietary surveys often have a small sample size, are resource-intensive, subject to misreporting and rarely provide information on the brand of products being consumed (139).

Commercial data provided by third-party companies have long been used by economists, business schools and health researchers, including in research relating to tobacco use (140), beauty and personal care products (141) and firearms (142). Commercial food sales and purchase data are a complimentary source of information for researchers looking at dietary patterns. Although much happens between a food item being bought and it being consumed, including food preparation, distribution among household members and waste, food purchase data are a good indicator of diet. The value and volume sales of food and beverage products are available from private market research companies and are predominantly used by the food industry to track product performance, market shares, sales, brand loyalty and the success of advertisement campaigns and promotions (137). These data are usually presented as annual totals at the national level, or split by product category, company, brand and sociodemographic factors. Food sales data measures how much of a product has been sold from the supplier side, where as food purchase data measures how much of a product has been purchased by consumers. While neither sales nor purchase data measure exactly what individuals have consumed, they have the potential to be used by public health nutrition researchers and policy makers to monitor changes being made to the nutritional quality of the food supply.

The main aim of this review is to systematically establish how sales and purchase data for food and non-alcoholic drink products from third-party companies have been used in public health nutrition research, and to consider how this type of data may contribute to the advancement of knowledge to accelerate improvements in dietary intake. It will provide a synthesis of the principal research questions, the methods employed and the conclusions drawn, with the objective of ascertaining what sources of food sales data, methods and analyses can be utilised in this thesis to develop a method that allows an individual company's contribution to the food supply to be quantified and monitored over time.

Methods

Search identification

In March 2018, five databases (PubMed, Web of Science, Psych Info via Ovid, Scopus and Business Source Complete) were searched for terms relating to the names of six companies known as providers of relevant data with no restrictions on date: Euromonitor, Kantar, Mintel, GlobalData, Canadean and IRI in the UK and globally. Search terms related to food or beverage sales data, consumption, household panel, retail, supermarket, nutrition and diet were also included to ensure that studies that use data from a company that was not listed or studies that do not name a specific company in the abstract were included. For the full search terms, see the published PROSPERO protocol (CRD42018091421)

Study screening and eligibility

Only studies that use food and non-alcoholic drink sales data in a way relevant to public health nutrition were included. All populations in all settings, including household, national, multi-national or global level, were included and all interventions and exposures were deemed of interest.

The primary study outcomes for eligibility were:

Value or volume sales of food or beverage products e.g. sales of fruit and vegetables or sales of confectionery

Volume sales of nutrients e.g. calories, grams of sugar, fat, salt per day

Only papers that used data from a commercial provider were included – papers that use data directly from individual grocery stores, supermarkets and other retail outlets were excluded. This is because this review focussed on commercial data that is readily available to researchers in public health nutrition. Accessing sales data from stores directly can involve significant negotiations and contracts. Only articles published in peer-reviewed journals were included. There was no restriction on date and only papers written in English were included.

Identified records were exported to Mendeley (Desktop version 1.17.13) and duplicates were removed. The records were then exported to CSV and saved as an MS Excel worksheet for the management of the screening. One investigator (LB) first screened by title, and then two investigators (LB and VA) independently reviewed the included titles, abstracts and methods.

Data extraction

Data extraction was conducted for all included studies and completed by two investigators (LB and VA), with a 10% check done by a third investigator (MR). Any discrepancies between the investigators were discussed and LB made the final decision. The following data were extracted for each article where relevant: study ID (first author and date), title, research aims/questions, setting (geographical location), population demographics, study design, exposure and outcome variables measured, source of sales data, source of nutrient composition data, classification system used for definitions of “healthy” or “unhealthy” foods, summary of key findings.

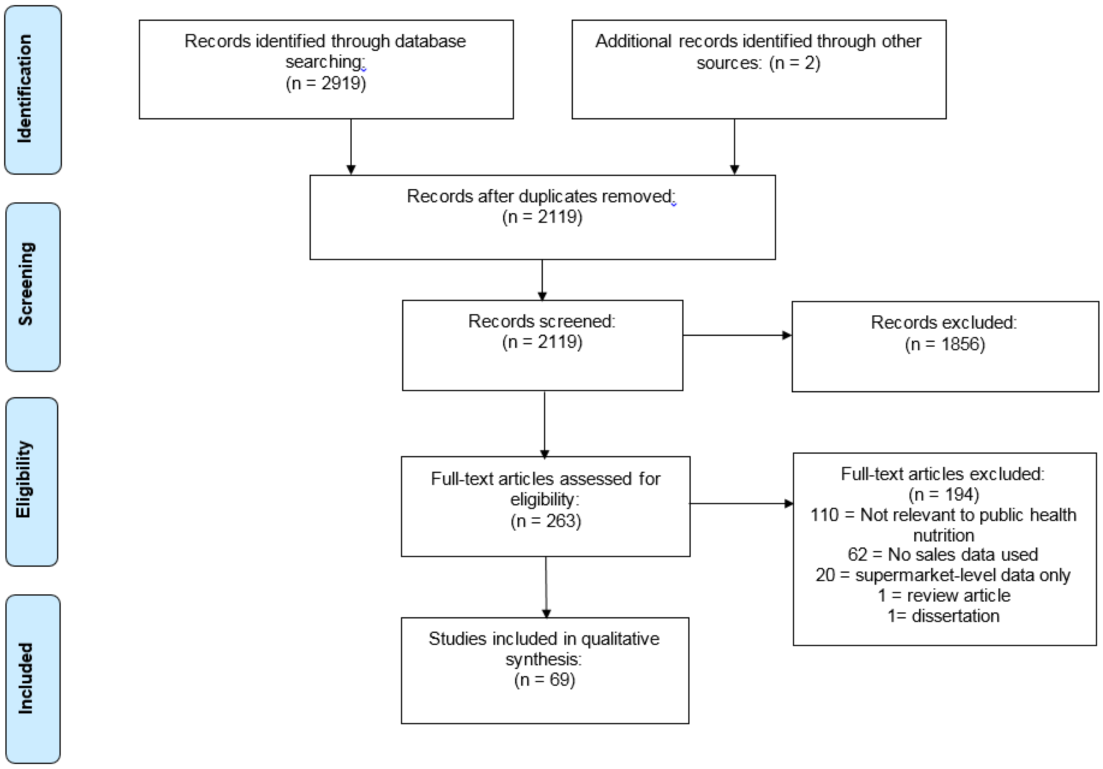
Quality appraisal

Two reviewers (LB and MR) independently assessed risk of bias and study quality using the National Institutes of Health (NIH) Quality Assessment Tool for Cohort and Cross-Sectional Studies. Any discrepancies between the two investigators were discussed and a third opinion (VA) sought if an agreement could not be made. LB made the final decision.

Results

A total of 2920 potential articles were identified during the search, from which 69 were selected for inclusion. Figure 4 shows a flowchart of the literature search and study selection.

Figure 4: Study selection flow chart



Data sources

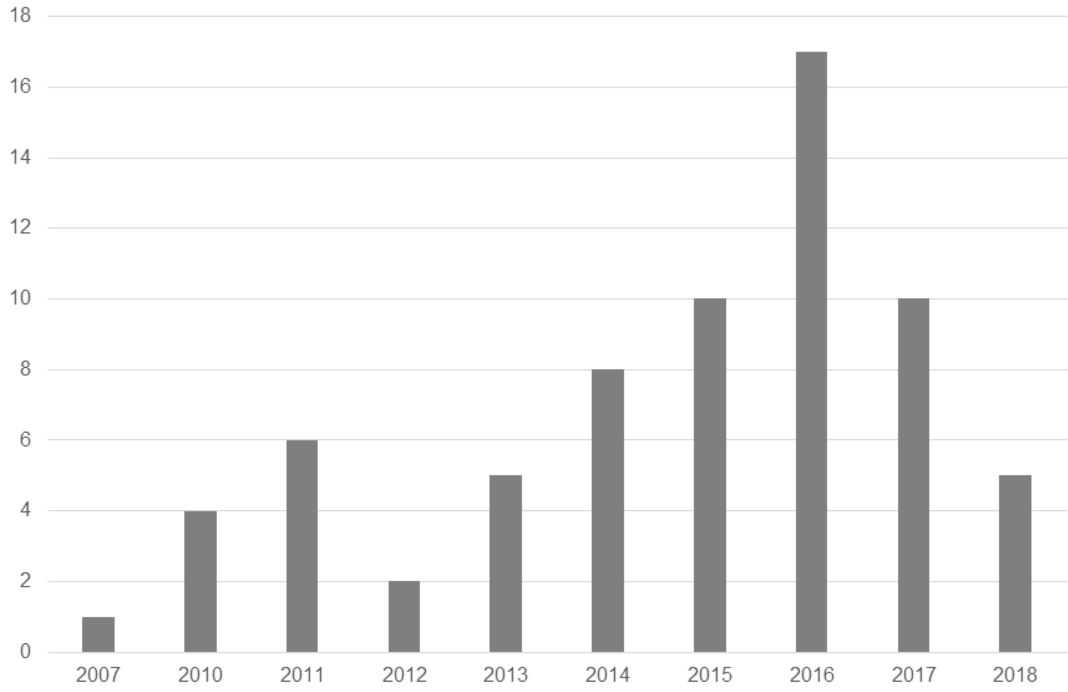
Four commercial sources of sales and purchase data were identified. These were: Euromonitor, GfK, Kantar and Nielsen. Euromonitor provided data on what has been sold by food and beverage companies and GfK, Kantar and Nielsen provided data on what has been purchased by household panels. The majority of papers (n=56) used data from either Nielsen or Kantar. A clear geographical pattern was identified, with all of the studies in the

USA using Nielsen data, all the studies in the United Kingdom and France using Kantar data, all of the Danish studies using GfK data and those that looked at multiple countries or had a global outlook used Euromonitor data. The first study that used food sales data was published in 2007. From 2011 until 2016, the number of studies increased year-on-year. A full breakdown of the sources of data and their geographies used can be found in table 3 and the number of studies published by year is represented in **figure 5**.

Table 3: Number of papers published that use food sales data by source company and country of research

	Data source company				
Country	**Nielsen**	**Kantar**	**GfK**	**Euromonitor**	**Total**
USA	29	0	0	0	29
UK	0	13	0	0	13
France	0	6	0	0	6
Denmark	0	0	5	0	5
Multiple countries/global	0	0	1	4	5
Mexico	3	0	0	0	3
Australia	2	0	0	0	2
New Zealand	2	0	0	0	2
Canada	1	0	0	0	1
India	0	0	0	1	1
Netherlands	0	0	1	0	1
Sweden	0	0	1	0	1
Total	**37**	**19**	**8**	**5**	**69**

Figure 5: The number of studies that used food sales data by year of publication



Data from all four companies were used to analyse the volume and value sales of food or beverage products, with GfK, Kantar and Nielsen also providing data on price. Forty-seven of the papers used nutrient composition data alongside sales/purchase data in their analysis, with data from GfK, Kantar and Nielsen being used to translate product sales into the purchases of nutrients. Kantar and GfK provided paired sales and nutrition composition data for 11 of the included studies. Composition data from other sources, including national composition databanks and other commercial companies, were used in the remaining 36 papers that combined sales/purchase and composition data. A summary of the different types of data used by each data source is given below in **table 4**.

Table 4: Summary of data types used in the included studies by company

Company	Research method	Volume sales	Value sales	Nutrient purchases	Product price data	Granularity of data	Provided composition data
Euromonitor	Secondary data collection	Yes	Yes	No	No	Brand level sales only	No
GfK	Household panel	Yes	Yes	Yes	Yes	Individual product sales	Yes
Kantar	Household panel	Yes	Yes	Yes	Yes	Individual product sales	Yes
Nielsen	Household panel	Yes	Yes	Yes	Yes	Individual product sales	No

Note: this table summarises the data types used in the included studies only. The data providers should be contacted directly for information on coverage and other data types.

Methods of data collection for each data provider differed, although GfK, Kantar and Nielsen all use household panels to collect their data used in the included studies. Participating households are given a handheld scanner and asked to scan the barcode of every individual grocery product that they purchase, collecting the product name, pack size, price and location of the retailer where the items were purchased. Incentives for participation, in the form of high-street vouchers, are used by all three companies. Euromonitor do not undertake primary data collection but instead undertake 'desk research' – that is they use economic indicators, publicly available information, trade news, company reports and data shared in trade interviews as the basis for their data set (143).

Quality of studies

The study quality assessment tool for observational cohort and cross-sectional studies was applied to the 69 papers. Overall, the studies were found to be of a similar quality, but all had limitations.

The 64 studies that used purchase data derived from household panels were limited by their recruitment process. The recruitment of the households to the panels was undertaken by each commercial company, meaning the authors had no control over this process, the incentives for participation used, and could not report on recruitment bias and drop-out rates. Few of the studies mentioned these limitations in their discussions and few raised questions on other limitations of the data, including the fact that out of home purchases were not covered. This may have been due to publication restrictions imposed by the data provider and therefore cannot be overcome by the authors of the individual studies themselves.

Scanned data, while more objective than other methods such as food diaries and 24-hour recalls, are still not 100% accurate for two main reasons. Firstly, there is a reliance on participants scanning all products, including ones they have purchased when they do not have immediate access to the scanner. Secondly, products without barcodes – such as those purchased at a market or in a restaurant - cannot be scanned and therefore the data is liable to be under-reported. Euromonitor sales data is not derived from primary data collection but based on desk research (i.e. secondary data collected from the trade press and trade interviews); the exact sources of the data are not made available and so transparency, reliability and accuracy are all open to question. None of the five studies included in this review that use Euromonitor sales data discussed these limitations.

Objectives and key findings of the included studies

For the purpose of this analysis, the studies have been split into three groups based on their study design: longitudinal studies (n=37), cross-sectional studies (n=22) and modelling of future scenarios (n=10). These are further subdivided based on whether they are purely observational or are studies reporting the outcome of an intervention study. Further details on each study, including objectives, data sources, measured variables and a summary of key findings, can be found in the Appendix of this thesis.

Longitudinal intervention studies

14 papers were of longitudinal design and examined interventions. Two of these papers looked at marketing interventions. One examined the impact of breakfast cereal coupons on the nutritional quality of purchases, finding that breakfast cereals purchased with a manufacturer or retail coupon had a higher sodium and sugar content (144). The second analysed the impact of Coca-Cola's sponsorship of the Winter Olympic Games in 2006 and Summer Olympic Games in 2008, with results suggesting consumers chose Coca-Cola more frequently than Pepsi during this three-year time period (145).

Twelve papers examined public health interventions. Four papers evaluated national-level taxes; two in Mexico using Nielsen data and two in Denmark using data from GfK. One paper used Nielsen data on the purchases of soft drinks to evaluate the excise tax on sugar-sweetened beverages in Mexico that was introduced in 2013 (88). The study found that over

2012 to 2014, purchases of taxed beverages had declined by an average of 6%, with higher reductions seen among households classified as low socioeconomic status (88). Another paper used a similar data set from Nielsen and similar methods to evaluate the tax on non-essential energy dense foods (146). It found a 5% decline in the mean volume of purchases of taxed foods over 2012 to 2014, with a 10% decline in low socioeconomic households (146). Two papers used data from GfK to analyse the impact of the 2011-2012 Danish tax on saturated fat. One analysed purchases of butter, blends, margarines and oils from 2008 to 2012 and found that the tax led to a reduced consumption of these products by 10-15%, with a shift in purchasing from discount retailer chains (147). The second paper used GfK data on processed foods in combination with nutrient composition data from the Danish Food Composition Databank to estimate the effects of the tax on packaged food consumption and model these effects on mortality from NCDs (148). It found the tax led to a 4% reduction in the consumption of saturated fat, an increased vegetable consumption and increased salt consumption, with a modelled reduction in mortality showing that 123 lives saved annually (148).

Three papers in the United States used purchase data to analyse the effect nutritional assistance programmes had on the composition of household diets. Two papers looked at the Special Supplemental Nutrition Assistance Program for Women, Infants and Children (WIC) and profiled the purchases of households before and after major policy revisions in 2009. The results showed that WIC participation was associated with increased purchases of wholegrains compared to non-participating households (149) and that the revisions had led to a significant reduction in purchases of calories, sodium, saturated fat, sugar, refined grains, high-fat milk and sugar-sweetened beverages (SSBs), and an increase in fruit and vegetables (150). A third paper looked at the Supplemental Nutrition Assistance Program (SNAP) and found that SNAP households had reduced mean purchases of fruit and vegetables and fibre and an increase in junk food products, saturated fat and salt (151) compared to non-participating households.

One paper looked at what impact banning the sale of carbonated beverages in schools had in households with school-age children in the US (152). Results showed that when high schools banned the sales of sodas, the affected children increased their household consumption of non-diet sodas by 3.4 cans per month, offsetting the impact of the reduction in consumption in schools (152).

Four studies evaluated voluntary initiatives. Two looked at the impact of front-of-pack (FOP) labelling. One study using GfK data showed that consumers paid higher prices for products that carried the Choices and Keyhole labels in the Netherlands and Denmark respectively (153) and another looked at the impact of the Health Star Rating FOP label in New Zealand using Nielsen data (154). It found that products displaying the label had a higher energy density but lower saturated fat and sugar and sodium content (154). One paper looked at how the introduction of voluntary sodium reduction targets in the UK impacted on sodium consumption and the sodium content of food products between 2006-2011 (155). Using Kantar purchase and composition data, it found sodium consumption fell by 7% overall, with snack foods, dairy products and sauces and spreads seeing the greatest reductions (155). Another paper evaluated the effect of the calorie reduction pledge of the Healthy Weight Commitment Foundation in the US (156). The results using Nielsen data showed that participating companies' products represented 25% of calories consumed in the US in 2007.

They estimated that the calorie reduction pledge target of 1.5 trillion calories was equivalent to 0.8% of total calories purchased from packaged food and beverages (156).

Longitudinal observation studies that focussed on nutrient composition

Five papers looked at trends in nutrient composition of foods over time. Two of these used Kantar data to track the nutritional content of foods in France, with one finding that the sales-weighted sodium content of potato chips and breakfast cereals had fallen by 6.7-11.1% and 7.3-9.7% respectively from 2008 to 2011 (157) and another finding that the energy density of foods overall had increased, but that total caloric purchases had fallen by 6.7% over 1969-2010 despite the energy density of foods increasing, overall purchase of energy had fallen by 6.7% (158). Two studies conducted in the US analysed the nutritional quality of food purchases based on store-type. One found there had been significant reduction in energy, sugar and salt densities of packaged food products from Walmart from 2000-2013 (159), and the other found that packaged food products sold in warehouse-club, convenience and mass-merchandise stores had poorer nutrient densities than other store types (160). Another paper compared the nutritional quality of foods with their degree of processing and convenience, with results suggesting that highly-processed foods have a higher sugar, saturated fat and sodium content compared to less-processed foods (161).

Three papers looked at trends in individual components of foods as opposed to the overall nutritional quality. One tracked the use of sweeteners in packaged food and beverages, with results showing that 73% of products in the US contained an added caloric sweetener (162). Another analysed the sodium content of packaged foods, finding that the amount of sodium purchased from packaged foods fell by 396mg/day per capita from 2000 to 2012 and a third paper analysed the nutritional content of an individual food product, grain-based desserts, finding a reduced saturated fat and sugar contents of these products led to a reduction in their energy density (from 433kcal/100g in 2005 to 422kcal/100g in 2012).

Longitudinal observational studies that focussed on food purchasing

Fifteen observational studies focused on the purchasing patterns of foods.

Six papers examined the relationship between sociodemographic factors and food purchasing patterns and behaviours. One paper examined the association between ethnicity, income and store preference in the US, with results showing that there was no association between these factors, except for low income non-Hispanic black households, which were less likely to use mass-merchandise stores (163). Two looked at how food purchase patterns vary with race and ethnicity in the US, with one study finding that black households purchased less processed and ready to eat foods and more basic foods including oils and sugar when compared to white households (164), and another study found that total energy purchased declined from 2003-2013, with smaller reductions seen in black and low-income households compared to white, high income households (165). Another US paper found that purchases of energy in households with pre-school aged children declined over 2000-2011, but smaller reductions were seen those households with a low income (166). One study that took place in Mexico found that low socioeconomic status households purchased more food and beverage products defined as unhealthy but also saw the largest reductions in purchases of these products from 2012-2014 (167). Another study in Denmark looked how unemployment affected food purchase behaviours, with findings showing that medium-term unemployment led to a reduction in food expenditure and a reduction in the amount of animal products, fats and proteins purchased (168).

Three papers focused on the purchasing patterns of soft drinks. One analysed Euromonitor data in 44 low and middle income countries and found that tariffs on sugar-sweetened beverages were inversely, but not significantly, associated with consumption (169). The second paper used Nielsen data to look at the trends in soft drink sales in Australia over 15 years, concluding that volume sales had fallen from 8.4kg per capita a year to 6.2kg per capita per year (170). A third paper looked at the impact that soft drink purchases had on the nutrients purchased from other foods, with results showing that for each 1 serving/day increase in consumption of sweetened beverages purchases of total calories, carbohydrates, total sugars and total fats also increased (171).

Three papers used purchase data as a basis for modelling consumer preferences. One used Nielsen data in Canada to model consumer preferences for meat, finding that health preferences triumphed over price (172) and another using GfK data showed that Danish consumers who preferred high-fat milk did not change their preferences after reading health information on fat intake (173). A third modelled the short- and long-term effects of the first choice of a low-fat product on the subsequent purchases of calories and product volume. Results showed that purchasing low-fat crisps/chips leads to an increase in overall caloric purchases in the short- and long-term (174).

The remaining three papers looked at the impact of the 2007-2010 global recession on dietary habits. One looked at how changes in the relative price of foods affected nutrient purchases in the UK in 2007-2008 and found that price changes led to a decline in the nutritional quality of household food baskets (175). A second paper in the UK looked at how adjusting for waste affected the trend in declining energy purchases from foods during the recession (176). Energy purchases were found to decrease from 8.6MJ/adult to 8.2MJ/adult equivalent per day between 2007 and 2012, although this decrease was not significant after adjusting for waste (176). A third paper conducted in the US using Nielsen data also found that energy purchases had declined from 2003-2010 but increased slightly during the recession, with a 1% increase in unemployment associated with a 1.6-4.1 kcal per capita per day increase in the total energy purchased (177).

Cross-sectional observational studies that focussed on nutrient composition

One paper used food purchase data from Kantar to assess the nutrient content of bakery and breakfast products. They predicted that reformulating the levels of sugar, fat, fibre and salt in products of the lowest nutritional quality could lead to a significant variation in an individual's nutrient intake (178). Another paper used Kantar data in the UK to focus on the sodium content of products purchased, with table salt, processed meat and bakery products being the top contributing categories to sodium intake (179). One paper used US Nielsen data to establish if there was a difference in the nutritional quality of foods purchased based on the stores that households shop in (160), with results showing that there was no difference between the nutrient content of food products purchased primarily in grocery stores compared to other store types, including convenience and mass-merchandise stores (160).

Two other papers focused on the development or comparison of methods, rather than the results of the purchase data themselves. One paper compared the results of an in-store survey with that of food purchase data, finding that the mean sodium and sugar content of the products recorded in the in-store survey were higher than those recorded in the food sales data (180). Another outlined how food purchase data can be paired with nutrition composition data taken from multiple sources in the US, allowing for a monitoring tool to be developed that tracks the nutritional quality of foods “from factory to fork” (181).

Cross-sectional observation studies that focussed on food purchasing

Seven papers describing cross-sectional studies examined associations between the sociodemographic factors of household food and beverage purchases. Three examined the adherence of households to dietary guidelines. One paper looked at the affordability of meeting the MyPyramid fruit and vegetable scheme. They found that in 2008, a wide variety of fruit and vegetables were available at $0.40-0.50 per cup equivalent, meaning that low-income households would have to have spent 40-50% of their food budget on fruit and vegetables to meet the target amount (182). Two studies conducted with Kantar data in Scotland found that households with a higher level of deprivation were less likely to achieve the revised Scottish Dietary Goals (183)(184). Another paper that used Kantar data in Scotland analysed the expenditure on fresh foods and fruits and vegetables across urban and rural households (185). They found that rural households spent the most on fresh foods, fruits and vegetables but prices in urban locations were significantly higher, suggesting that factors other than availability and price were causing the difference (185). Two UK studies using the same Kantar dataset from 2010 also looked at food purchase patterns in households in relation to sociodemographic factors. One looked at store preferences and found that although supermarket choice and shopping behaviour were both associated with the healthfulness of purchases, neither appeared to be associated with socioeconomic differences (186). A second paper aimed to explore how food expenditure mediates socioeconomic inequalities in the healthiness of household food choices and found that higher social class was associated with higher expenditure on foods that were healthy, suggesting that lower spending on food leads to less healthy choices for lower socioeconomic groups (187).

Three studies with a cross-sectional design used Euromonitor data to analyse food sales by company. One study looked at the value sales and market shares of member companies of the International Food and Beverage Alliance (IFBA). It concluded that while the global top 10 soft drink companies account for half of global sales of soft drinks, the top 10 packaged food companies represent only 15% of global food sales (188). This means that public health commitments from these companies is likely to have a much smaller public health impact (188). Another study identified the main companies contributing to food and beverage sales in 12 countries in Asia, finding that sales of ultra-processed foods from a limited number of companies was driving the nutrition transition in the region (189). The third study used sales data paired with nutrition information collected from the packaging and nutrient profiling to assess the healthiness of India's largest food companies' product portfolios (190). Overall, they found that the healthiness of products was low, with significant variation within the same product category (190).

One paper used sales data from Euromonitor and looked at the sale of soft drinks and prevalence of obesity and type 2 diabetes in 75 countries, finding a positive association between the two (191). Another study used sales data to examine the patterns of food and nutrient purchases by BMI, finding that individuals with overweight and obesity consume more energy at all ages and 20% more fat than those individuals with a normal weight (192). One US study looked at how the food purchases of diet soda drinkers compared to those of regular soda drinkers. The results showed that diet soda consumers spent a smaller proportion of their total annual grocery spend on foods higher in energy, such as fruit juice and dairy products, and spent a higher proportion on lower fat versions of foods, such as dairy products, frozen entrees and salad dressings (193). One study examined patterns in breakfast cereal purchases in Denmark. They showed that breakfast cereal purchases were very habitual, although the persistence of the behaviour was weaker in households with one or more children, compared to single-adult households (194). Another study focussed on how breakfast cereal purchasing patterns varies depending on sociodemographic makeup of households in the US, with results showing that low income African-American and Asian households and those with one or more children purchased the most ready-to-eat breakfast cereals (195). An analysis of household sociodemographic trends in relation to price promotions in the UK found that sales of promotional items was higher in low SES households compared to high SES households. However, there was no significant SES gap in the purchase of less-healthy foods on promotion (196). Another paper used food sales data to examine consumer demand patterns for products with claimed nutritional benefits. It found that consumers are more sensitive to price decreases and less sensitive to price increases for both healthy and unhealthy food and that these sensitivities are greater for products with no nutritional benefit, supporting the hypothesis that products with nutritional benefits have a higher brand equity than those without (197).

Scenario modelling studies

Thirteen papers used purchase data to model different scenarios, with seven papers looking specifically at soft drink tax scenarios in Australia (198), the UK (199)(200) or USA (201)(202)(203)(204). All reported that an increase in the price of selected soft drink products led to a reduction in their volume consumption. Three papers used Nielsen data to model the impact of a 20% tax on selected soft drinks on body weight. The results showed a 20% tax led to weight loss ranging from 0.32kg/capita/year (202), 0.4kg/capita/year (198) to 0.7-1.16kg/capita/year (71). Three examined the impact of a tax by household income, with two finding the greatest reductions in beverage consumption and body weight for low income households (198)(199) and the other for middle income households (202). Two papers looked specifically at the impact of soft drink taxes on the diets of preschool children using UK Kantar and US Nielsen data respectively, with both finding a tax was associated with reductions in energy purchased from beverages but not with an improved total dietary intake (203)(204). One paper used Kantar data in the UK and concluded a tax on soft drinks would have a minimal impact on calorie consumption (70).

Three other papers modelled the introduction of taxes on food products. One used US Nielsen data and found that the introduction of a sodium tax on meats eaten at lunchtime reduced the consumption in terms of both products and sodium (205). The second, which used Kantar data to consider a tax on French packaged food products based on their fat and sugar content, reported small and ambiguous effects (206). The third paper also used Kantar data. It compared the effects of a tax on standard yoghurts, fromage blanc and dessert yoghurts to front-of-pack nutritional labelling in France. It found that both policies were equally effective at reducing purchases of fat from these products at around 7% and 8%

respectively, but the tax had an economic benefit to the state that the labelling policy did not (207).

Studies that specifically used company-level data

Five studies in this review were identified as using company and/or brand level data: Alexander et al 2011, Baker and Friel 2016, Jones et al 2016, Mendez Lopez et al 2017, Slining et al 2013. These studies are marked with ** in table 1, appendix 1. Four of these studies used Euromonitor sales data, while a fifth (Slining 2013) used data from Nielsen. Three papers used the sales data as economic measures in their studies, while Jones 2017 and Slining 2013 used sales data combined with nutrition composition data to measure companies' contribution to the food supply. One study (Alexander 2011) named companies specifically and one study (Jones 2017) analysed specific company contributions, although the names were anonymised.

Slining et al 2013 analysed whether companies in the United States that committed to the Healthy Weight Commitment Pledge (HWCP) reduced their total calories sold by the target 1.5 trillion calories between 2007 and 2015 and how this translated into per capita and household consumption. This was done using household panel data from Nielsen in combination with nutrition facts panel data from the Gladson Nutrition Database. The results showed that 38.5% of all calories consumed by children aged 2-18 are from companies committed to the HWCP, compared to 31% from non-HWCP companies and 30% from private label products.

Jones et al 2017 used Euromonitor sales data in combination with nutrition information collected directly from product labels to assess the healthiness of 943 products sold by the largest 11 Indian packaged food manufacturers. They found that only 17% of sales were healthy, with marked differences between products in the same category.

Discussion

This review has drawn together the wide range of studies using food purchase and sales data for public health nutrition research, identifying a range of applications including the monitoring of the nutrient content of foods over time, analysing dietary patterns by demographic factors, evaluating existing food and beverage taxes and scoring the healthiness of individual companies' product portfolios. The use of food sales data in academic research has increased rapidly in recent years, with nearly three quarters of the papers included in this review being published since 2015.

Strengths and limitations

This systematic review is the first that has looked at how food sales and purchase data has been used for public health nutrition research. The search methods were comprehensive and included business, economic and marketing journals, as well as traditional biomedical and social science journals. The searches, screening and data extraction were done in a systematic and documented manner based on the PRISMA best-practice statement for conducting systematic reviews. However, since this data is mainly used by the food industry to analyse sales performance there are likely to be other studies not included here. This review focussed on the published literature in established scientific databases and journals and the grey literature was not explored. Industry reports and policy documents at the national and international level that have used food sales data are not included. Studies that used data directly from retail outlets were excluded. This is because this review focussed on commercial data that is readily available to academics interested in this area of research. Accessing sales data from stores directly can involve significant negotiations and contracts. However, by excluding these papers, this systematic review may have missed papers with similar analyses to those reviewed here.

The quality of studies was assessed using the National Health Institute's quality assessment tool for observational cohort and cross-sectional studies. However, some of the elements in this tool were not applicable to the studies that were included, given that few had a traditional exposure/outcome study design. There may be weaknesses in the quality assessment as a result, but there were no other established tools that seemed likely to provide a more detailed critical appraisal (208)(209).

One common issue that limits the quality of the studies included in this review is that household recruitment to panels is conducted by the data providers. Data companies can and do share information on recruitment, dropout rates and participation incentives, but academic researchers themselves have no control over this recruitment process. Datasets are often incomplete, and gaps are filled by modelled data, again done by the commercial company rather than the researcher, adding to a lack of transparency at how exactly the final datasets were derived. However, these limitations are based on the data sources and cannot necessarily be overcome by the authors of individual studies. A major limitation of food purchase and sales data is that they are often very expensive, limiting their accessibility to academic researchers, unlike national food survey results, which are usually publicly available. Commercial data providers also limit what can be published, including restrictions on detailed methods and company and brand names. These weaknesses in transparency, combined with the high price tag, arguably means that sometimes the negatives of food sales data outweigh the benefits.

There are however some instances in which there are clear benefits to using food purchase/sales data compared to food consumption studies. Most studies included in this systematic review used data collected from hundreds of thousands of households, whereas dietary surveys usually have a smaller number of participants (210). Purchase and sales data are usually more granular than dietary survey data and include information on price, store location, product size, brand and manufacturer and allow a detailed demographic breakdown. Household panel data from GfK, Kantar and Nielsen are collected and updated continuously, unlike dietary surveys results, where publication is often delayed by a number of months and at a national level, generally not reported more than once a year and often less frequently.

For studies that used GfK, Kantar and Nielsen data, the size of the household panels used varies significantly from study to study; for example, a number of US studies (211)(159)(212)(160) used Nielsen data collected from hundreds of thousands of households, compared to other studies in Europe that analysed the purchases of a just a few hundred households (174)(213). Larger household panels are more likely to generate datasets that more representative of the general population’s dietary habits. Euromonitor does not conduct primary data collection and its data is based on industry research and trade interviews conducted by research analysts.

Implications of this research

The findings of this review show that food sales data can be used by public health nutrition researchers to measure dietary patterns and monitor the nutrition composition of food products over time. These data can be used as a tool for international comparisons since the commercial companies that provide food sales data are multinational and use the same methods for data collection across countries. This is particularly useful for countries that do not have national dietary surveys, whose results on dietary surveys are poor or whose dietary surveys are carried out irregularly.

Five studies were identified as using company-level data in their analysis. Two of these studies used company-level data in combination with nutrition composition data to assess company-level contributions to the nutritional quality of the food supply in India and in the US. In the case of the US study (Slining 2013), companies were grouped and analysed according to whether or not they participated in the Healthy Weight Commitment Foundation and were not named. In the case of the study in India (Jones 2017), the healthiness of 11 companies' products was assessed, but companies were not named.

Monitoring how companies react to voluntary policies and greater accountability surrounding the nutritional quality of companies' product portfolios is an important element of public health nutrition research. The results of this systematic review show that a small number of studies have done this to some extent, it is an area of research that is currently underexplored. As well as the academic studies included in this review, there are other initiatives that have done this, including the Access to Nutrition Index (ATNI). This uses Euromonitor sales data and nutrition information to rank the quality of the world's top 22 food and beverage companies by the nutritional quality of their products (214). INFORMAS (International Network for Food and Obesity/NCD Research, Monitoring and Action Support) uses Euromonitor sales data to identify prominent food companies in different sectors as part of their Business Impact Assessment on Obesity and Population-level Nutrition (BIA-Obesity) tool, whereby company policies and commitments to obesity and population health are assessed (215). Public Health England uses food sales data from Kantar to evaluate progress being made towards the 20% sugar reduction targets they set for selected food categories, although this is being done by food category and not company (216).

Recommendations for future research include reviewing the grey literature, where food purchase and sales data has been used by a host of different actors, including government departments, food manufacturers, marketing companies and investment banks. A review of studies that use food purchase data directly from supermarket stores and chains is also recommended. Further discussions with data providers, researchers who have used these data and economists are also recommended to draw out detailed case-studies on how food sales data can best be used to improve public health.

Conclusion

The results of this systematic review have shown that food purchase and sales data can be used by public health nutrition researchers to measure dietary patterns, estimate nutritional intake, track the nutritional composition of food products over time, model disease outcomes and evaluate policies. Its use in academic research has increased significantly the last few years and despite its high cost, lack of transparency over household recruitment and imputed data and some restrictions in publication. The use of food sales data has great potential when it comes to evaluating some food policy interventions, including tracking the nutritional quality of the food supply and assessing how individual food companies are responding to mandatory or voluntary targets. However, researchers using these data should be fully aware of their limitations and contextualise their findings accordingly. The authors also call for food sales data providers to be more transparent with their data collection methods to ensure that public health nutrition researchers using their data meet the standards required for peer-reviewed literature.

In context of this thesis, this systematic review has identified six potential sources of food sales data that could be used in combination with nutrition composition data to analyse the nutritional content of companies' products in the UK. The next step is to analyse how suitable these sources are for this specific analysis. This review also highlights that current methods to assess how companies are responding to policies that aim to improve public health outcomes are underdeveloped.

Chapter 3: Data sources and methods of analysis

Chapter summary

This chapter tests the suitability of the data sources of identified in the systematic review (Chapter 2) for answering the research questions in this thesis. Six data sources are first narrowed down by using a set of selection criteria and an adapted version of a quality assessment tool, before two datasets, Euromonitor and Kantar, were cross-compared to assess whether the choice of data source is likely to have a meaningful impact on the results presented in this thesis. While Euromonitor and Kantar sales volumes varied significantly, the sales-weighted mean sugar content and nutrient profiling scores for comparing the healthiness of company portfolios were similar. Euromonitor sales data was selected for use in this thesis, based on the fact that it seemed to cover a larger proportion of the market, the results of analyses using the data could be freely published (while Kantar imposed restrictions) and the data was accessible through the Oxford University Library system at no extra cost. For the analysis chapters of this thesis, the sales data were paired with nutrition composition data from Brand View, which was collected by scraping the websites of online retailers Tesco, Sainsbury's and Asda on the same day in four consecutive years.

Introduction

The systematic review of the use of sales data for public health research identified six companies as potential sources of food sales data in the UK. These companies are Euromonitor, GfK, IRI, Kantar, Mintel and Nielsen. The aim of this analysis was to identify which of these six sources of food sales data was most suitable to answer the main research questions of this thesis, as outlined in Chapter 1, and to then identify a compatible source of nutrition composition data.

To be a suitable data source of sales data for the analyses presented in this thesis I considered that it must satisfy four criteria: 1) It must provide appropriately granular data on both sales value and sales volumes for food and soft drink products in the UK; 2) the methods used to construct and maintain the database must be robust and transparent; 3) Access to and use of the data must not be constrained by terms and conditions that will affect the reporting of results; 4) the cost of accessing the database must be within the resource limitations of the project, set at £5,000 per year of data.

In order to test the suitability of the data for the methods planned, a single food category was identified. This also saved on resources, as food sales data from the sources identified in the systematic review (chapter 2) are mainly purchased and used by manufacturers and retailers, and so prices are set at levels acceptable for the food industry and are often beyond academic budgets. The soft drinks category was chosen because it is a distinct and easily definable category, ensuring the datasets from each source would be cross-comparable. Given the current interest in this category with the announcement and implementation of the soft drink industry levy in the UK (217), it also seemed like a pertinent category to be analysing first.

The aims of this chapter are to: 1) assess the possible data sources against selection criteria and an adapted version of the National Institutes of Health's Quality Assessment Tool for Cohort and Cross-sectional Studies 2) and to conduct a cross-validation study to assess whether the choice of data source is likely to have a meaningful impact on the results presented in this thesis and 3) identify a suitable source of nutrition composition data.

Methods

The methods for this study were broken into three steps: 1. The six companies were narrowed down based on selection criteria; 2. The remaining data sources were compared using an adapted version of the National Institutes of Health's Quality Assessment Tool for Cohort and Cross-Sectional Studies; 3. A cross-validation study was carried out to test the differences in results.

Step 1

For each of the six data sources, details on the methods used to compile their datasets and how their data are presented were obtained from company websites, published papers and personal correspondence in the form of emails, phone calls and face-to-face meetings over the course of this project. Each company was approached and asked to provide a quote for a single year of disaggregated value and volume sales data for soft drinks in the UK. The information compiled was then used to assess whether or not the companies met the four criteria described above.

The following scoring system was used for the four criteria:

Criteria 1: Granularity of data

For the analyses presented in this thesis the sales data had to include information about brands and manufacturers. Sources that only provided sales data by category received a score of 0. Sources that provided data at the brand level received a score of 1 and individual product level data scored the maximum of 2.

Criteria 2: Methods

The six companies identified have three main research methods: secondary data collection/desk research, primary data collection via household panels and primary data collection via point of sale (i.e. scan data from retailer checkouts).

Sources that base their research methods on desk research – that is secondary data collected from the trade press, public and national records, company reports and trade interviews – received a score of 0. This is because the exact sources of the data are not available and so reliability, transparency and accuracy of the data are all open to question.

Sources that use household panels, recruit participants from the general population and therefore provide data that is representative of actual purchasing including purchases from multiple stores (218). However, recruitment methods, incentives for participation, recruitment biases and drop-out rates are not transparent (219). Data sources that use household panels received a score of 1.

The third research method is point of sale (POS). This is where a sample of retail outlets is selected and all items scanned and purchased at the checkout are recorded (220). However, store recruitment and how representative these stores and purchases are to the total population are not known (221). Despite this, it is the most objective and robust method of the three and reduces misreporting. Sources that use POS for data collection received a maximum score of 2.

Criteria 3: Publication restrictions

Data must not be constrained by terms and conditions that will affect the reporting of results. Any company that imposes such restrictions received a score of 0. If the company does not impose any restrictions and the data can be freely used, it received the maximum score of 2.

Criteria 4: Cost of data

A limit of £5,000 for a single year of soft drinks data was set as a reasonable public investment given the value of the analyses which may be generated. Any company that provided a quote that exceeded this received a score of 0. If a data source quoted less than this, it received the maximum score of 2.

Step 2

A single year of soft drinks data was acquired from the companies that received the highest score according to the suitability criteria. The strengths and weaknesses of each of these selected data sources was assessed using an adapted version of the NIH Quality Assessment Tool. This tool, formed of 14 questions based around study design, study population and selection and outcomes, is designed to determine the overall quality and establish the internal validity of an observational or cross-sectional study. The tool was created for the use of more traditional academic studies, but was the only relevant tool to assess the quality of the databases included in this piece of research.

Step 3

These data were compared in a cross-validation study. Using each sample data set (sales volumes of soft drinks and nutrition composition data directly from each data source company), the following variables were calculated for each soft drink manufacturer in 2015.

- Total sales volume of soft drinks (millions of litres)
- Total sugar volume (tonnes)
- Unweighted mean and sales-weighted mean sugar content (g/100ml) of brands
- Sales-weighted mean nutrient profiling score. The UK FSA/Ofcom nutrient profiling model was applied to the composition data and used to assess the healthiness of companies' product portfolios by calculating a sales-weighted score.

Data analysis

A chi-squared test was used to test for significant difference between the results. Spearman's rank order correlation coefficient was used to test for a difference between the ranking of the soft drink companies between each data source. A Bland-Altman test was used to test the variation between the two sources, whereby the mean of the nutrient profiling scores by company was calculated between the datasets and plotted against the difference between the means. If the data sets are in alignment, then the markers appear close to the central line. Data points that fall above or below the upper or lower limit (95% confidence interval calculated around the total mean difference) are significantly different. All analyses were completed in R and Excel, with some figures being produced in Tableau.

Results

Step 1: Selecting data sources

All six companies could provide data on volume and value sales of soft drinks disaggregated to the brand level (see **Table 5**). However only three companies (IRI, Kantar and Nielsen) provide sales data at the individual product level. Two of the companies (IRI Worldwide and Mintel) did not respond to requests for a quote for the provision of data. Two further companies (GfK and Nielsen) provided quotes higher than the maximum amount available to this study.

Table 5: Food sales data companies, their data types and criteria for selection

	Euromonitor	**GfK**	**IRI Worldwide**	**Kantar**	**Mintel**	**Nielsen**
Data collection method	Desk research	Desk research	Point of sale	Household panel	Desk research	Point of sale
Volume Sales	Yes	Yes	Yes	Yes	Yes	Yes
Value Sales	Yes	Yes	Yes	Yes	Yes	Yes
Product price	Some	No	Yes	Yes	No	Yes
Brand/ company sales	Yes	Yes	Yes	Yes	Yes	Yes
Level of granularity	Brand	Brand	Individual product	Individual product	Brand	Individual product
Paired nutrition composition data	Yes	No	Unknown	Yes	New products only	No
Data split by demographic	No	No	Yes	Yes	No	Yes
Price of soft drinks dataset	No cost	£50,000	Unknown	£5,000	Unknown	£97,000

Using the information given in **table 5**, each company was scored based on the four criteria outlined in the methods section. These scores are given in **Table 6** below.

Table 6: How food sales data company scores against each of the four suitability criteria

	Euromonitor	**GfK**	**IRI**	**Kantar**	**Mintel**	**Nielsen**
Criteria 1: Does the source provide data at an appropriately granular level? **(No, 0. Brand level data, 1. Individual product level data, 2.)**	1	1	2	2	1	2
Criteria 2: Are the methods used to construct and maintain the database robust and transparent? This will be determined by the type of research method. **(Secondary data collection, 0. Household panel, 1. Point of sale, 2.)**	0	0	2	1	0	2
Criteria 3: Does the data source allow for the results of studies conducted using their data to be freely published? **(No, 0. Yes, 2)**	2	Unknown	0	0	2	0
Criteria 4: Is the cost of a single year of data of aggregated soft drinks data £5,000 or less? **(No, 0. Yes, 2).**	2	0	Unknown	2	Unknown	0
TOTAL SCORE	**5**	**1**	**4**	**5**	**3**	**4**

Euromonitor and Kantar were the two companies that received the highest total score (5) during the criteria assessment. They were selected for a more detailed comparison and cross-validation (described later). GfK and Nielsen were excluded because they failed the fourth criteria on price. IRI and Mintel were excluded because they failed to respond to email requests enquiring about the cost of data. It was therefore assumed that these companies were not willing to work on academic projects.

Step 2: Comparison of data sources

The comparison of Euromonitor and Kantar was comprised of two stages. First, more detailed information about each company's data was explored, including data types, data collection methods and strengths and weaknesses, the results of which are given below. Their data collection methods were then assessed using an adapted version of the NIH Quality Assessment Tool for Cohort and Cross-Sectional Studies (222).

Euromonitor

Company background

Euromonitor is a privately-owned market research company that collects data on sales of thirty types of consumer goods including packaged food and soft drinks. It provides data for 80 countries through its online portal 'Passport', produces analytical reports and articles and also has a consultancy group.

Data collection methods and coverage

Research is done on an annual basis via desk research, Researchers use the previous year's figures as a basis and then collate publicly available data including economic indicators, national statistics, data from trade associations and the trade press, company reports and data received directly from companies. These data are validated by conducting trade interviews, whereby the industry provides feedback on Euromonitor's data. Over 200 food and beverage categories are covered in its data, including bakery products, confectionery, dairy, ice cream, snacks, ready meals, carbonated drinks, energy drinks and juice.

Data types

Data type 1: Annual retail sales in value terms by category, company and brand.

This is the total value sales (£m) of the product sold through retail channels (supermarkets, corner shops etc) in a given year. This can then be split further down to sales for an individual company and brand, in both actual and % terms.

Example: £22.1million was spent on ready to drink teas in the UK in 2015.

Data type 2: Annual retail sales in volume terms (tonnes/mn litres)

This is the total volume of the product sold through retail channels in a given year. For soft drinks, this data is also available at the company and brand level, but not for packaged food products.

Example: 12 million litres of ready to drink teas was sold in the UK in 2015.

Data type 3: Nutrition composition data

Euromonitor collected the nutrition information for one product per brand in 2014 and 2015 only.

Example: Lipton Ice Tea Peach Flavour contains 6.5g sugar per 100ml

Access and pricing

Students and staff with an Oxford email address all have access to the Euromonitor database Passport as the library has a University-wide subscription. Data is available for packaged food and soft drinks. Nutrition data is excluded from the current subscription. The subscription to the Euromonitor database is managed by the central University library with access at no extra cost for research projects.

Strengths

The strengths of this data set are that it is readily accessible, requires no extra cost and does not impose publishing restrictions (as long as data is not directly reproduced). Sales data are disaggregated by company and brand and the historic time series goes back 15 years (143).

Weaknesses

The data is based on secondary data sources and data is collected once a year. There is an element of data validation built into their data collection methods, as analysts conduct trade interviews with manufacturers and retailers, which comment on the results and provide additional data. Euromonitor does not produce a demographic breakdown of its sales data and its dependency on individual analysts makes its methods somewhat subjective and therefore its data are unlikely to be reproducible. A general list of data sources for their whole packaged food and soft drinks research programme is available upon request, sources are not provided for each data point and therefore the data is not completely transparent.

The sales data is only given by brand and not by individual product. This meant that individual product level composition data had be averaged before it could be paired with the corresponding brand's sales data (Chapters 4 and 5). The nutrition composition data from Euromonitor is only for one product per brand and is collected once per year. The nutrition information for brands with multiple product flavours and varying nutritional content - e.g. Innocent juice and smoothies – is therefore limited.

Kantar World Panel

Company background

Kantar is a business intelligence company that looks specifically at consumer behaviour and purchasing patterns. It covers many different consumer goods sectors, including the food and beverage market.

Research methods and coverage

Kantar's UK data is based on a panel of 30,000 households which are recruited to reflect the UK population's demographics in terms of geographical spread and household income. Participation in the panel is rewarded with high street shopping vouchers. Households are provided with a hand-held scanner and/or mobile app and are asked to scan the barcode of everything that is purchased by household members. Product information – brand, price, promotion, pack size and retailer – is all recorded from the barcode and purchases are also validated against the till receipt. The results of the household panel are then scaled up to represent the whole population. Kantar provide both the raw, household panel data as well as annual figures representative of annual totals. Kantar also conducts store audits twice annually by analysts who manually record the nutrition information from the back of the pack for an estimated two-thirds of available products.

Relevant data types

Data type 1: Annual retail sales in value terms by category, company and brand

This is the total value sales (£m) of the product sold through retail channels (supermarkets, corner shops etc) in a given year. This can then be split further down to sales for an individual company and brand in both actual and % terms.

Example: £22.1million was spent on ready to drink teas in the UK in 2015.

Data type 2: Annual retail sales in volume terms (tonnes/mn litres)

This is the total volume of the product sold through retail channels in a given year. This can be split further to looking at an individual company and brand level

Example: 12 million litres of ready to drink teas was sold in the UK in 2015

Data type 3: Household-level purchase data

The household-level data that is collected using the hand scanners is available and is split by region, income and other demographic factors.

Household 1001 spent £2.00 on 2 x 2 litre bottle of Diet Coke week commencing 03/02/15

Data type 4: Nutrition composition data

Kantar provides each line of sales data with paired nutrition composition data. This is collected directly from the back of the pack in a manual supermarket store check that is carried out twice a year. Missing data is imputed using category averages.

Example: Lipton Ice Tea Peach Flavour contains 6.5g sugar per 100ml

Access and pricing

As Kantar do not provide a subscription service, a quote for the volume sales of soft drinks for 2015, along with the nutritional information for each brand (i.e. sales and composition data linked by bar code) was sought over the phone. A price of £5,000 was agreed.

Strengths

Data is collected continuously from a large sample size of 30,000 households in the UK, although the participation rate also continuously fluctuates. The raw scan data is available by demographic breakdown (geographical region/postcode, number of individuals per household, age, household income etc) and is supposed to be representative of the UK's population, although this is hard to validate.

Weaknesses

This is a costly dataset. While purchasing the single category met the inclusion criteria for this stage of the project, the quote given for all grocery products was £165,000 for a single year (2017). This price is too high for this DPhil project and would not allow for a time series analysis. The other major limitation with Kantar is that, in this case, they sought to impose restrictions on publishing company and brand names. Other issues of concern include the transparency and reproducibility of the data, especially with the composition data. This was collected directly from the back of the pack in a manual store-check exercise and is repeated every six months. However, it is not known which products were last updated and missing data is imputed with data calculated from the category average.

In order to objectively assess the quality of the methods of each data source, the National Institutes of Health (NIH) Quality Assessment Tool for Cohort and Cross-Sectional Studies was adapted and applied (222). The adapted tool and the results for Euromonitor and Kantar as given in **Table 7** below.

Table 7: Results of the adapted Quality Assessment Tool as applied to Euromonitor and Kantar's research methods

Criteria	Euromonitor	Kantar
1. Was the study population clearly specified and defined?	Yes	Yes
2. Was the participation rate of eligible persons at least 50%?	The eligibility criteria for companies to be included in Euromonitor's research is unknown	The proportion of approached households that agreed to participate in the panel is unknown.
3. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	N/A	Households are reportedly representative of the general population and are recruited based on geographical location, socio-economic status, education level and ethnicity.
4. Was a sample size justification, power description, or variance and effect estimates provided?	No	No
5. Is the timeframe sufficient so that the data collected is reflective of the whole market/general population?	The research is conducted annually	The recruitment and data collection to the panel is continuous.

6. Were recruitment biases and participation incentives clearly outlined and addressed?	No information known about recruitment bias, but there were no participation incentives	No. No information is known about recruitment bias. The only information known about participation incentives is that households receive high street vouchers in exchange for their participation.
7. Was loss to follow-up after baseline 20% or less?	N/A	Drop-out rates are not reported

The poor transparency and reproducibility of the data are limitations with both sources, although this is common when working with data collected by a third-party company and cannot necessarily be overcome by academic researchers using the data. The restrictions placed by Kantar on the publication of their data – suggested that Euromonitor was likely to be the more viable data source. However, to test the level of detail in the data and compare the difference in results between the two datasets, a cross-validation between Kantar and Euromonitor was carried out.

Step 3: Cross-validation

Results from using the Kantar database

The Kantar dataset showed that the UK population purchased a total of 5.5 billion litres of soft drinks in 2015, or 0.23 litres per person per day. This is equivalent to 229,000 tonnes of sugars, or 9.6g per person per day. Non-diet carbonated products were the single largest contributing category to the volume of sugars purchased from soft drinks, at 41%, with a sales-weighted mean sugar content of 8.0g/100ml. Both the fruit juice and non-diet still categories had a higher mean sugar content (9.6g/100ml and 8.2g/100ml respectively) than the non-diet carbonated category.

Results from using the Euromonitor database

The Euromonitor database showed that the UK population purchased 8.97 billion litres of soft drinks in 2015, or 0.37 litres per person per day. This is equivalent to 346,000 tonnes of sugar, or 14.5g per person per day. Like the Kantar database, non-diet carbonated products were the single largest contributing category to the volume of sugars purchased from soft drinks, at 63%, with a sales-weighted mean sugar content of 8.1g/100ml. The Euromonitor fruit juice category was found to have a similar mean sugar content to Kantar, at 9.1g/100ml, however Euromonitor non-diet still category had a lower mean sugar content; 5.2g/100ml compared to 8.2g/100ml for Kantar.

Comparison of results

There are large differences in the volume sales of the top 20 companies between Kantar and Euromonitor, with a 44% difference in the total volume sales between the two data sources (**Table 8**). Given these differences in volume sales, there is also a significant difference in the calculated tonnes of sugars sold between the two data sources at the total and company level. Differences between the mean sugar content and mean nutrient profiling scores of products (**Table 9**) are much smaller and the Bland-Altman plots (**Figures 6 and 7**) confirm that there is no statistically significant difference between Euromonitor and Kantar data when looking at both mean sugar content of products and mean nutrient profiling scores.

Table 8: Comparison of Euromonitor and Kantar sales volumes and total sugar volumes for the top 20 soft drink companies in the UK in 2015

Company name	Euromonitor rank (volume sales)	Kantar rank (volume sales)	Euromonitor volume sales ('000 litres)	Kantar volume sales ('000 litres)	% difference	p-values (Chi Squared test)	Euromonitor total sugars sales (tonnes)	Kantar total sugars sales (tonnes)	% difference	p-values (chi-squared test)
Company A	1	1	1,995,000	954,000	-0.52	0.21	123,000	44,000	-0.64	<0.001
Company B	2	2	1,183,00	777,000	-0.34	<0.001	169,000	20,000	-0.88	0.00
Retailer A	3	3	756,000	775,000	0.03	<0.001	34,000	26,000	-0.23	0.01
Company C	4	8	493,000	116,000	-0.76	<0.001	6,000	2,000	-0.72	0.31
Retailer B	5	4	485,000	440,000	-0.09	<0.001	26,000	15,000	-0.42	0.03
Retailer C	6	5	482,000	320,000	-0.33	<0.001	23,000	11,000	-0.51	0.00
Company D	7	7	392,000	143,000	-0.63	<0.001	23,000	13,000	-0.46	<0.001
Company E	8	6	357,000	148,000	-0.59	<0.001	1,000	825	-0.40	1.00
Company F	9	9	200,000	120,000	-0.40	<0.001	20,000	8,000	-0.61	0.04
Company G	10	NA	194,000	NA	NA	NA	16,000	NA	NA	NA
Company H	11	11	187,000	68,000	-0.64	0.00	0	10	NA	0.57
Company J	12	13	141,000	53,000	-0.62	0.00	5,000	1,800	-0.67	0.32
Company K	13	12	106,000	63,000	-0.40	<0.001	6,000	1,700	-0.72	0.05
Company L	14	10	105,000	68,000	-0.35	0.09	8,000	6,000	-0.27	0.09
Company M	15	18	68,000	4,000	-0.94	0.08	0	4	NA	0.48

Company N	16	15	66,000	9,000	-0.87	0.11	7,000	550	-0.92	0.11
Company O	17	16	26,000	6,000	-0.75	0.21	1,000	330	-0.75	0.21
Company P	18	17	23,000	6,000	-0.75	0.00	195	400	1.08	0.52
Company Q	19	14	23,000	35,000	0.53	<0.001	1,300	3,000	1.22	0.01
Company R	20	19	16,000	2,000	-0.86	0.02	1,500	200	-0.87	0.52
Total			***7,300,000***	***4,107,000***	***-0.44***	***<0.001***	***474,000***	***154,000***	***-0.68***	***<0.001***

Table 9: Comparison of Euromonitor and Kantar nutrient profile scores and mean sugar content (g/100ml) for top 20 soft drink companies in the UK in 2015

Company name	Euromonitor sales-weighted mean nutrient profile score	Kantar sales-weighted mean nutrient profiling score	% difference	p-values (chi-squared test)	Euromonitor sales-weighted mean sugar content (g/100ml)	Kantar sales-weighted mean sugar content (g/100ml)	% difference	p-values (chi-squared test)
Company A	68.3	68.4	0.1%	0.85	5.3	5.2	-1.9%	0.87
Company B	67.0	68.7	2.5%	0.37	9.2	4.4	-52.2%	0.40
Retailer A	69.9	70.5	0.9%	0.53	3.5	5.8	65.7%	0.06
Company C	69.3	69.3	0.0%	0.99	2.7	3.0	11.1%	0.73
Retailer B	69.9	70.6	1.0%	0.51	3.6	4.8	33.3%	0.21
Retailer C	69.6	70.9	1.9%	0.22	3.5	5.2	48.6%	0.39
Company D	67.2	67.9	1.0%	0.71	8.6	6.9	-19.8%	0.79
Company E	69.3	68.9	-0.6%	0.73	2.3	3.2	39.1%	0.51
Company F	67.6	67.9	0.4%	0.72	6.8	7.5	10.3%	0.85
Company G	74.0	NA	NA	NA	8.1	NA	NA	NA
Company H	70.0	70.0	0.0%	NA	0.0	0.5	NA	0.57
Company J	70.0	68.9	-1.6%	0.30	2.3	3.2	39.1%	0.68

Company K	69.7	70.3	0.9%	0.48	6.2	5.5	-11.3%	0.89
Company L	78.0	75.9	-2.7%	0.40	8.1	9.5	17.3%	0.26
Company M	70.0	69.6	-0.6%	0.81	0.0	1.3		0.48
Company N	66.0	67.4	2.1%	0.54	11.0	7.2	-34.5%	0.54
Company O	73.0	70.4	-3.6%	0.47	5.7	5.8	1.8%	0.76
Company P	68.7	68.1	-0.9%	0.04	4.8	7.1	47.9%	1.00
Company Q	66.7	67.4	1.0%	0.52	10.1	7.5	-25.7%	0.40
Company R	76.7	68.3	-11.0%	0.02	9.0	7.6	-15.6%	0.64
Mean	**70.0**	**69.4**	**-0.9%**	**0.54**	**5.40**	**5.53**	**2.4%**	**0.05**

Figure 6: Bland-Altman plot to test differences between methods; Euromonitor vs Kantar sales-weighted mean nutrient profile scores by company

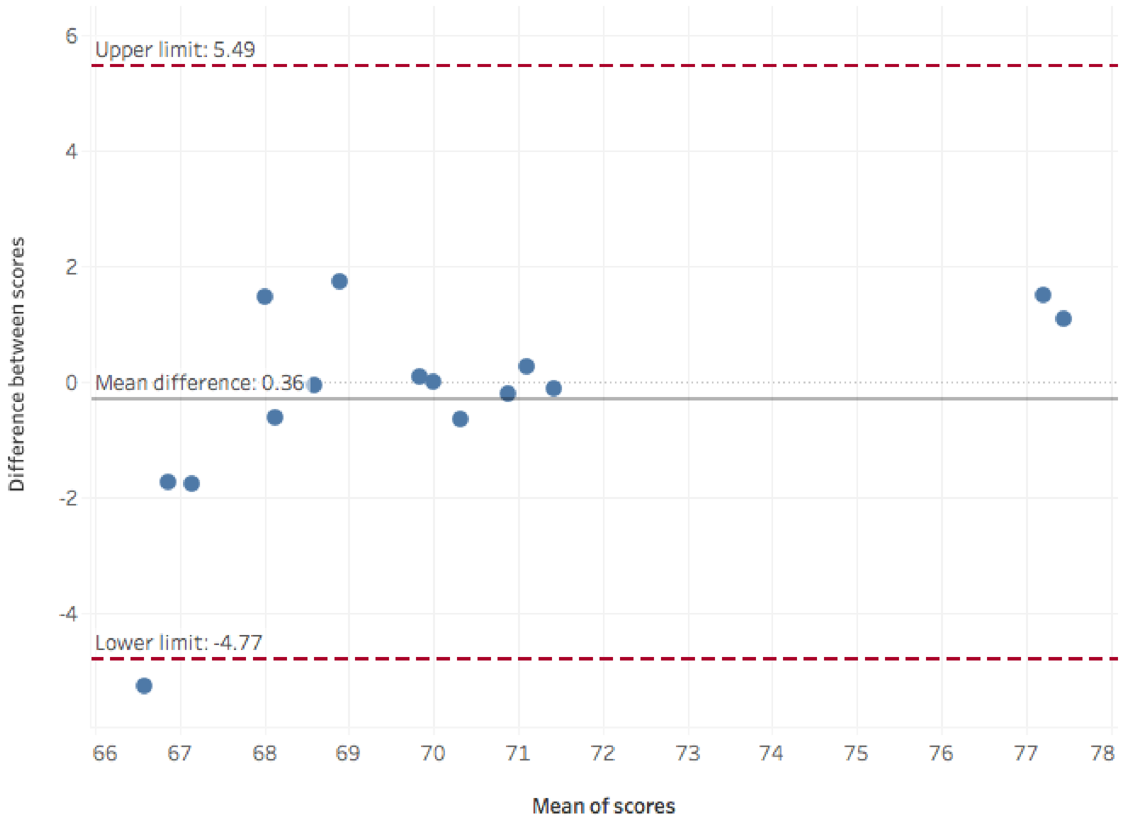
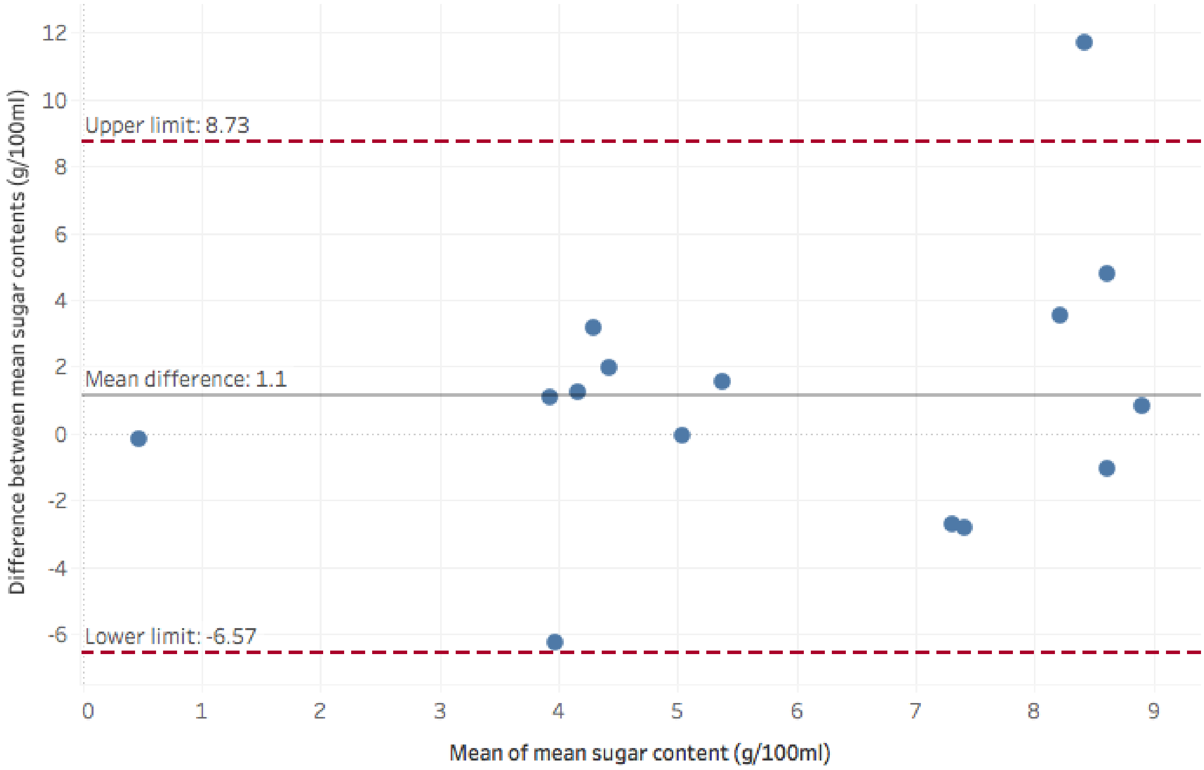
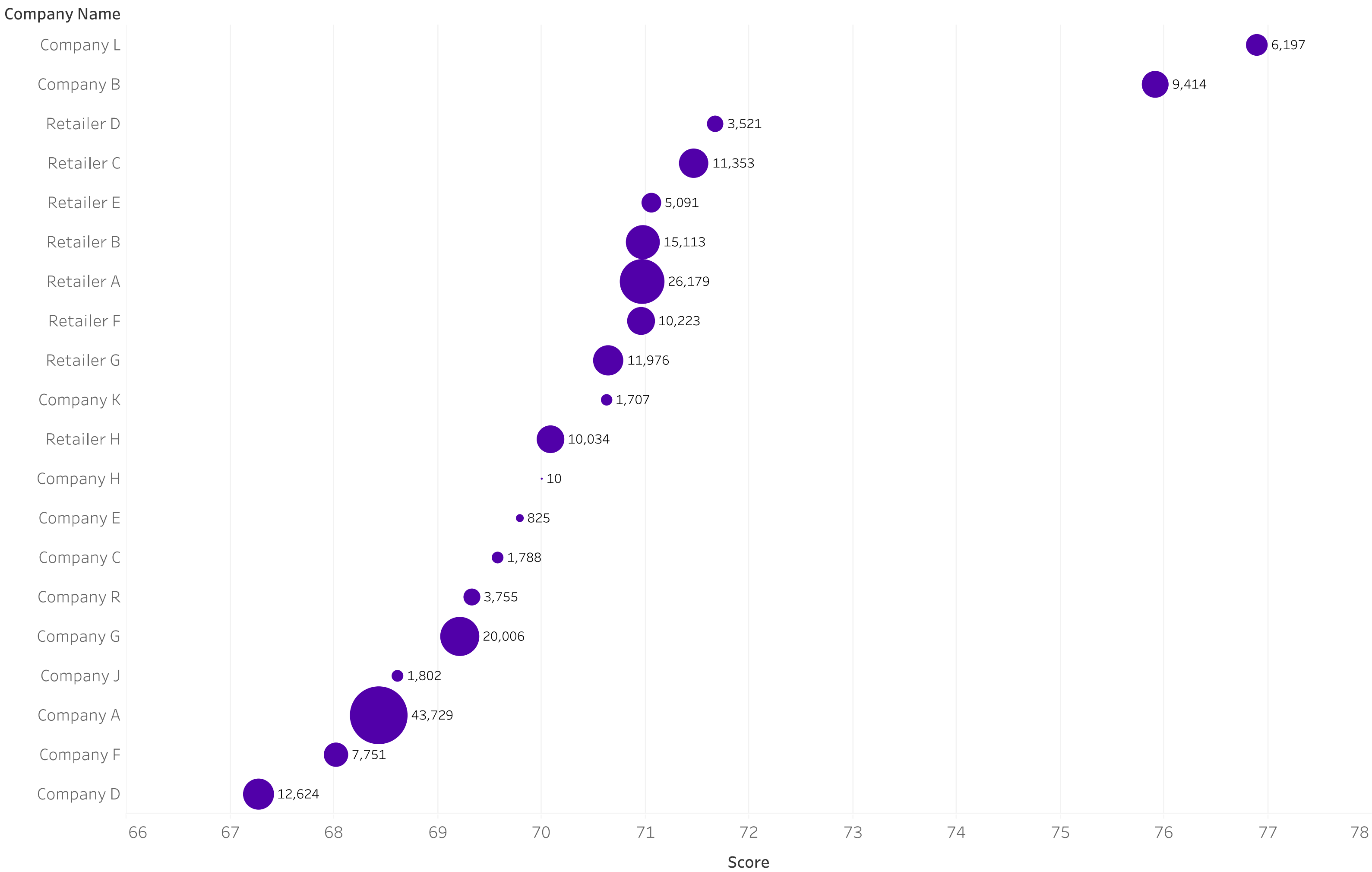


Figure 7: Bland-Altman plot to test differences between methods; Euromonitor vs Kantar sales-weighted mean sugar content (g/100ml) by company



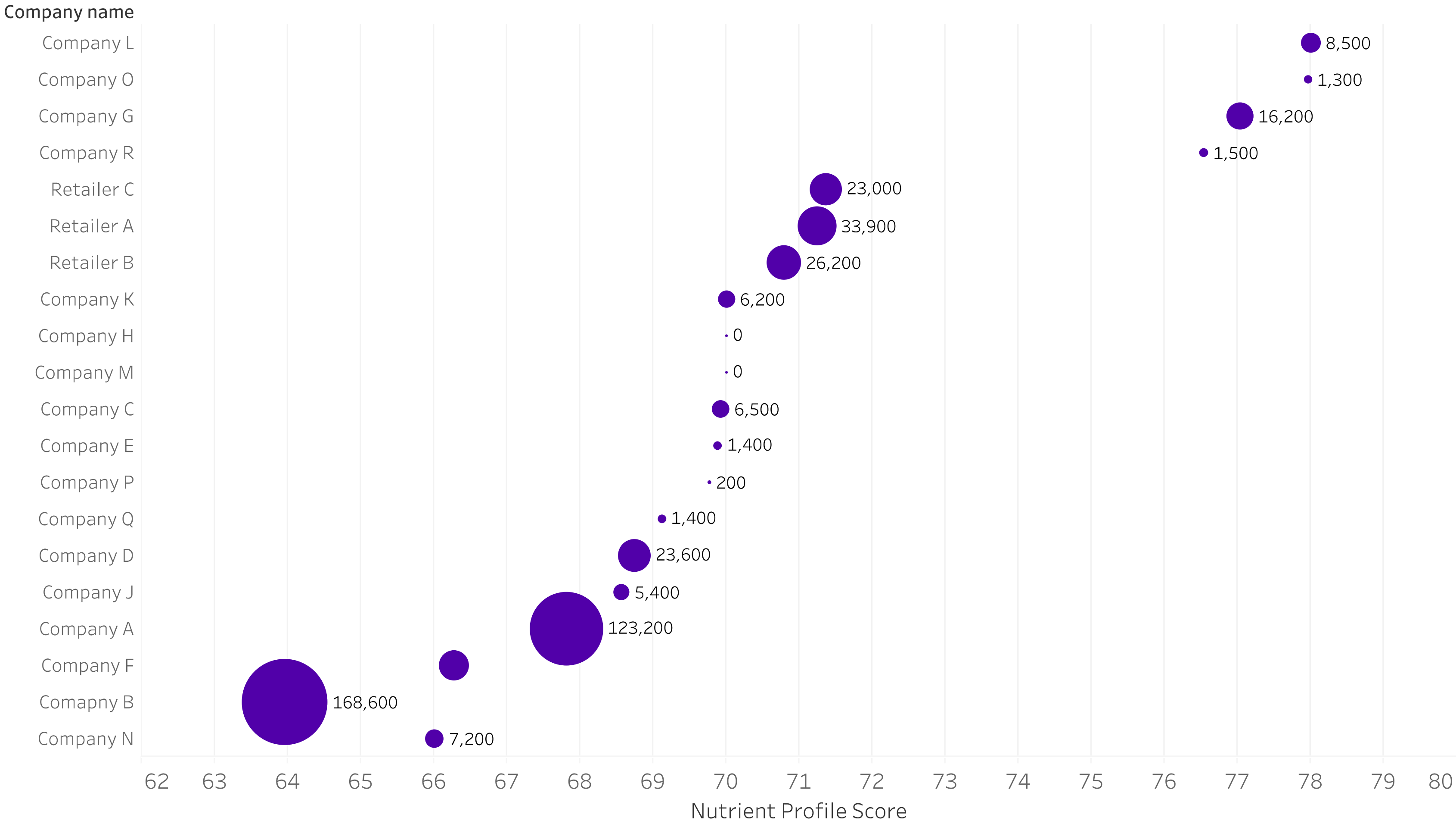
Figures 8 and 9 show that the nutritional quality of companies' product portfolios can be ranked and their relative impact on the food supply – the total tonnes of sugar sold – can be used to compare companies. The highest-ranking companies in terms of nutrient profiling score were juice manufacturers Company G, Company L and Company O, with retailers scoring higher than big brands, partly because of their high sales of own-label juices. The results of the Kantar data have Company B scoring much higher than Euromonitor – this is because of differences in how companies are classified, with Kantar including Company G under its parent company name (Company B) and Euromonitor including it under its UK company name, Company G. Because juices receive positive points from fruit and vegetable content, their nutrient profile score is higher than still and sparkling water. The bubble size refers to the total tonnes of sugars sold in 2015, with both Euromonitor and Kantar results showing that the top three companies contributing to sugar sales were Company A, Company B and Retailer A.

Figure 8: Kantar Soft Drink Company Index 2015. Sales-weighted nutrient profile score and total volume of sugars sold by top 20 companies



The size of the bubble and label refer to the total tonnes of sugar sold by company in 2015

Figure 9: Euromonitor Soft Drink Company Index 2015. Sales-weighted nutrient profile score and total volume of sugars sold by top 20 company



The size of the bubble and label refer to the total tonnes of sugar sold by company in 2015

Discussion

Of the six possible data sources this detailed analysis and comparison showed that Euromonitor is the best suited source of sales data for this project. This is because it is an affordable and readily accessible source of sales data and that the provider did not impose any restrictions on the results. The only viable alternative was Kantar and a cross-validation study with the more detailed Kantar data shows different results in terms of total volume sales of soft drinks and sugars, but that the differences between company rankings in nutrient profiling scores, and mean sugar content were small.

The process for identifying the most appropriate source of data has been novel and methodical. First, the potential sources of food sales data were identified from the systematic review, and then these sources narrowed down by using a strict set of criteria. While the NIH Quality Assessment Tool seemed like the most suitable tool to assess the quality of the methods, there are some elements specific to these datasets that it does not capture. For example, some of the data from Kantar is imputed and this cannot be captured under any of the assessment tool questions as it is currently published. This highlights that there are specific limitations to these datasets that a generic quality assessment tool will not capture.

Ideally, data would have been compared from all six sources, rather than just from two. However, this would not have been financially viable. While the soft drinks category was pertinent for analysing, it may not have been most appropriate for this study. The company index that will be built from the sales data and nutrient composition data will be based on the scores of the UK FSA/Ofcom nutrient profile model. This applies scores based on seven criteria, whereas soft drinks are only scored on three of these: their energy, sugars and fruit and vegetable content. If the cross-validation had been run again on a more nutritionally complex food group, the results may have been different.

The principal difference observed between Kantar and Euromonitor is in the total volume sales of soft drinks but also of sugars. The significantly lower volumes recorded by Kantar could be accounted for by the fact that household panel data is underreported (229). This may be particularly true for soft drinks given that often they are immediately consumed on purchase (230) and not brought back to the home and scanned.

Table 10 shows how the results of Euromonitor and Kantar compared with NDNS data (12) and the volumes reported in the 2016 British Soft Drinks Association (BSDA) annual report (231).

Table 10: The reported volumes of soft drink consumption/sales in the UK in 2015 by different sources

NDNS category	Euromonitor	Kantar	NDNS	BSDA
Bottled water (ml per person per day)	71	35	-	107
Diet carbonates	45	64	-	95
Non-diet carbonates	114	49	-	116
Non-diet concentrates	33	3	-	16
100% fruit juice	34	28	-	40
Total soft drinks (ml per person per day)	**322**	**231**	**129**	**553**

Considering that Euromonitor data covers a larger proportion of the soft drinks market – by including sales from corner shops, markets and vending machines, for example – and that their volumes are closer to those reported by the BSDA, it seems that Euromonitor data better represents the total soft drinks market than Kantar data.

Presentation of company names is an important factor for these analyses and thesis aims, and is not permitted by Kantar. All company names had to be anonymised for this thesis, making comparison between data sources difficult. These restrictions would also apply for peer-reviewed papers and is an important limiting factor for using Kantar data.

The robustness and transparency of commercial data is one of the major limitations in using food sales data for academic research. The results of the quality assessment highlighted limitations in the data collection methods for both Euromonitor and Kantar. The eligibility criteria for companies to be selected for research by Euromonitor are unknown and the exact sources used to compile the data are not shared. For Kantar, the participation rates, some aspects of the incentives for recruitment and drop-out rates are all unknown. However, the fact that these sources are used by the industry in some ways mitigates their limitations. Indeed, traditional methods of dietary measurement also have their limitations and it is accepted that the consumption volumes for soft drinks reported in NDNS are underreported (232)(233)(133).

Nutrition composition data

Nutrition composition data provides information on the nutrient content per 100g or per 100ml of food and drink products. These data are calculated based on chemical analysis of foods or estimated based on the nutrient content of ingredients. In the UK, it is mandatory for nutrition information, i.e of energy, fat, saturated fat, carbohydrates, sugars, protein and salt to be declared on pre-packaged foods (223). Fibre is not subject to mandatory labelling. Pre-packaged foods must also declare a full ingredients list and if a product name refers to ingredients (e.g. carrot and coriander soup), then the proportion of those ingredients mentioned must be declared in the list (224).

Historically, the UK national food composition data was published in book format as 'McCance and Widdowson's The Composition of Foods', but is now updated and managed online by Public Health England (PHE) as the 'Composition of Foods Integrated Dataset (CoFID)' (225). The 2019 version of CoFID contains the nutrition composition data of 2910 generic foods (226). While CoFID is comprehensive – its data is based on multiple samples and includes ambient, frozen, fresh and processed foods – the information given is generic (e.g. mayonnaise, standard, retail) and does not include information by brand or manufacturer. To monitor company-level changes in this thesis, nutrient composition data need to be: 1) product-specific and include information on manufacturers and 2) the data also need to be available historically, so that changes over time can be tracked.

The nutrition composition data used in this chapter were sourced directly from Euromonitor and Kantar. Euromonitor only collect the nutrition information for one product per brand (for example, strawberry and banana Innocent Smoothie, 200ml) and not every product that has that brand name. This is not granular enough for this research as it does not allow a company's whole product portfolio to be assessed. The Kantar data was collected by analysts directly from the back of the pack during a store check carried out every six months. Nutrition information for approximately two-thirds of products. Again, this was not deemed a suitable coverage to assess a company's entire product portfolio and other sources of composition data were investigated.

FoodDB, an online platform developed in-house at the Centre on Population Approaches NCD Prevention (CPNP), collects information online from 10 UK retailers, including nutrition information (227). This data source was originally selected to be used for this thesis, although at the time of this project starting (2016), FoodDB was still in its infancy and data collection did not start fully until 2017. Therefore, alternative sources were considered.

Enquiries were made about using the composition database that supports the mobile application Food Switch, which allows users to scan barcodes of products, offering suggestions for healthier swaps (228). Run by The George Institute for Global Health and Queen Mary University of London, the database behind Food Switch is accessible at no cost to academic researchers on application. However, Food Switch database was not used for two reasons:

1. It does not always provide historic data. If the nutrition composition data of a product is updated, then the historic product information is sometimes overwritten. This means that it cannot be used to systematically track how a product has changed over time
2. An application form and research proposal were submitted to The George Institute, but a timely response was not received, and therefore other sources were considered.

Brand View is a commercial company (now known as Edge by Ascential after a recent merger) that scrapes product information from retailer websites in a similar way as FoodDB. The data it collects includes nutrient composition data and its database stretches back to 2015. Enquiries were made about sourcing information on products sold on the three leading UK retailers' websites: Asda, Sainsbury's and Tesco. Data from Brand View was chosen for subsequent analyses in this thesis for three reasons: 1) it provided information at the individual product level, including product name, brand and its manufacturer; 2) Data was available historically, allowing product changes to be tracked over time, and 3) the cost of the data fell within the resources available for this DPhil project.

Brand View data was identified as the source of the nutrition composition data for use in later in this thesis. It includes the product information and nutrition composition data all of the products sold on the Tesco, Sainsbury's and Asda websites on the same date (13th December) on four consecutive years (2015-2018).

The main limitation of this dataset is that it is likely to be an underestimation of the number of products available on the market for two reasons. Firstly, it only includes products that are sold in the three supermarkets – products sold exclusively at discounters, corner shops or markets for example will not be covered. Second, taking data from a single snapshot in time means that the churn of products over the year will not be captured (e.g. products leaving the marketplace and being replaced by new ones).

Pairing the datasets together

The methods used for this thesis, and the strengths, limitations and implications of using these data sources, are outlined in detail in each chapter. The basic principle of the method used in this thesis is to pair Euromonitor food sales data with corresponding Brand View composition data, to allow for changes in the food supply by company and category to be tracked. For example, if you know what volume of Coca-Cola has been sold, and you know how much sugar is in Coca-Cola, you can work out how much sugar has been sold through Coca-Cola and how this has changed over time. Doing this systematically for all products builds a picture of the nutritional quality of the food supply, and weighting by sales allows for analysis of not just what is available, but of what is sold.

Conclusion

This chapter has narrowed down six potential sources of foods sales data in a novel analysis, exploring the strengths and weaknesses of two main datasets: Euromonitor and Kantar. Euromonitor data has been selected for this thesis for two main reasons. Firstly, it seems more accurate given that it better represents the total market. Its data are not greatly affected by underreporting, a larger proportion of outlets are covered (e.g. corner shops, vending machines) and volumes were much closer to those reported by BSDA. Secondly, Euromonitor did not impose any restriction on the reporting of results. Euromonitor sales data at the brand level will be paired with the mean nutrient content of individual products collected from online supermarkets by analytics company Brand View. The analyses in the following chapters will cover the time period 2015-2018.

Chapter 4: Sugar reduction in selected foods and soft drinks in the UK between 2015 and 2018

Part of this chapter has been published in a peer-reviewed paper, with the following citation: Bandy, L.K., Scarborough, P., Harrington, R.A. *et al.* Reductions in sugar sales from soft drinks in the UK from 2015 to 2018. *BMC Med* **18,** 20 (2020)

Chapter summary

In 2017, Public Health England published a series of voluntary, 20% sugar reduction targets for nine food categories that contribute the most to children's sugar intake, and in 2018, the Soft Drinks Industry Levy was introduced. The aim of this chapter was to analyse how the sales-weighted mean sugar content and total volume of sugars sold by category and company has changed between 2015 and 2018. The results show that substantial reductions were seen in soft drinks, with the sales-weighted mean sugar content falling by 34%, from 4.4g/100ml to 2.9g/100ml, and the volume of sugar being sold from soft drinks dropping by 30%, equivalent to 4.6g per capita per day. In contrast, the reductions in the included food categories were much smaller, with sales-weighted mean sugar content falling by just 6% overall, equivalent to a reduction in the volume of sugar sold of 1.6g per capita per day (-8%). This analysis has provided novel analysis on the sugar content of products, and shows the heterogeneity in how companies have responded to both mandatory and voluntary policy designed to reduce the sugar content of foods and soft drinks.

Introduction

In 2015, the World Health Organisation (WHO) and the UK Scientific Advisory Committee on Nutrition (SACN) recommended that the guideline intake on sugar should be revised from 10% to 5% of total dietary energy (125). Citing the success of the salt reduction targets, and in an effort to reduce the population's consumption of sugars, Public Health England outlined a series of 20% voluntary sugar reduction targets for nine food categories in 2017 (116). These nine food categories represent 54% of sugar consumed by children aged 4-10 years, and 34% for adults aged 19-65 (**Table 11** (repeated from Chapter 1) (116).

Table 11: Percentage contribution of food groups covered by PHE's sugar reduction targets (excluding morning goods) to average daily free sugars intake in children and adults in 2016-17 (116)

	Percentage contribution (%)		
Category	**4-10 years**	**11-18 years**	**19-64 years**
Breakfast cereals	8	8	4
Biscuits	9	8	7
Cakes	8	7	7
Chocolate confectionery	7	7	7
Ice cream	5	3	2
Puddings	4	2	2
Sugar confectionery	7	4	2
Yoghurts	6	3	3
Total	**54**	**42**	**34**

Using the average sugar content in 2015 as a baseline, PHE set out 5% and 20% sugar reduction targets for each category for 2018 and 2020 respectively. It also included guidelines on the calories per serving for each category. It highlighted that sugar reductions should be achieved without an increase in saturated fat and where possible, be accompanied by a reduction in calories.

In March 2016, the Treasury announced a three-tiered levy on sugar-sweetened soft drinks, which was implemented in April 2018 (126). Products that contain more than 8g sugar per 100ml are now taxed at 24 pence per litre and products that contain 5-8g/100ml are taxed at 18 pence per litre. Products with less than 5g sugar per 100ml are not subject to the tax (126). Pure, unsweetened fruit juice and flavoured milk drinks (amongst other smaller categories) are excluded from the levy. The introduction of the tax and the challenge to the industry to reformulate their products has been accompanied by a strong focus on soft drinks and sugar through the Change4Life programme (45) as well as increased attention on sugar in the mass media (127).

The success of these two government-led sugar reduction programmes is dependent on industry changing their behaviour – by reducing the sugar content of their products, reducing the sales of high-sugar products, by helping to shift sales to lower sugar alternatives by introducing new product lines or focusing marketing and advertising practices on low sugar products. Public Health England are monitoring the 20% sugar reduction targets and the sugar content of soft drinks using Kantar sales and composition data, although this is reported by category only, not company, and the analysis is not independent or peer reviewed.

The aim of this chapter is to use sales data in combination with nutrition composition data to analyse how food and soft drinks companies have responded to the sugar reduction programme in the UK. This will be done by answering the following research questions:

1. How has the sales-weighted mean sugar content of food and soft drinks by category and company changed between 2015 and 2018?
2. How has the total volume of sugars sold from food and soft drinks by category and company changed between 2015 and 2018?
3. What proportion of the change in total volume of sugars sold is due to changes in mean sugar content, compared to changes in volume sales?

Methods

The total contribution of sugar to the food supply for all of the selected food groups was estimated by pairing brand-level sales data with individual product-level nutrient composition data on an annual basis for four consecutive years from 2015 to 2018.

Data types and sources

We identified manufacturers in the selected categories in 2018, including retailers who manufacture their own-label products, using data obtained from Euromonitor. Further information about the Euromonitor data, including data types and coverage, can be found in Chapter 3. The total annual volume sales for all brands in the selected categories were calculated, with sub-categories defined by Euromonitor (**Table 12**).

Table 12: Number and list of categories and sub-categories included in analysis

Food group	Number of sub-categories	Included sub-categories
Soft drinks	8	Bottled water, carbonates, concentrates, energy drinks, 100% juice, juice drinks, sports drinks and others
Biscuits and cereal bars	7	Cereal bars, chocolate coated biscuits, cookies, filled biscuits, plain biscuits, snack bars, wafers
Breakfast cereals	5	Children's breakfast cereals, flakes, hot cereals, muesli and granola, other ready to eat cereals
Chocolate confectionery	5	Boxed assortments, chocolate pouches and bags, chocolate with toys, countlines (individual chocolate bars), tablets (large chocolate bars)
Sugar confectionery	7	Boiled sweets, liquorice, lollipops, mints, other sugar confectionery, pastilles, gums, jellies and chews, toffees, caramels and nougat
Yoghurts	5	Drinking yoghurt, flavoured fromage frais and quark, flavoured yoghurt, plain fromage frais and quark, plain yoghurt

A brand was defined as a set of products that have the same name and are manufactured by one company. One brand may have multiple variants. For example, the company Britvic manufactures a number of different brands, including Pepsi, Pepsi Max, Lipton Ice Tea and Robinsons. Within a single brand there may be a number of different products, for example Lipton Ice Tea with Peach and Lipton Ice Tea with Lemon.

The product-level nutrient composition data were provided by Brand View, a private analytics company that collects product information, including nutrient composition data, by scraping from websites of the three leading UK retailers: Asda, Sainsbury's and Tesco.

These data were scraped from Tesco, Asda and Sainsbury's websites on the same date (13th December) for four consecutive years (2015, 2016, 2017 and 2018).

Matching the sales data and composition data

To estimate the sales-weighted mean sugar content of the selected food groups in the UK market and to calculate the total amount of sugars sold by each company, the Euromonitor brand-level data was matched with the Brand View product-level data based on brand/product name and year. This was carried out manually in Microsoft Excel, using the search and filter functions. Each brand in the sales data was assigned a unique number, and this number was matched to the individual products in the Brand View composition dataset, based on the name, category and manufacturer of the product. When one brand had multiple flavour variants, the mean sugar content for the all the variants included under that brand was calculated. For example, the 2018 volume sales data for the brand Lipton were matched with the mean nutrient information collected from five individual ready to drink teas with different flavours.

Corresponding nutrient composition data could not be found for 62 brands in the sales database for all of the categories included. This represented 2% of total volume sales. For 20 of these brands it was because they were not sold in the supermarkets included in the Brand View database. For these brands, the nutrient composition data were sourced online from the brand website in mid-2019 and this data was used for all four years. The remaining 42 brands did not have matching composition data in the given time period and were removed from the data set. Euromonitor classifies a number of small and local brands under the umbrella of “others” and these products, representing an average of 15% of the total volume sales for each category, were excluded from all analysis.

Variables calculated

The total volume of sugars sold (tonnes per year) and the sales-weighted mean sugar content were calculated for each category and company. Sales-weighted mean sugar content was given per 100g, but also per serving size, using serving size data declared by the manufacturer on the packet and included in the Brand View data. To adjust for population changes and to make the results more relevant to a public health audience, per capita results were calculated using annual population estimates from the Office for National Statistics (ONS) (234) and per day results were calculated by dividing by 365, to give per capita per day figures.

For soft drinks, each product was also categorised according to its sugar content in relation to the tax payable under the SDIL. Products that are subject to the SDIL and contain >8g/100ml sugar were categorised as “high sugar” and those between 5-8g/100ml as “mid sugar”. Products with less than 5g of sugar and not subject to the SDIL were split into two discrete groups: “low sugar” if they contained 0.1-5g/100ml sugar and “zero sugar” if they contained <0.1g/100ml sugar. Plain bottled water was assigned its own category, “bottled water”. Fruit juices with no added sugar are excluded from the tax and were categorised as “exempt”.

For each food category, 5% and 20% sugar reduction targets were calculated using the sales-weighted mean sugar content in 2015 as a baseline, as is done by Public Health England for their sugar reduction targets (116). This would allow individual categories' and companies' progress against current policy targets to be monitored, and allow for a direct comparison with PHE's results.

Statistical analysis

For soft drinks and sugar confectionery, the composition data were not normally distributed, so the mean and median sugar content, and interquartile ranges, were calculated. A Kruskal-Wallis test was used to test for differences between the sales-weighted mean sugar content of each category – here the analysis was weighted so that each brand had influence proportional to total sales, but the sum of the units of analysis was equal to the number of brands. For the other food categories, the data were normally distributed, so 95% confidence intervals were calculated using absolute and sales-weighted standard deviations and means, and chi squared tests were used to test for differences between the mean sugar content. For soft drinks, chi-squared tests were used to assess the differences in the number of products in categories sold by individual companies over time.

Results

All products

Overall, the sales-weighted mean sugar content of foods and soft drinks included in this analysis fell by 20% between 2015 and 2018 (**Table 13**). Most of this change was driven by soft drinks. When soft drinks are removed from this analysis, the decline is more modest, with the total sales-weighted mean sugar content for the five included food categories falling from 28.7g/100g to 27.2g/100g, equivalent to -6%.

Table 13: Sales-weighted mean sugar content of food categories between 2015-2018

Category	Sales-weighted mean sugar content 2015 (g/100g/100ml)	Sales weighted mean sugar content 2018 (g/100g/100ml)	Percentage change 2015-2018 (%)
Biscuits and cereal bars	30.0	28.1	-6%
Breakfast cereals	18.8	16.3	-14%
Chocolate confectionery	51.7	51.2	-1%
Soft drinks	4.4	2.9	-34%
Sugar confectionery	62.2	60.7	-2%
Yoghurts	11.2	9.3	-17%
TOTAL	**8.7**	**6.9**	**-20%**

There were changes in the serving sizes of foods, as reported by manufacturers on the packet, and the amount of sugars sold per serving (**table 14**). The serving size of breakfast cereals fell by 3% and chocolate confectionery by 6%, while the amount of sugars per serving from these categories fell by 15% and 8% respectively. Biscuits and cereal bars, sugar confectionery and yoghurts saw small increases in serving size, but declines in the amount of sugars per serving (-1%, -3% and -13.4% respectively).

Table 14: Serving size and mean sugars per serving of food categories, 2015-2018

Category	n 2015	n 2018	Serving size 2015 (g/ml)	Serving size 2018 (g/ml)	Percentage change 2015-2018 (%)	Sugars per serving 2015 (g/100g)	Sugars per serving 2018 (g/100g)	Percentage change 2015-2018 (%)
Biscuits and cereal bars	549	417	25.2	25.8	+2.4%	8.4	8.3	-1%
Breakfast cereals	345	311	42.1	40.8	-3.2%	8.3	7.1	-15%
Chocolate confectionery	325	293	25.5	23.9	-6.3%	13.1	12.1	-8%
Sugar confectionery	352	350	10.1	10.1	+0.9%	6.2	6.1	-3%
Yoghurts	270	224	121.8	123.9	+1.7%	14.2	12.3	-13%
Soft drinks (g/100ml)	1187	1018	248	250	+0.8%	12.7	9.3	-27%

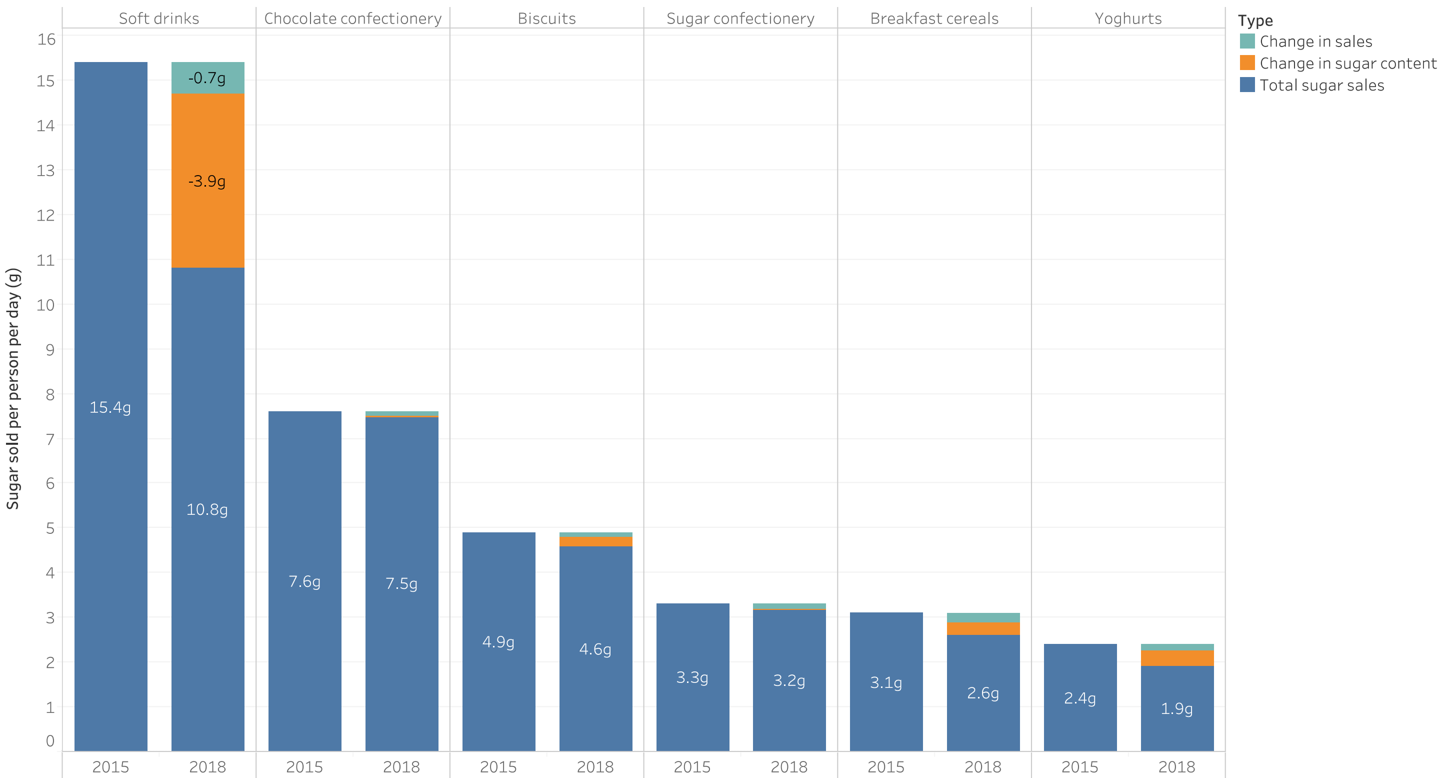
The total volume of sugar sold from soft drinks and foods fell from 36.9g in 2015 to 30.5g per capita per day in 2018, a reduction of 6.4g or 17%. Once soft drinks were excluded, the total volume of sugar sold from the five food categories included here was 19.7g in 2018, down from 21.4g in 2015, a reduction of 1.7g or 7% (**table 15**). In 2018, soft drinks remained the largest contributing category to sugar sales from the included categories, at 35%, followed by chocolate and sugar confectionery (34%) and biscuits and cereal bars (15%).

Table 15: Total volume of sugars sold by food category in per capita per day terms, 2015-2018

Category	Total sugar sales 2015 (g/capita/day)	Total sugar sales 2018 (g/capita/day)	Percentage change 2015-2018 (%)	% of category to total sugars included 2018
Biscuits and cereal bars	4.9	4.6	-6%	15%
Breakfast cereals	3.1	2.6	-18%	8%
Chocolate confectionery	7.6	7.5	-2%	24%
Soft drinks	15.5	10.8	-30%	35%
Sugar confectionery	3.4	3.2	-6%	10%
Yoghurts	2.4	1.9	-20%	6%
TOTAL	**36.9**	**30.5**	**-17%**	**100%**

The change in the total volume of sugar sold from the five food categories is equivalent to a reduction of 1.7g per capita per day. 43% of this change was due to a change in the sales volume of products. The remaining 57% was due to changes in the mean sugar content of products (**figure 10**). This change is small compared to the 4.6g reduction seen in soft drinks, where 73% (-3.9g) of the change was due to reformulation with the remaining 27% (-0.7g) due to changes in sales.

Figure 10: Change in the total volume of sugars from food and soft drinks split by change in sales and change in mean sugar content, 2015 vs 2018



Of the 63 companies presented in the analyses below, only five met at least one 20% target for sales-weighted mean sugar content (**Table 16**). Kellogg's was the only company to meet more than one target for different categories, with its sales-weighted mean sugar content of its breakfast cereals and biscuits falling by 25% and 28% respectively. Fifteen companies met one 5% reduction target, with two companies meeting multiple targets across different categories: Tesco met the 5% reduction targets for breakfast cereals, sugar confectionery and yoghurts, while Sainsbury's met the sugar reduction targets for breakfast cereals and yoghurts.

Table 16: List of companies that met 20% and 5% reduction targets for sales-weighted mean sugar content of products in 2018 compared to 2015, by food category (companies listed in order of descending percentage change)

	Food category				
Reduction target met	**Biscuits and cereal bars**	**Breakfast cereals**	**Chocolate confectionery**	**Sugar confectionery**	**Yoghurts**
20%	Kellogg's	Morning Foods Raisio Kellogg's	Green & Black's		Epicurean
5%	Fox's Biscuits United Biscuits Burton's Biscuits	Cereal Partners Sainsbury's Tesco Dorset Cereals	Hershey Fox's Carambar	Perfetti Tesco	Muller Yoplait Onken Yeo Valley Tesco Lactalis Rachel's Sainsbury's

Soft Drinks

In 2015, 55 soft drink companies sold 195 brands (**Table 17**). This rose to 57 companies and 199 brands in 2018. The total volume sales of soft drinks in the UK increased by 7% between 2015 and 2018, reaching 8.9 billion litres. Once adjusted for changes in the population and expressed in per capita terms, the volume sales of soft drinks rose by 5%, from 351ml per person per day, to 367ml per person per day.

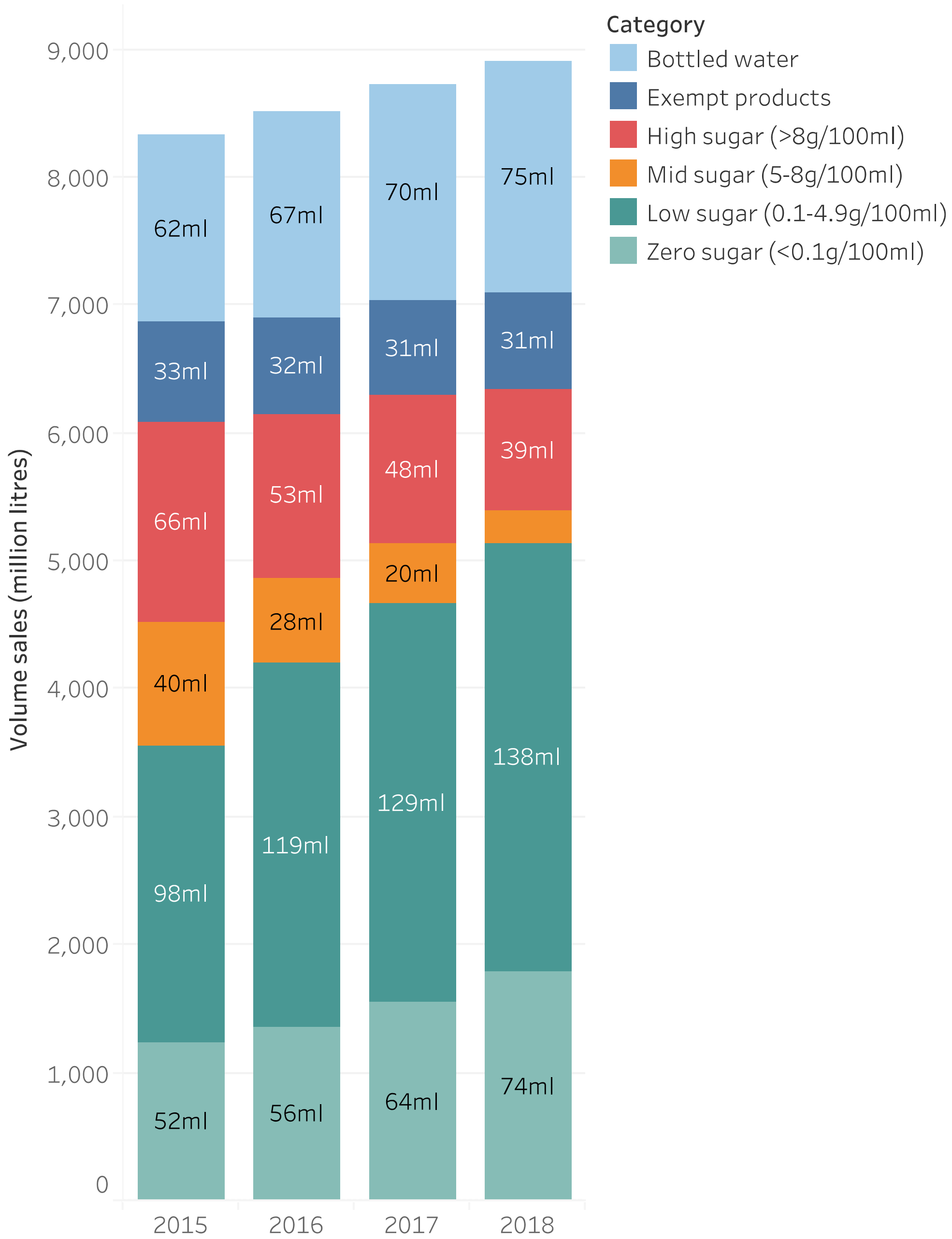
Table 17: Data points in the sales volume and nutrient composition databases, 2015-2018

Description	2015	2016	2017	2018
Number of individual products in nutrient composition database	1966	1851	1725	1735
Number of brands in sales volume database	195	195	198	199
Number of companies in sales volume database	54	55	57	57
Total volume sales of soft drinks (million litres)	8,336	8,519	8,728	8,910
Volume sales of soft drinks (per capita per day)	351	356	362	367

There have been marked shifts in the proportion of drinks sold by sugar content. The total volume sales of high and mid sugar soft drinks included in the SDIL, with sugar content >5g/100ml, fell from 31% in 2015 to 15% in 2018, equivalent of 106ml per person per day to 50ml per person per day. The combined low and zero sugar category increased from 43% to

48%, equivalent of 150ml per person per day in 2015 to 212ml in 2018 (**figure 11**). The total volume sales of bottled water and products exempt from the SDIL rose by 23%.

Figure 11: The volume sales of soft drinks by category, 2015-2018



Labels marked in bars refer to the volume adjusted for population changes and expressed in ml per capita per day

The total volume of sugars sold from soft drinks decreased by 29%, from 368,000 tonnes in 2015 to 261,000 tonnes in 2015 (**Table 18**). The proportion of sugars sold from products included in the SDIL (i.e. high and mid sugar products) decreased from 63% to 44%, while the proportion increased for low sugar products from 16% to 28%.

Table 18: The total volume of sugar sold from soft drinks, 2015-2018

	Total sugars (tonnes) sold by soft drink category			
Soft drink category	**2015**	**2016**	**2017**	**2018**
Total volume of sugars sold (tonnes)	367,965 (100%)	328,685 (100%)	305,732 (100%)	261,324 (100%)
High sugar (>8g/100ml)	170,541.0 (46%)	139,192.3 (42%)	127,580.80 (42%)	102,553.10 (39%)
Mid sugar (5-8g/100ml)	61,273.2 (17%)	43,325.3 (13%)	30,712.40 (10%)	13,948.90 (5%)
Low sugar (0.1-5g/100ml)	58,739.3 (16%)	72,330.8 (22%)	76,015.40 (25%)	72,894.40 (28%)
Zero sugar (<0.1g/100ml)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Exempt products	77,411.6 (21%)	73,836.4 (22%)	71,423.10 (23%)	71927.7 (28%)
Bottled water	0 (0%)	0 (0%)	0 (0%)	0 (0%)

The total volume results were converted to per capita per day to account for population changes (**table 19**). Very similar trends were found, with the volume of sugars sold from soft drinks falling from 15.5g per person per day in 2015 to 10.8g in 2018, a reduction of 30%.

Table 19: The volume of sugars sold by soft drink category, per capita per day, 2015-2018

	Volume of soft drink and sugars sold per capita per day g/capita/day			
Soft drink category	**2015**	**2016**	**2017**	**2018**
Volume of sugars sold from soft drinks	15.5	13.7	12.7	10.8
High sugar (>8g/100ml)	7.2 (46%)	5.8 (42%)	5.3 (42%)	4.2 (39%)
Mid sugar (5-8g/100ml)	2.6 (17%)	1.8 (13%)	1.3 (10%)	0.6 (5%)
Low sugar (0.1-5g/100ml)	2.5 (16%)	3.0 (22%)	3.2 (25%)	3.0 (28%)
Zero sugar (<0.1g/100ml)	0.0	0.0	0.0	0.0
Exempt products	3.3 (21%)	3.1 (22%)	3.0 (23%)	3.0 (28%)
Bottled water	0.0	0.0	0.0	0.0

The absolute mean sugar content of soft drinks fell from 5.4g/100ml in 2015 to 3.9g/100ml in 2018, a reduction of 28% (**Table 20**). The annual changes from 2015-18 were -7, -10 and -13%. The mean sugar content of the high and mid sugar drinks remained unchanged, but for the low sugar category the mean sugar content rose from 0.9g/100ml (0.5-3.2g/100ml) to 4.2g/100ml (0.9-4.7g/100ml).

Table 20: The average sugar content of soft drink products by category, 2015-2018

	Mean sugar content (g/100ml) and IQR (Q2, Q1-Q3)				
Soft drink category	**2015**	**2016**	**2017**	**2018**	**p-value**
Total soft drinks (g/100ml)	5.4 (5.0, 0.2-10.0)	5.0 (4.3, 0.0-9.5)	4.5 (4.1, 0.0-8.9)	3.9 (3.8, 0.0-7.1)	<0.01
High sugar (>8g/100ml)	10.8 (10.8, 10.0-11.8)	10.6 (10.6, 9.6-11.3)	10.6 (10.6, 9.9-11.0)	10.6 (10.6, 10.0-11.0)	0.18
Mid sugar (5-8g/100ml)	6.7 (6, 6.0-7.3)	6.8 (6.8, 6.0-7.3)	6.7 (6.7, 5.9-7.2)	7.0 (7.0, 5.8-7.3)	0.94
Low sugar (0.1-5g/100ml)	0.9 (0.9, 0.5-3.2)	1.1 (1.1, 0.5-3.8)	3.1 (3.1, 0.7-4.5)	4.2 (4.2, 0.9-4.7)	<0.01
Zero sugar (<0.1g/100ml)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.99
Exempt (g/100ml)	10.0 (10.0, 8.7-11.0)	9.8 (9.8, 8.6-11.0)	9.8 (9.8, 8.6-11.0)	9.7 (9.7, 8.7-11.0)	0.21
Bottled water	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.99

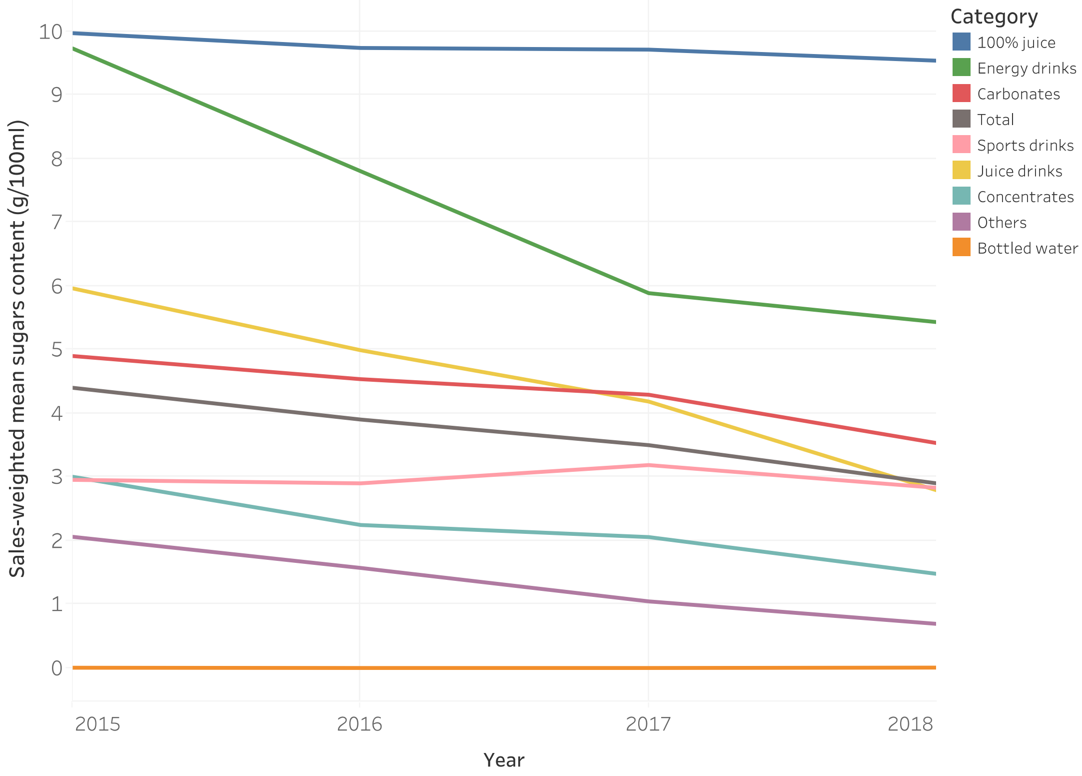
Once adjusted for sales, the weighted mean sugar content of all soft drinks decreased significantly from 4.4g/100ml (IQR: 0.0-9.2g/100ml) to 2.9g/100ml (0.0-4.3g/100ml), an overall reduction of 34% (**Table 21**).

Table 21: Sales-weighted average sugar content of soft drinks by sugar content category, 2015-2018

	Mean sugar content (g per 100ml) and IQR (Q2, Q1-Q3)				
Soft drink category	**2015**	**2016**	**2017**	**2018**	**p-value**
Total soft drinks (g/100ml)	4.4 (2.4, 0.0-9.2)	3.9 (1.8, 0.0-7.1)	3.5 (2.1, 0.0-6.1)	2.9 (1.2, 0.0-4.3)	<0.01
High sugar (>8g/100ml)	11.0 (10.6, 10.6-11.0)	11.0 (10.6, 10.6-11.0)	11.0 (10.6, 10.6-11.0)	10.8 (10.6, 10.6-11.0)	0.58
Mid sugar (5-8g/100ml)	6.4 (6.1, 5.7-7.3)	6.4 (6.3, 6.2-6.8)	6.5 (6.5, 5.9-7.4)	5.4 (5.2, 5.0-5.7)	0.15
Low sugar (<0.1-5g/100ml)	2.5 (2.3, 2.0-3.6)	2.4 (1.9, 1.4-3.9)	2.4 (2.1, 1.5-3.9)	2.2 (1.8, 1.1-2.9)	0.85
Zero sugar (<0.1g/100ml)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.99
Exempt (g/100ml)	10.0 (9.9, 9.6-10.2)	10.0 (9.7, 9.3-10.0)	9.7 (9.9, 9.2-10.4)	9.5 (10.0, 9.2-10.1)	0.75
Bottled water	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.99

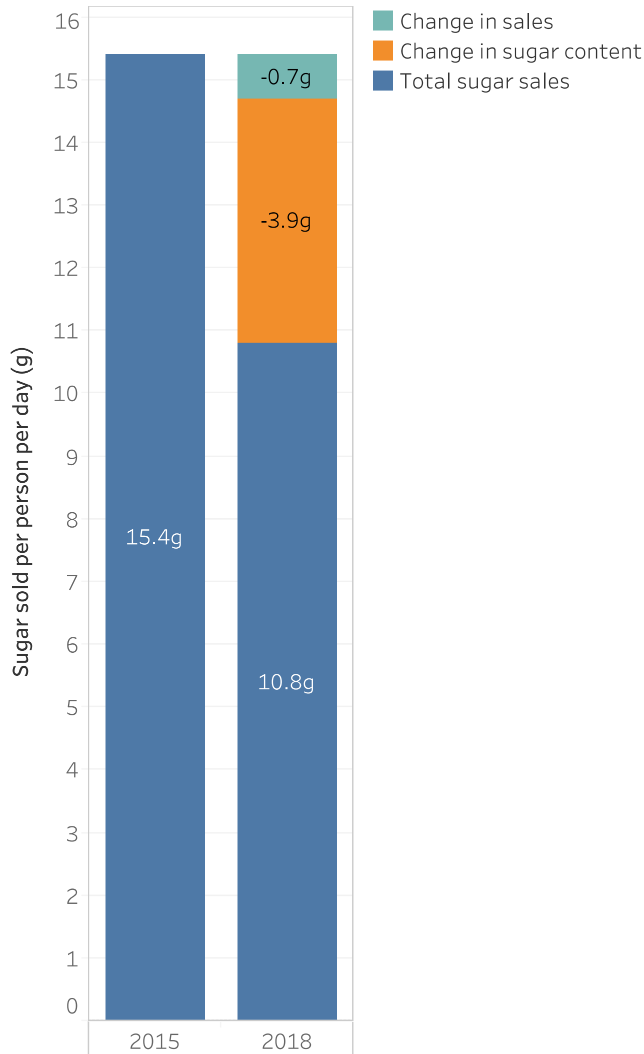
Energy drinks saw the greatest absolute reduction in sales-weighted mean sugar content (-4.3g/100ml) (**Figure 12**). Juice drinks also saw a significant reduction in sales-weighted mean sugar content (-3.2g/100ml). Sales-weighted mean sugar content of carbonates, the category with the largest volume sales, fell by 29%. Changes in 100% juice and sports drinks were minimal.

Figure 12: Sales-weighted mean sugar content of soft drinks by product type, 2015-2018



Of the 4.6g per capita per day reduction in the volume sales of sugar from soft drinks, 73% was due to a drop in the mean sugar content of products, while the remaining 27% was due to a change in the volume sales of soft drinks (**Figure 13**).

Figure 13: Proportion of change in sugar sales from soft drinks due to change in mean sugar content compared to change in volume sales

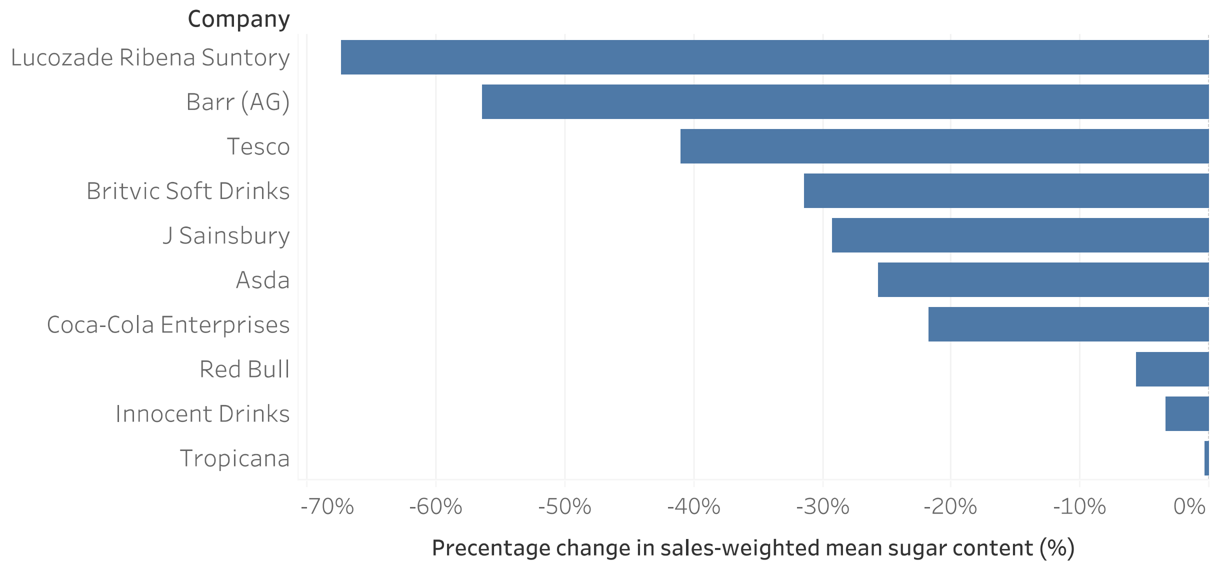


Of the top ten soft drink companies, Red Bull, Tropicana and Innocent had the overall highest sales-weighted mean sugar contents in 2018, at 9.9g, 9.8g and 8.9g per 100ml respectively, and saw only small decreases over time (**Figure 14**). The largest absolute reductions were seen in Barr (-4.5g/100ml) and Lucozade Ribena Suntory (-5.2g/100ml). Lucozade Ribena Suntory and Britvic had the lowest sales-weighted mean sugar contents in 2018 at 2.5g and 2.0g per 100ml. Retailers Sainsbury's, Tesco and Asda had mean sugar contents of 3.0g/100ml or below.

Figure 14: Sales-weighted mean sugar content of soft drinks by company

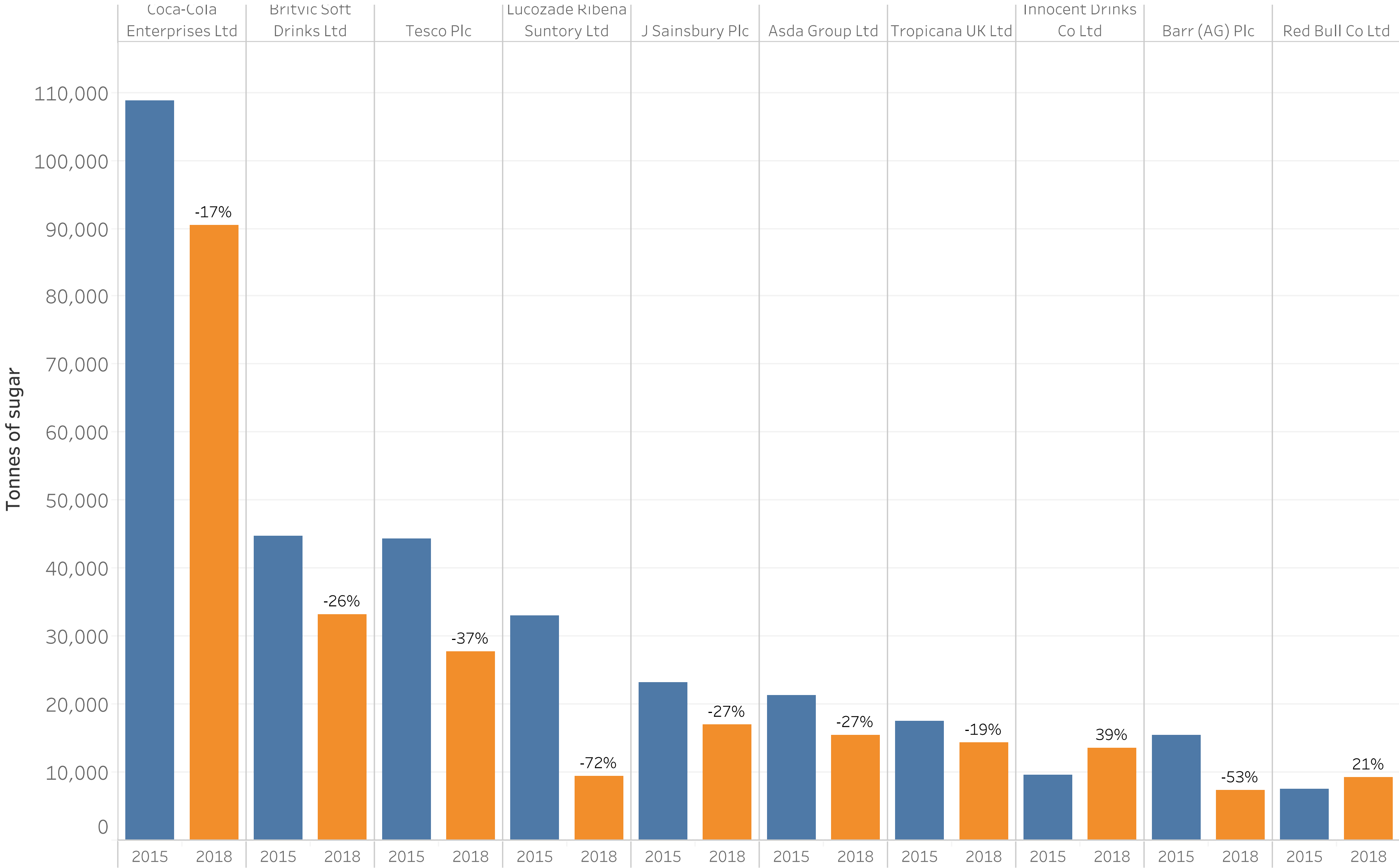
Lucozade Ribena Suntory and Barr also saw the greatest percentages changes in overall sales-weighted mean sugar contents of their products, at -67% and -56% respectively (**Figure 15**). Tesco saw a reduction of 41%, compared to more modest reductions of 29% and 26% for Sainsbury's and Asda. Red Bull, Innocent and Tropicana little to no change, at -6%, -3% and 0% respectively.

Figure 15: Percentage change in the sales-weighted mean sugar content of soft drinks by company, 2015-2018



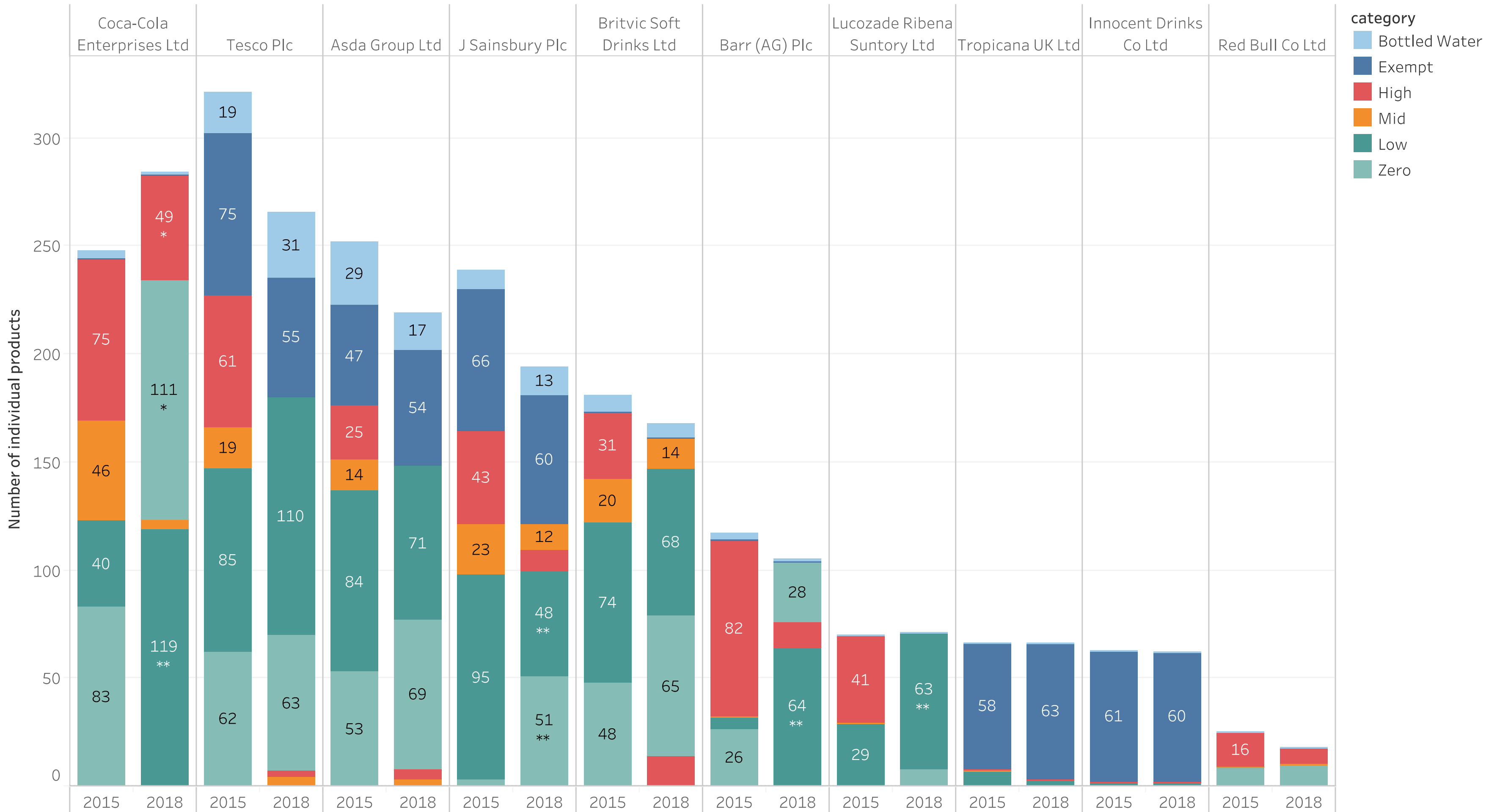
Changes in consumer behaviour and shifts in industry practice mean there was a decrease in the total volume sales of sugars for eight of the top ten companies (defined by their total contribution to total volume sales of sugars) (**Figure 16**). The largest soft drinks company in terms of total volume sales of sugars in all four years was Coca-Cola; for this company volume sales increased while the sugar content of products fell, leading to a 17% decrease in the total volume of sugars sold over time. Volume sales for Red Bull and Innocent increased with little change in the mean sugar content of their products, leading to increases in the volume sales of sugars for these two companies.

Figure 16: Total volume of sugars sold by top 10 UK soft drink companies, 2015 and 2018



There have been significant changes in the product portfolios of soft drink companies since 2015, including the reformulation of existing products and the introduction of new products. In 2015, eight of the top ten companies manufactured at least 50% of high and mid sugar products that are targeted by the SDIL and two companies – Innocent and Tropicana – sold only exempt products (**Figure 17**). Of the eight companies that sold products target by the SDIL, six reformulated or removed more than 50% of the high and mid sugar products from their portfolios – leading to a 72% reduction in high and mid sugar products by 2018.

Figure 17: The availability of soft drinks by company by sugar content range, 2015 and 2018



Biscuits and cereal bars

In this dataset, 563 different biscuit and cereal products under 85 different brands were included, manufactured by 33 companies in 2018 (**Table 22**). This was a decline of 11% from 629 products in 2015.

Table 22: Data points in nutrient composition and sales data sets

	2015	**2016**	**2017**	**2018**
Number of individual products in nutrient composition dataset	629	658	611	563
Number of brands in sales dataset	85	85	85	85
Number of companies	33	33	33	33

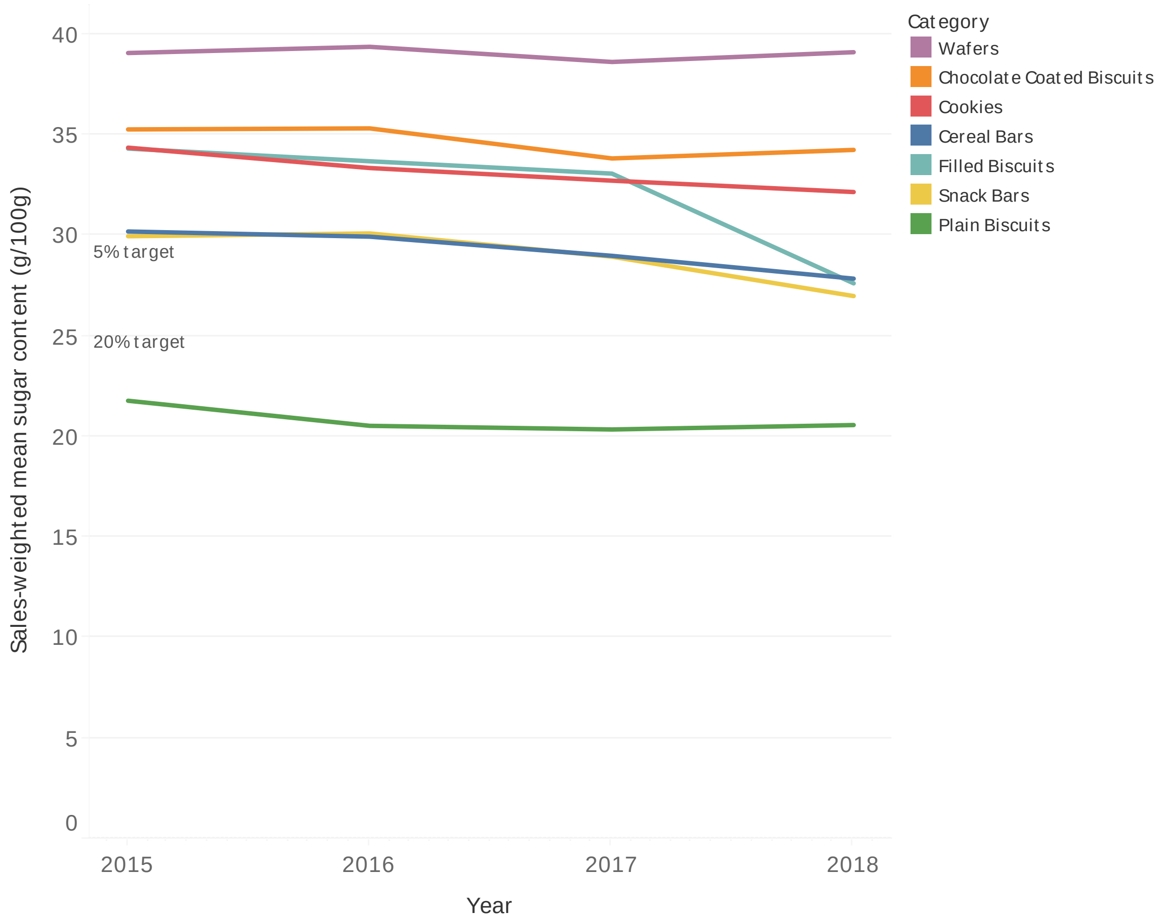
The total volume of biscuits and cereal bars sold rose by 2% from 2015-2018, from 386,000 tonnes to 395,000 tonnes (**Table 23**). However, the sales-weighted mean sugar content of the category fell by 6% from 30.0g/100g to 28.1g/100g, resulting in a 4% decline in the total volume of sugars sold. In 2018, 111,000 tonnes of sugars were sold from biscuits and cereal bars, equivalent to 4.6g per person per day on a population level.

Table 23: Total volumes and mean sugars content of biscuits and cereal bars 2015-2018

	2015	2016	2017	2018	% change 2015-18
Sales volume (tonnes)	386,000	391,000	395,000	395,000	+2%
Total sugars volume (tonnes)	116,000	114,400	112,900	111,200	-4%
Total sugars per capita per day (grams)	4.9	4.8	4.7	4.6	-6%
Sales weighted mean sugar content (g/100g)	30.0 (29.3-30.7)	29.3 (28.6-30.0)	28.5 (27.7-29.3)	28.1 (27.3-29.0)	-6%
Absolute mean sugar content (g/100g)	32.4 (31.7-33.1)	31.9 (31.1-32.5)	31.3 (30.6-32.1)	31.4 (30.6-32.2)	-3%

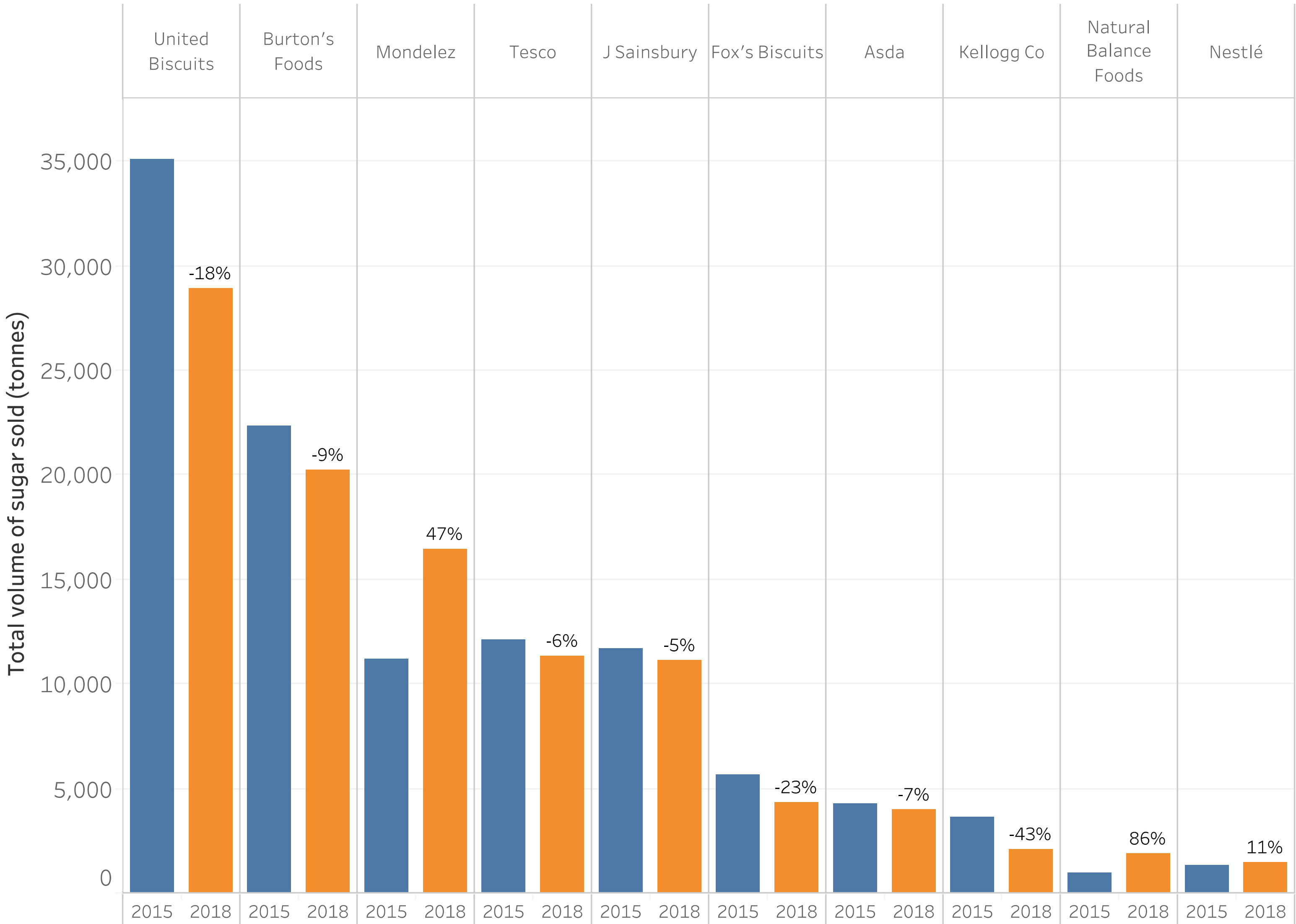
Wafers, chocolate coated biscuits and cookies had the highest sugar content in 2018 at 39.1g/100g, 34.3g/100g and 32.2g/100g respectively (**Figure 18**), all above the 5% target of 28.5g/100g. The sales-weighted mean sugar content of filled biscuits declined by 20% to reach 27.6g/100g. Cereal bars and snack bars also fell below the 5% target with sugar contents of 27.9 and 27.0g/100g respectively. The mean sugar content of plain biscuits was below the 20% target of 24.0g/100g for all four years.

Figure 18: Mean sugar content of biscuit and cereal bar categories over time in comparison to 5% and 20% sugar reduction targets



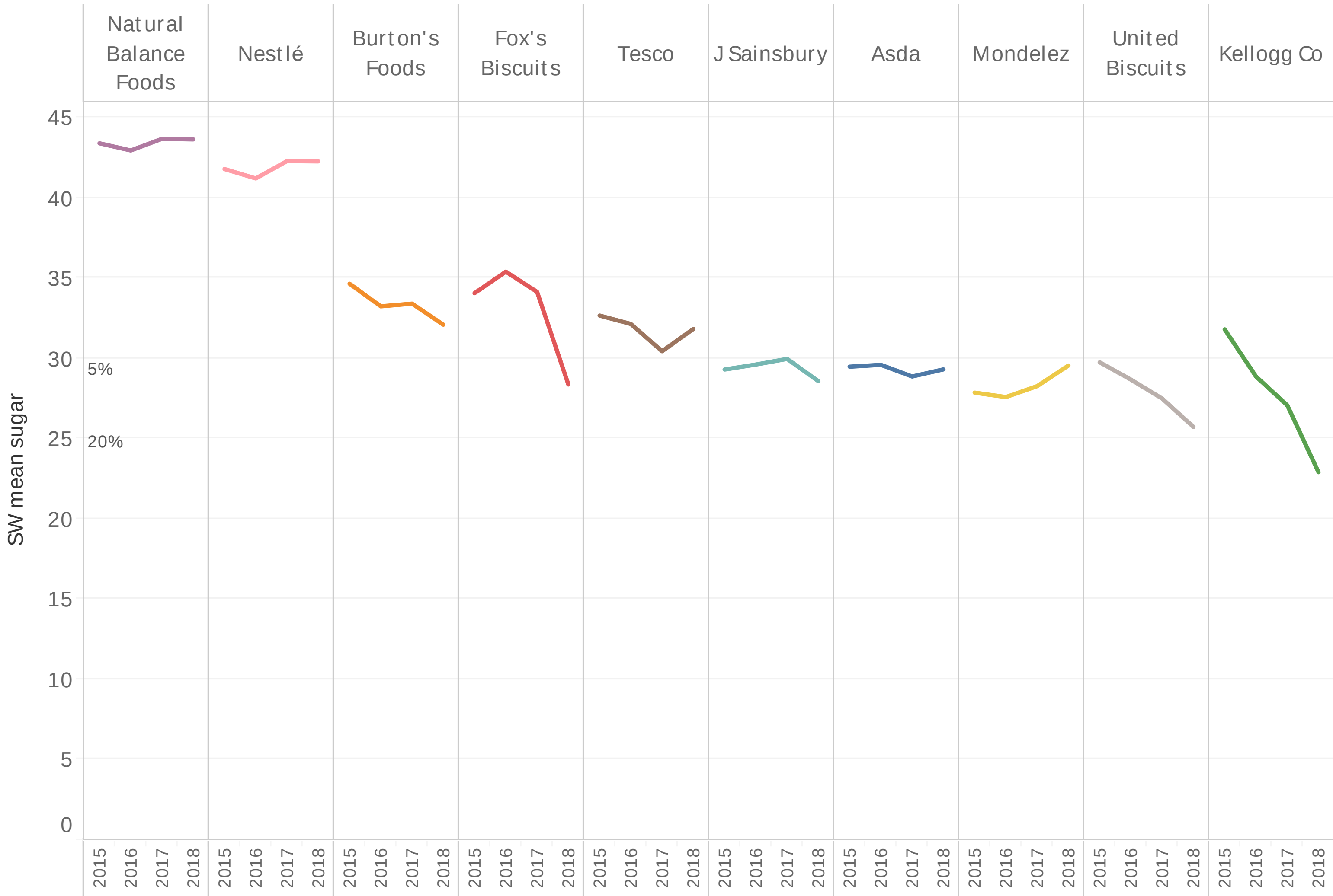
In 2018, 111,000 tonnes of sugar were sold from biscuits and cereal bars, equivalent to 4.6g sugar per person per day. The top five companies – United Biscuits, Burton's, Mondelez, Tesco and Sainsbury's – represented 80% of this total volume (**Figure 19**). All but one of these five companies, Mondelez, saw a decline in the total volume of sugars sold.

Figure 19: Total volume of sugar sold from biscuit and cereal bar by company, 2015 and 2018



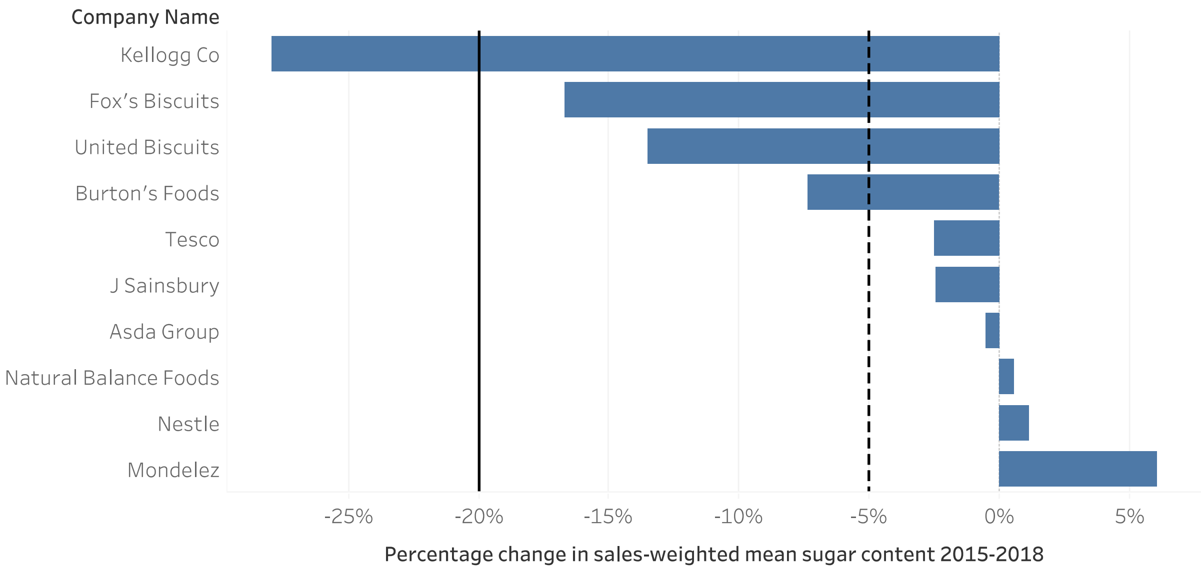
In 2018, only one third of biscuit companies had met the 5% sugar reduction target of 24.0g/100g (**Figure 20**). Only one of the top five companies – United Biscuits, which manufactures McVities – had met the 5% sugar reduction target of 28.5g/100g. The largest company United Biscuits in terms of volume sales, saw a fall in the mean sugar content of its product portfolio from 29.8g/100g to 25.8g/100g, a reduction of 13%. Tesco and Sainsbury's both saw changes of less than 2% and the mean sugar content of Burton's biscuits was 3.5g higher than the 5% target in 2018. Mondelez saw rising volume sales of its Oreo and Belvita brands. This, combined with no change in the mean sugar content of these brands, meant that its sales-weighted mean sugar content and total volume of sugars sold rose between 2015 and 2018.

Figure 20: Sales-weighted mean sugar content of biscuit and cereal bar company product portfolios in comparison to 5% and 20% sugar reduction targets



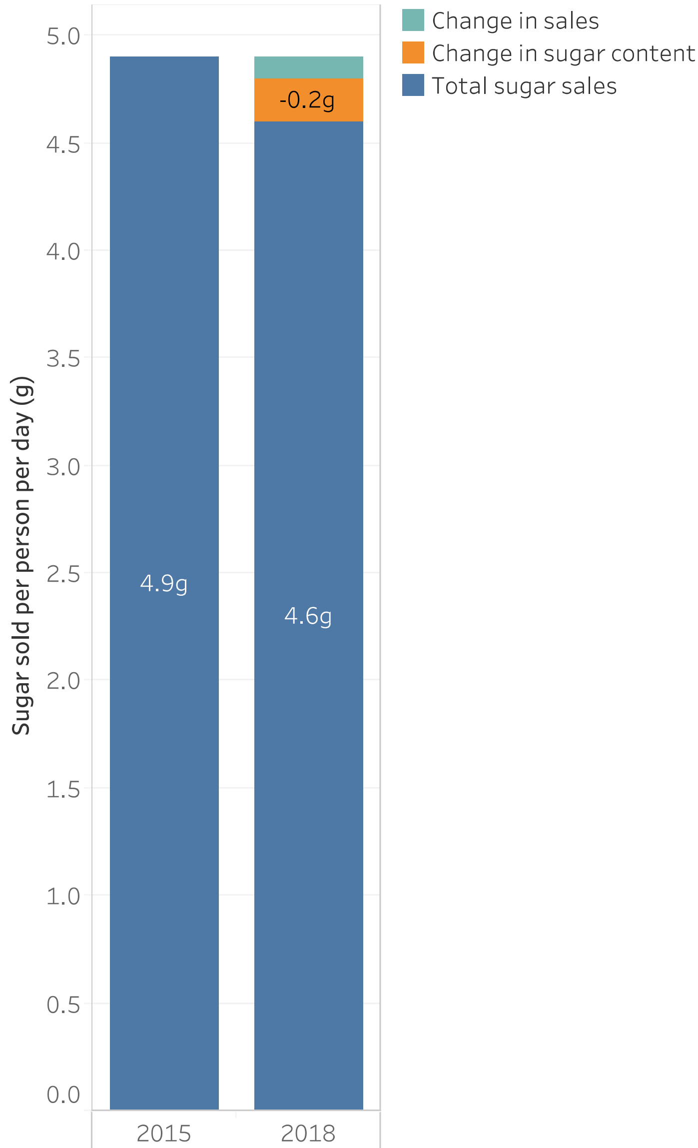
Of the top ten biscuit companies, Kellogg's saw the greatest percentage change in the overall sales-weighted mean sugar content of its products at -28% and was the only company to fall by more than 20% (**Figure 21**). This was due to changes in volume sales, but also a fall in the sugar content of its breakfast bars. Fox's Biscuits, United Biscuits and Burton's Foods all saw reductions greater than 5%, at -17%, -14% and -7% respectively. Both Nestle and Natural Balance saw small rises in the sales-weighted sugar content of their products. Mondelez rose by 6% and this was due to rising volume sales of its Oreo and Bel Vita brands.

Figure 21: Percentage change in sales-weighted mean sugar content of biscuits and cereal bars by company 2015-2018



The volume sales of sugar from biscuits and cereal bars fell by 0.3g from 2015 to 2018 (**Figure 22**). Two-thirds of this reduction was due to a change in the mean sugar content of products, with the remaining one-third due to a change in total volume sales.

Figure 22: Proportion of change in sugar sales from biscuits and cereal bars due to change in mean sugar content compared to change in volume sales, 2015 vs 2018.



Breakfast cereals

There were 338 breakfast cereal products under 55 different brands included in this dataset in 2018, which were manufactured by 13 different companies (**Table 24**). This was an 8% decrease on 368 products manufactured in 2015.

Table 24: Data points in nutrient composition and sales data sets

	2015	**2016**	**2017**	**2018**
Number of individual products in nutrient composition dataset	368	362	350	338
Number of brands in sales dataset	57	55	53	55
Number of companies	13	13	13	13

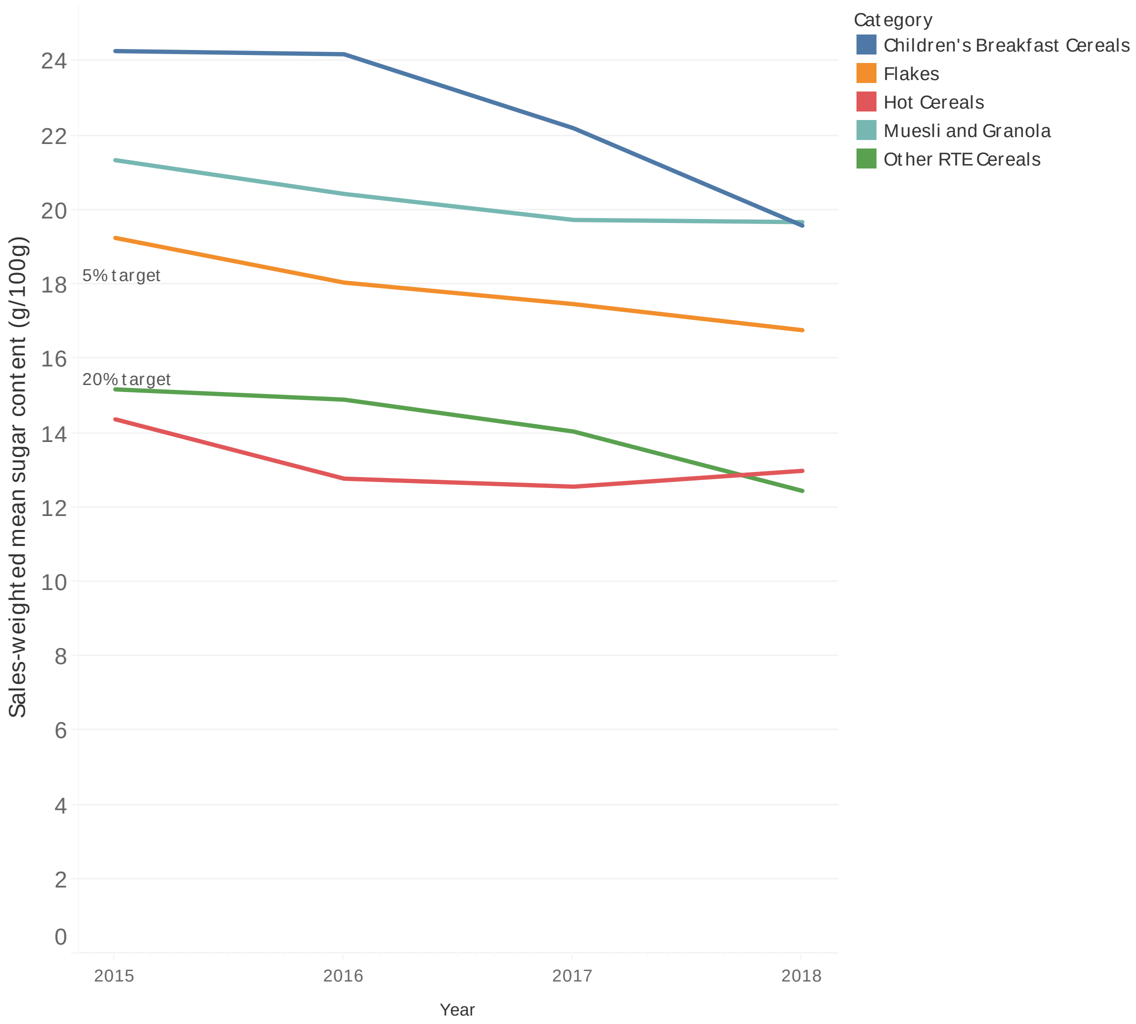
The sales-weighted mean sugar content of breakfast cereals fell by 14% from 2015-2018 (**Table 25**). This, combined with a 3% decline in the total volume sales, meant that the total volume of sugar sold from fell by 16%, from 74,000 tonnes to 62,000 tonnes. This is equivalent to 0.5g sugar per person per day

Table 25: Total volumes and mean sugars content of breakfast cereals 2015-2018

	2015	2016	2017	2018	% change 2015-18
Sales volume (tonnes)	394,000	391,000	384,000	383,000	-3%
Total sugars volume (tonnes)	74,338	70,551	65,994	62,275	-16%
Total sugars per capita per day (grams)	3.1	2.9	2.7	2.6	-18%
Sales weighted mean sugar content (g/100g)	18.8 (18.0-19.5)	18.0 (17.2-18.9)	17.2 (16.4-18.0)	16.3 (15.5-16.9)	-14%
Absolute mean sugar content (g/100g)	19.1 (18.1-20.0)	18.4 (17.5-19.4)	17.6 (16.7-18.6)	17.5 (16.5-18.3)	-8%

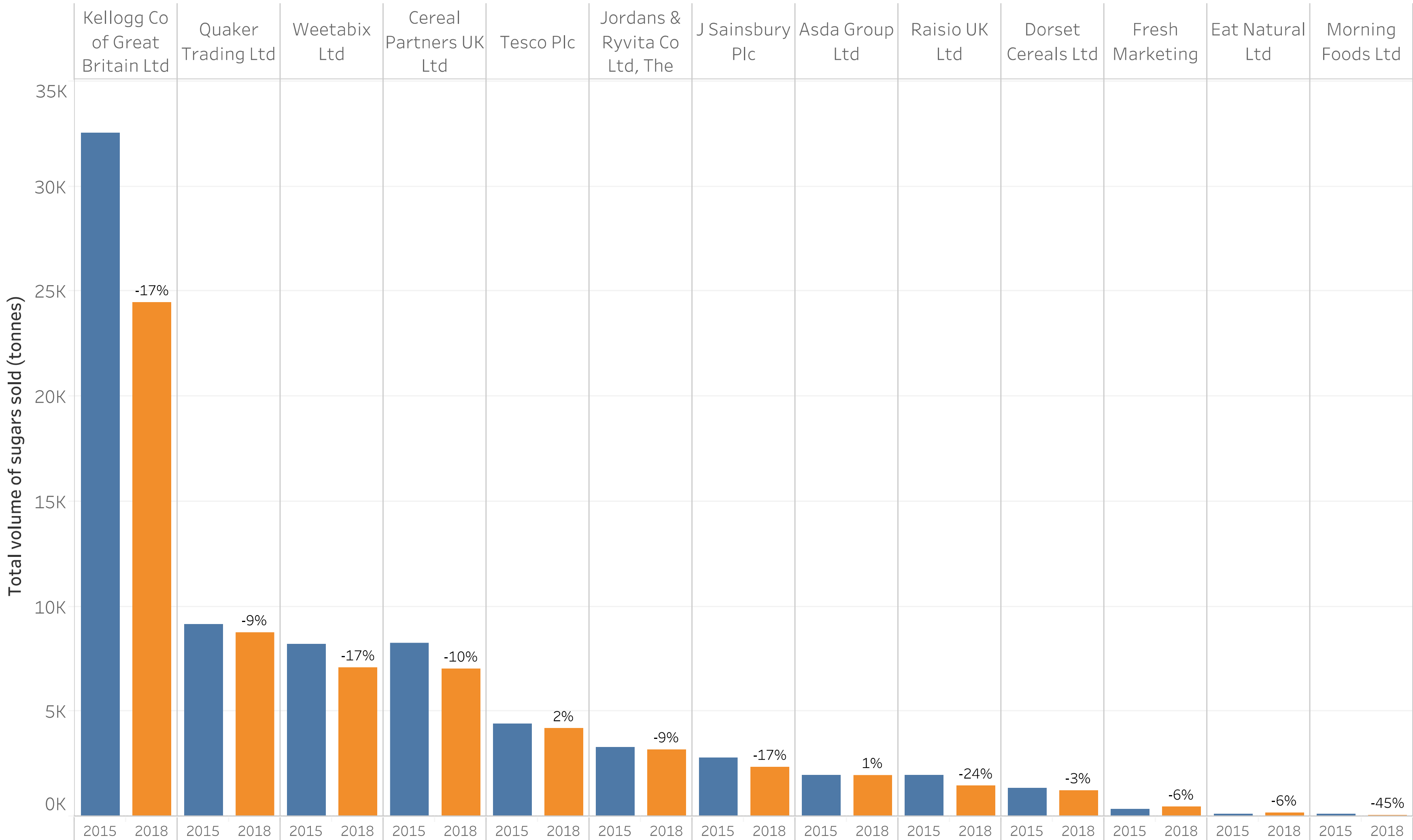
Children's breakfast cereals had the highest sugar content in 2015 at 24.3g/100g, but this fell by nearly 20% over the time period to 19.6g/100g in 2018 (**Figure 23**). In 2018, muesli and granola had the highest sugar content of all breakfast cereals, at 19.7g/100g, after seeing a decrease of 7% since 2015. Both of these categories failed to meet the 5% sugar reduction target of 17.9g/100g. Other ready to eat (RTE) cereals – namely wheat biscuit cereals – had the lowest sugar content, along with hot cereals such as porridge. Both of these categories already fell below the 20% sugar reduction target of 15.1g/100g in 2015.

Figure 23: Sales-weighted mean sugar content of breakfast cereals by category, 2015-2018



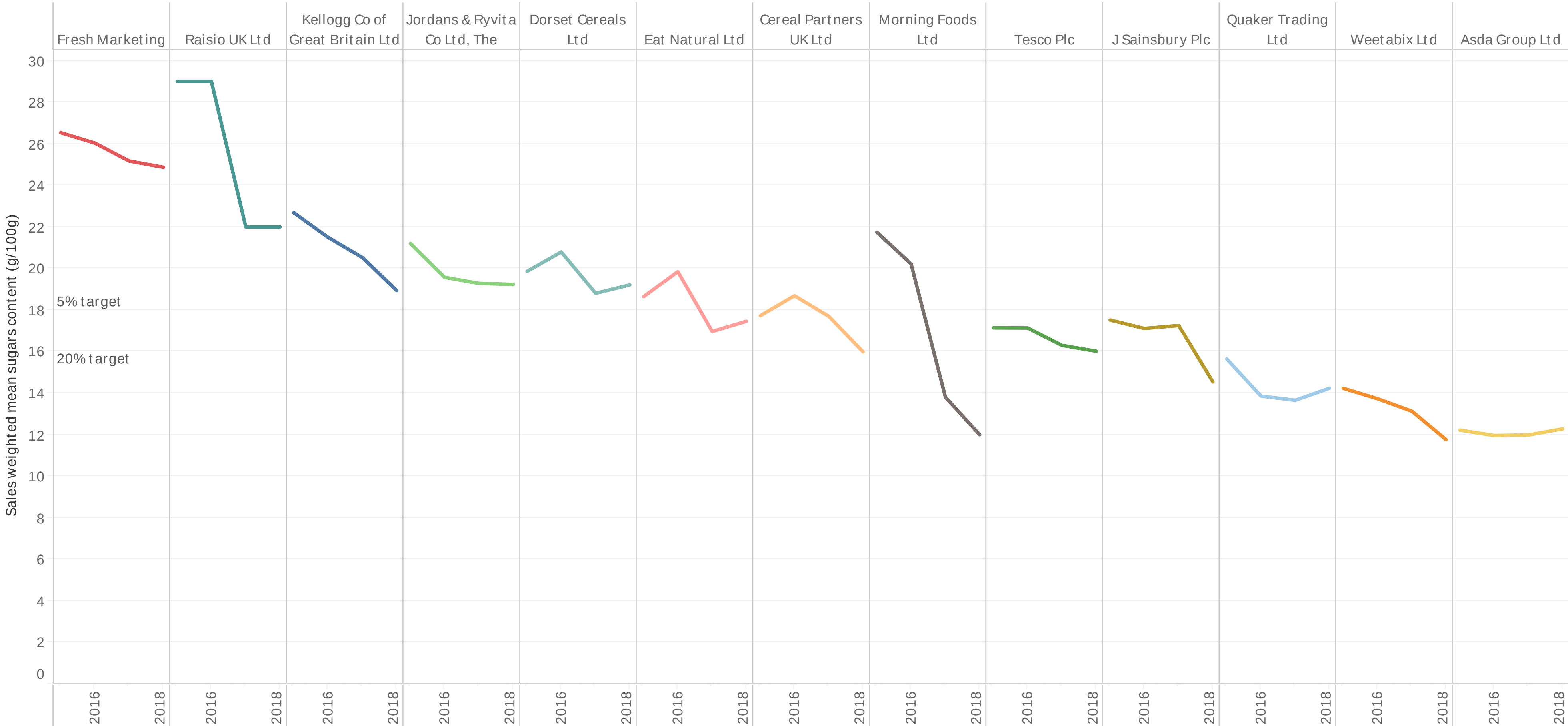
In 2018, the total volume of sugars sold from breakfast cereals was 62,000 tonnes, equivalent of 2.6g sugar per person per day at the population level. The largest breakfast cereal company, Kellogg's, represented 40% of this total in 2018. Of the 13 breakfast cereal companies included here, ten saw a decline in the total volume of sugars sold from 2015-2018 (**Figure 24**). Asda saw no change, while two small companies Fresh Marketing and Eat Natural saw their total volume of sugar sold rise by 30% and 46% respectively due to rising volume sales.

Figure 24: Total volume of sugars sold from breakfast cereals by company in 2015 and 2018



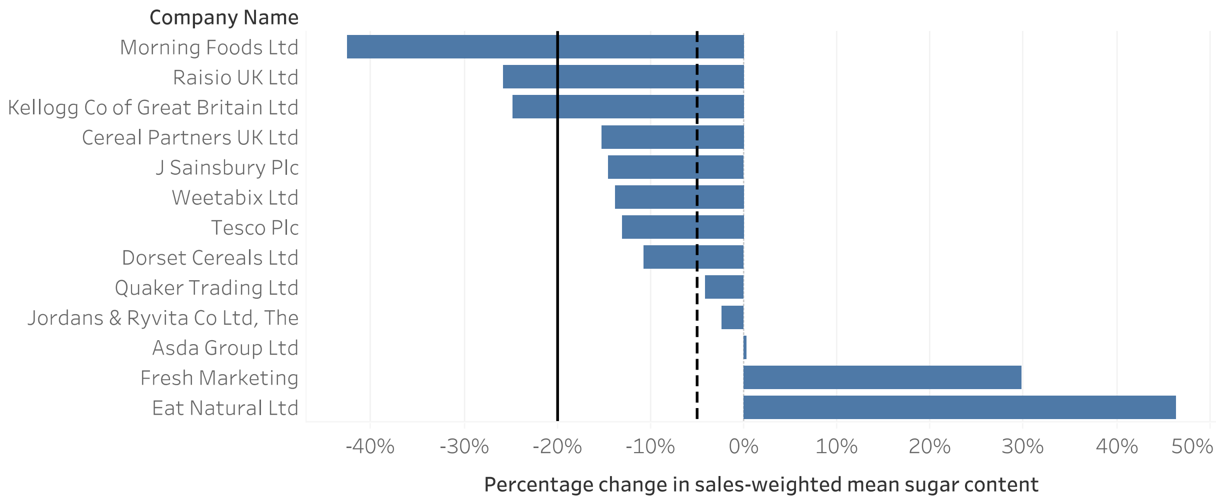
The top five breakfast cereal companies in terms of volume sales of sugar in 2018 were Kellogg's, Quaker, Weetabix, Cereal Partners and Jordan's. Kellogg's did not meet either the 5% or 20% sugar reduction targets in 2018, despite the sales-weighted mean sugar content of its products falling from 22.7g/100g to 18.9g/100g, a decline of 17% (**Figure 25**). Jordan's Cereals also failed to meet either target, while Cereal Partner's mean sugar content fell by 11% to 17.2g/100g, below the 5% target of 17.9g/100g. Quaker and Weetabix were below the 20% target of 15.1g/100g in 2018, with mean sales-weighted sugar contents of 14.2g/100g and 11.8g/100g respectively.

Figure 25: Sales weighted mean sugars content of breakfast cereals by company in comparison to 5% and 20% sugar reduction targets, 2015-2018



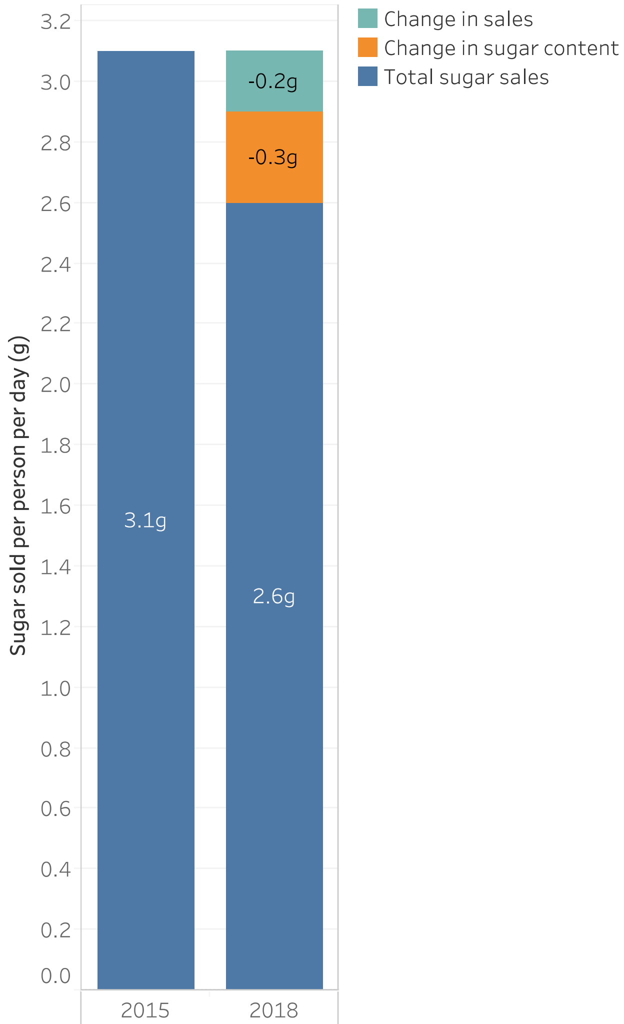
Of the 13 breakfast cereal companies included here, all but three saw a decline in the sales-weighted sugar content of their products (**Figure 26**). Smaller companies Fresh Marketing and Eat Natural saw large growth in volume sales of their products, resulting in a significant increase in sales-weighted mean sugar content of their portfolios. Morning Foods, manufacturer of the Mornflake brand, launched a range of no added sugar granolas, leading to a 43% fall in its sales-weighted sugar content. Raisio and Kellogg were the two other companies that saw their sales-weighted mean sugar content of the breakfast cereals fall by more than 20%, with declines of 26% and 25% respectively. Five other companies saw reductions of over 5%, including Cereal Partners (-15%), Weetabix (-14%), Sainsbury's (-15%) and Tesco (-13%).

Figure 26: Percentage change in sales-weighted mean sugar content of breakfast cereals by company 2015-2018



The total volume of sugar sold from breakfast cereals fell by 0.5g per capita per day, with 60% of this due to a change in the mean sugar content of products, and 40% due to a change in product sales (**Figure 27**).

Figure 27: Proportion of the change in the total volume of sugars sold from breakfast cereals due to a change in mean sugar content compared to a change in product sales, 2015 vs 2018.



Chocolate confectionery

There were 544 different chocolate confectionery products under 102 different brands included in this dataset in 2018, which were manufactured by 17 different companies (**Table 26**). This was a decline of 11%, down from 609 products in 2015.

Table 26: Data points in nutrient composition and sales data sets

	2015	**2016**	**2017**	**2018**
Number of individual products in nutrient composition dataset	609	578	545	544
Number of brands in sales dataset	102	103	105	102
Number of companies	14	18	18	17

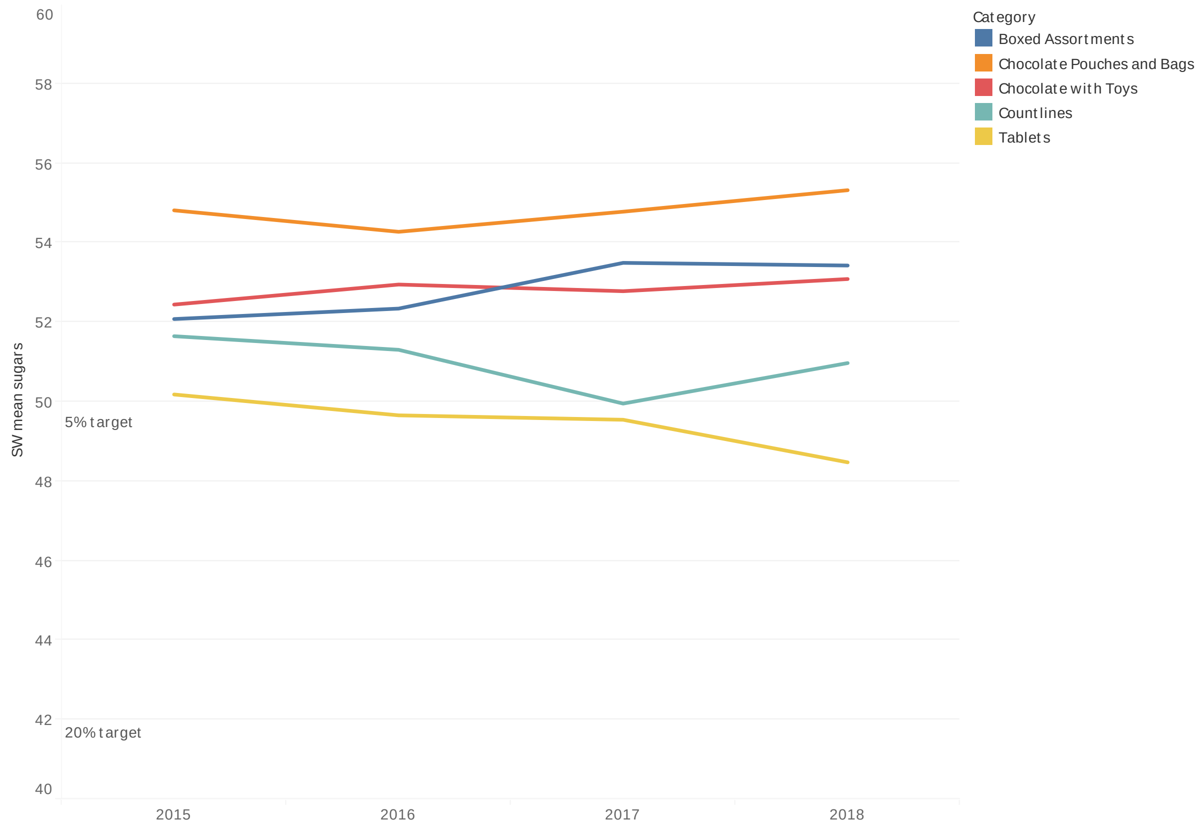
The total volume sales of chocolate confectionery rose by 1% from 2015-2018, from 350,000 tonnes to 354,000 tonnes, (**Table 27**). The change in sales-weighted mean sugar content of the category changed negligibly and was 51.2g/100g in 2018, meaning there was no change in the total volume of sugars sold from confectionery over the time period examined.

Table 27: Total volumes and mean sugars content of chocolate confectionery 2015-2018

	2015	2016	2017	2018	% change 2015-18
Sales volume (tonnes)	350,000	354,000	352,000	354,000	+1.1%
Total sugars volume (tonnes)	181,000	182,000	181,000	181,000	0.0%
Total sugars per capita per day (grams)	7.6	7.6	7.5	7.5	-2.0%
Sales weighted mean sugar content (g/100g)	51.7 (50.8-52.7)	51.4 (50.4-52.5)	51.2 (50.1-52.4)	51.2 (50.2-52.4)	-1.0%
Absolute mean sugar content (g/100g)	51.3 (50.3-52.6)	50.9 (50.2-52.6)	50.4 (49.1-51.6)	50.5 (49.2-51.6)	-1.6%

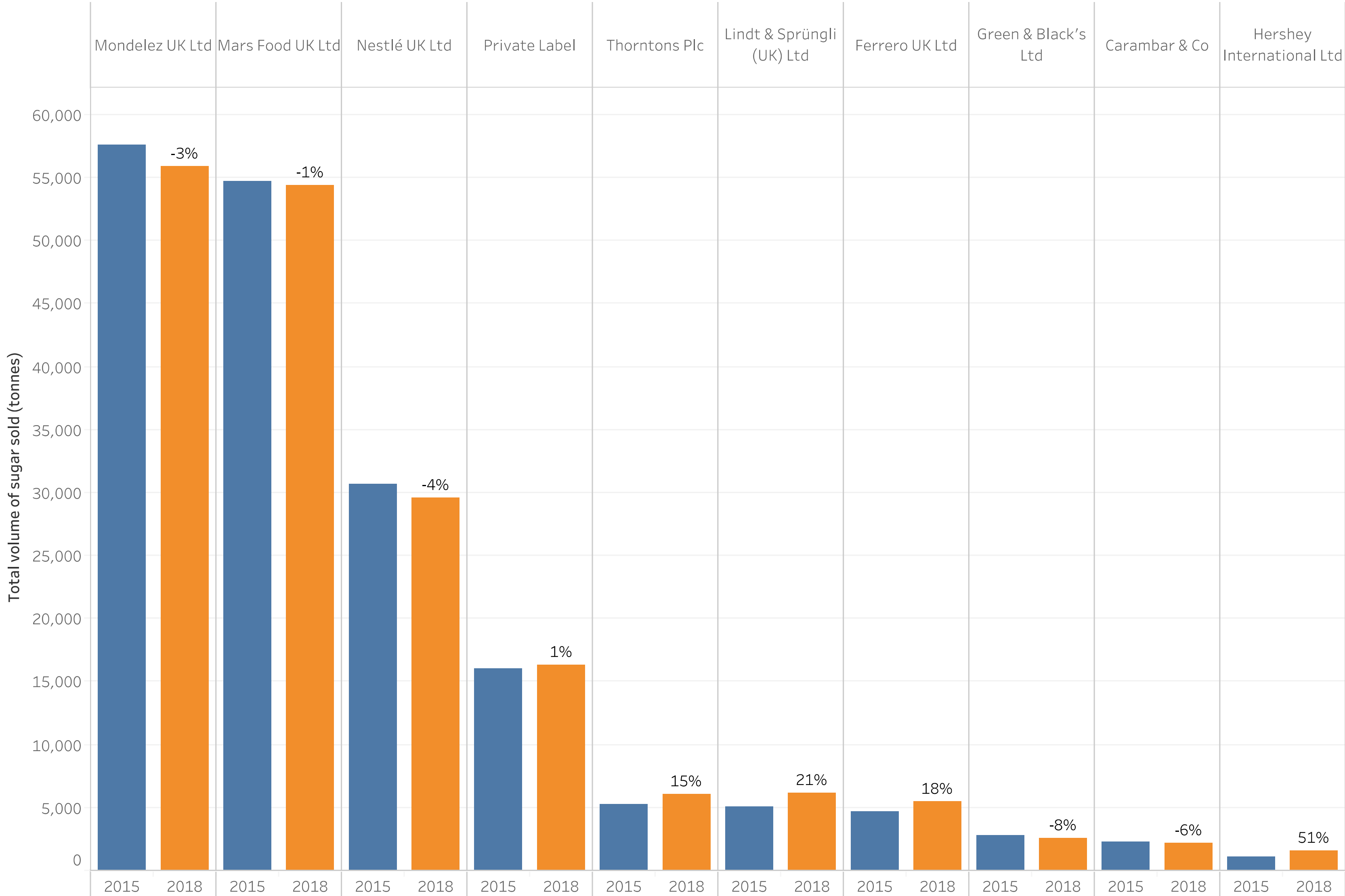
Chocolate pouches and bags – i.e. chocolate sold in bitesize pieces – and boxed assortment chocolates were the two categories with the highest sales weighted mean sugar content at 55.3g/100g and 54.3g/100g respectively (**Figure 28**). The only category that fell below the 5% sugar reduction target of 49.2g/100g was chocolate tablets (large bars of chocolate). This was due to a rise in the number of dark chocolate products, which have a lower sugar content, although the decline was still low at 3%.

Figure 28: Sales weighted mean sugar content of chocolate confectionery by category, in relation to 5% and 20% sugar reduction targets



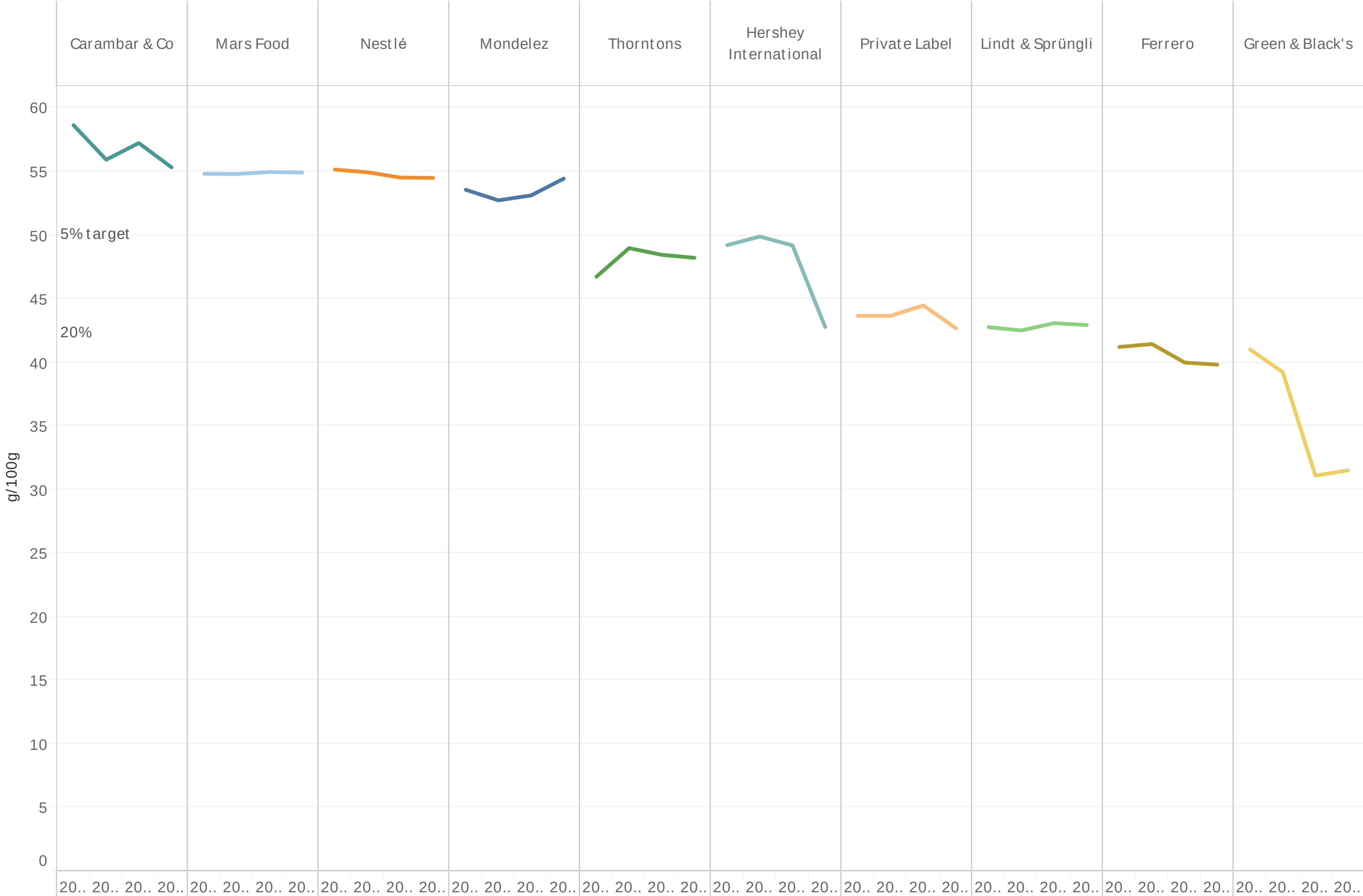
In 2018, 181,000 tonnes of sugar were sold from chocolate confectionery, equivalent to 4.6g sugar per person per day on a population level. The top three companies contributing to total sugar sales – Mondelez, Mars and Nestle – represented 77% of the total volume of sugar sold from chocolate confectionery in 2018 (**Figure 29**). Five of the top ten companies saw increases in their total sugar sales.

Figure 29: Total volume of sugar sold by chocolate confectionery company, 2015 and 2018



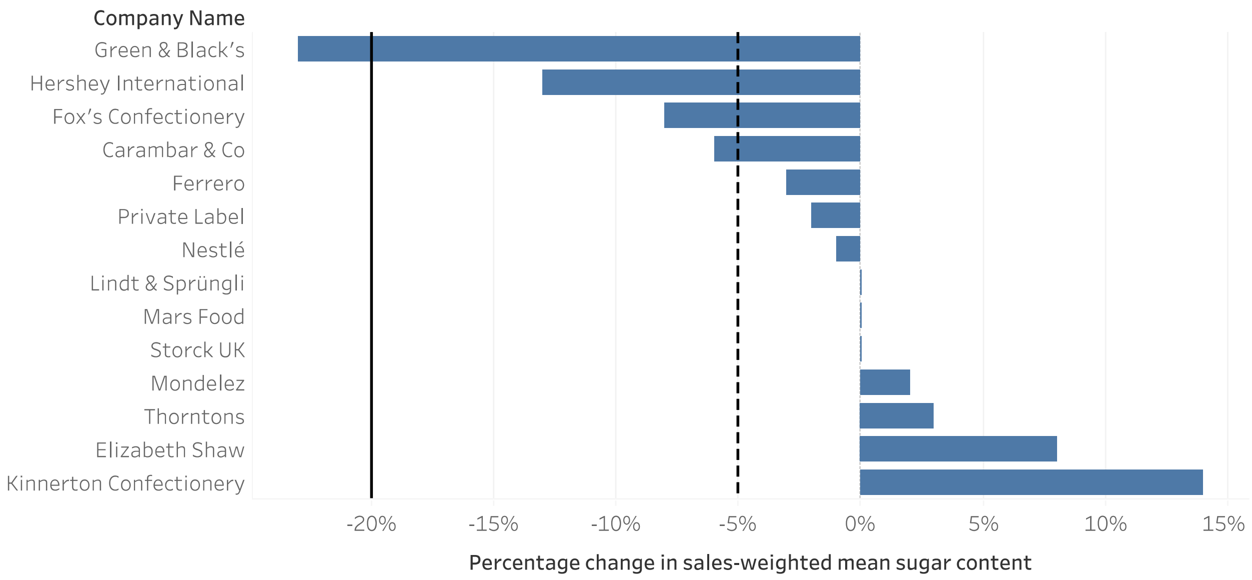
In 2018, six companies had a mean sugar content below the 5% reduction target of 49.2g/100g (**Figure 30**). Two of these – Ferrero and Green & Black's – had mean sugar contents below the 20% target of 41.4g/100g. The three largest players in chocolate confectionery, Mondelez, Mars and Nestle, saw no change in the sales-weighted mean sugar content of their products.

Figure 30: Sales-weighted mean sugar content of chocolate confectionery company product portfolios in comparison to 5% and 20% sugar reduction targets



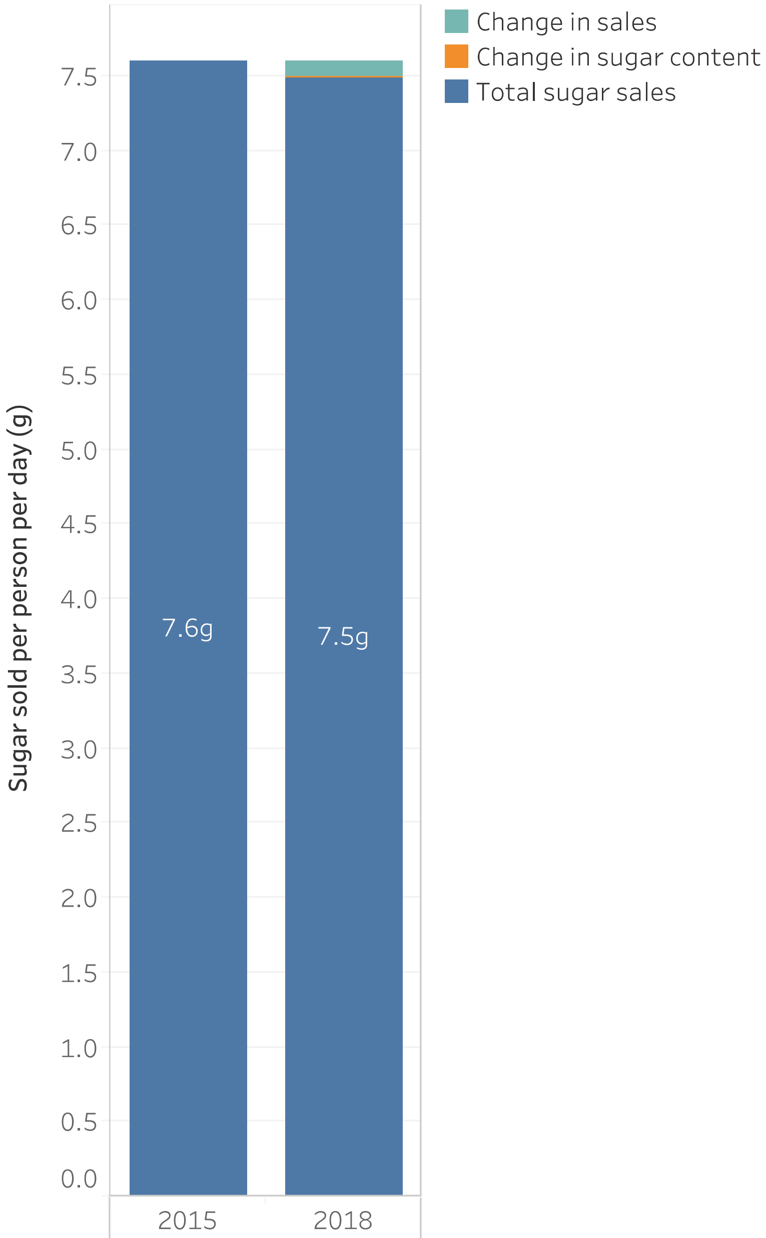
Green & Black's was the company that saw the greatest percentage reduction in sales-weighted mean sugar content over 2015-2018, at -23% (**Figure 31**). Hershey, Fox's and Carambar all saw declines greater than -5%, at -13%, -8% and -6% respectively. Large players Lindt, Nestle, Mars and Nestle saw little change, while Thorntons, Elizabeth Shaw and Kinnterton saw increases in their mean sugar content.

Figure 31: Percentage change in sales-weighted mean sugar content by chocolate confectionery company 2015-2018



The total volume of sugar sold from chocolate confectionery fell by 0.1g, with 100% of this change due to a change in sales (**Figure 32**).

Figure 32: Proportion of change in sugar sales from sugar confectionery due to change in mean sugar content compared to change in volume sales, 2015 and 2018



Sugar confectionery

There were 360 individual sugar confectionery products with 58 different brand names included in this dataset in 2018, which were manufactured by 18 different companies (**Table 28**). This was a slight reduction compared to 371 products in 2015.

Table 28: Data points in nutrient composition and sales data sets

	2015	**2016**	**2017**	**2018**
Number of individual products in nutrient composition dataset	371	372	356	360
Number of brands in sales dataset	59	58	58	58
Number of companies	18	18	18	18

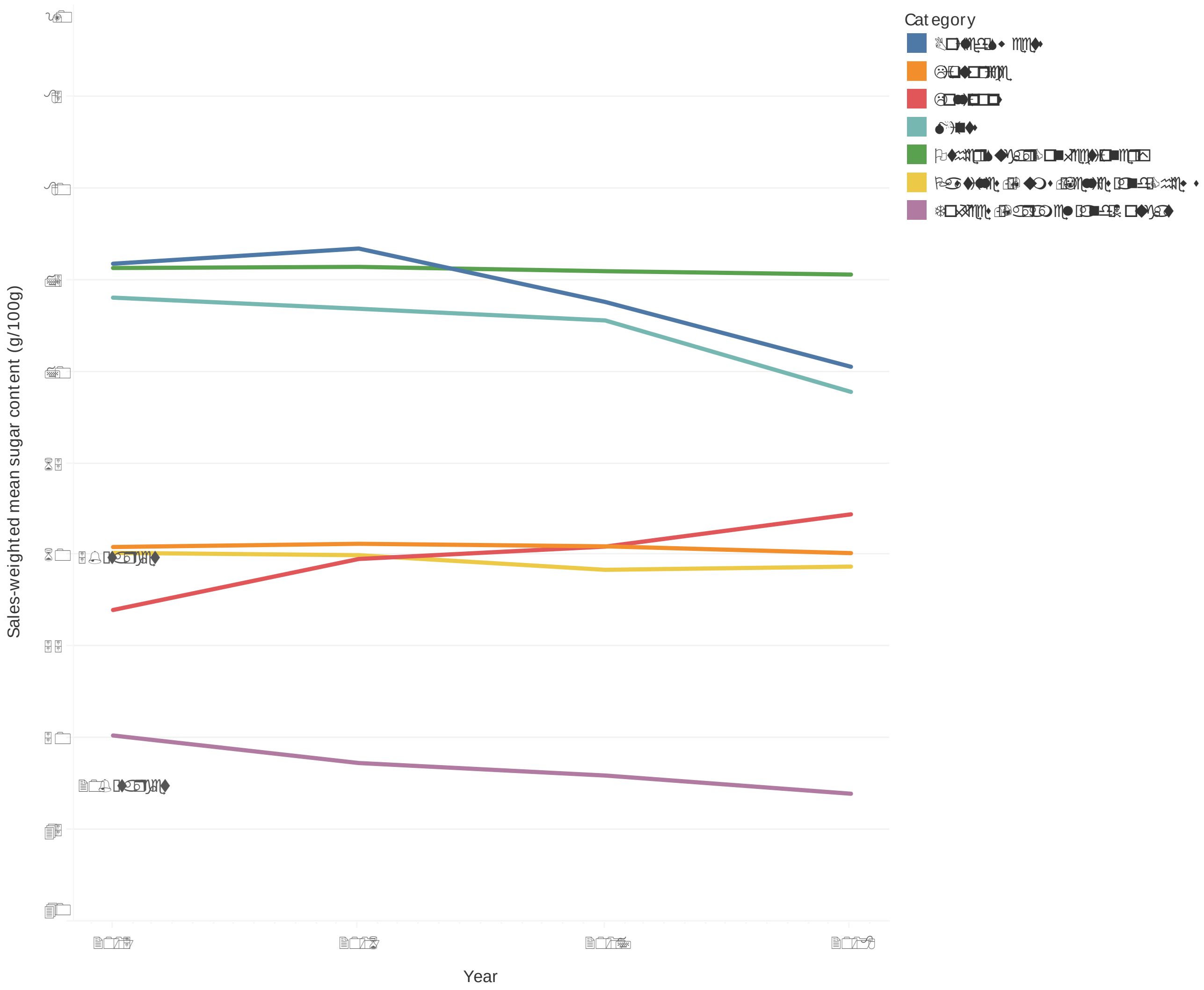
The sales weighted mean sugar content of sugar confectionery fell by 2.5% from 2015-2018 (**Table 29**). This, combined with a small decrease in the sales volume of sugar confectionery, resulted in the total volume of sugar sold from sugar confectionery declining by just under 3%.

Table 29: Total volumes and mean sugars content of sugar confectionery 2015-2018

	2015	2016	2017	2018	% change 2015-18	p-value
Sales volume (tonnes)	128,000	128,000	127,000	127,000	-1%	
Total sugars volume (tonnes)	80,000	79,000	78,000	77,000	-3%	
Total sugars per capita per day (grams)	3.3	3.3	3.2	3.2	-5%	
Sales weighted mean sugar content (g/100g)	62.2 (57.0, 50.0-75.6)	62.1 (57.0, 51.1-71.6)	61.2 (57.3, 50.6-72.1)	60.7 (57.9, 52.8-69.0)	-2%	0.89
Absolute mean sugar content (g/100g)	55.9 (61.0, 52.0-74.4)	55.7 (61.8, 52.5-75.3)	55.5 (60.0, 52.0-75.2)	55.5 (58.5, 50.0-74.0)	-3%	0.49

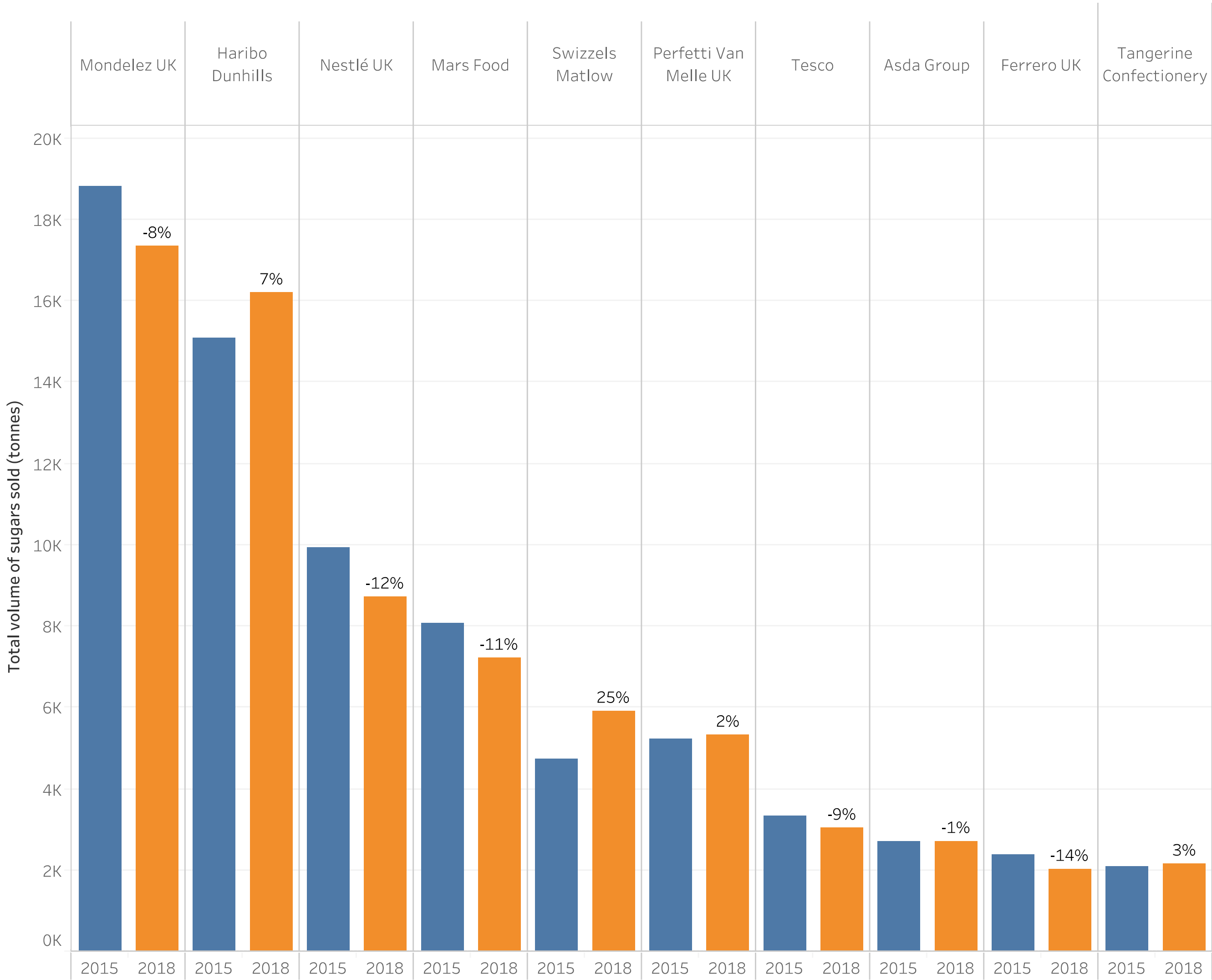
Mints, boiled sweets and other sugar confectionery were the three categories with the highest sales-weighted mean sugar content in 2018, at 68.9g, 70.3g and 75.3g/100g respectively (**Figure 33**). Other sugar confectionery saw no change in its content between 2015-2018. Boiled sweets and mints both declined by 7%. Toffees, caramels and nougat had a sugar content of 47.0g/100g. This was below the 5% target of 59.1g/100g and just above the 20% target of 46.7g/100g.

Figure 33: The sales-weighted mean sugar content of sugar confectionery by category over time, in relation to the 5% and 20% sugar reduction targets



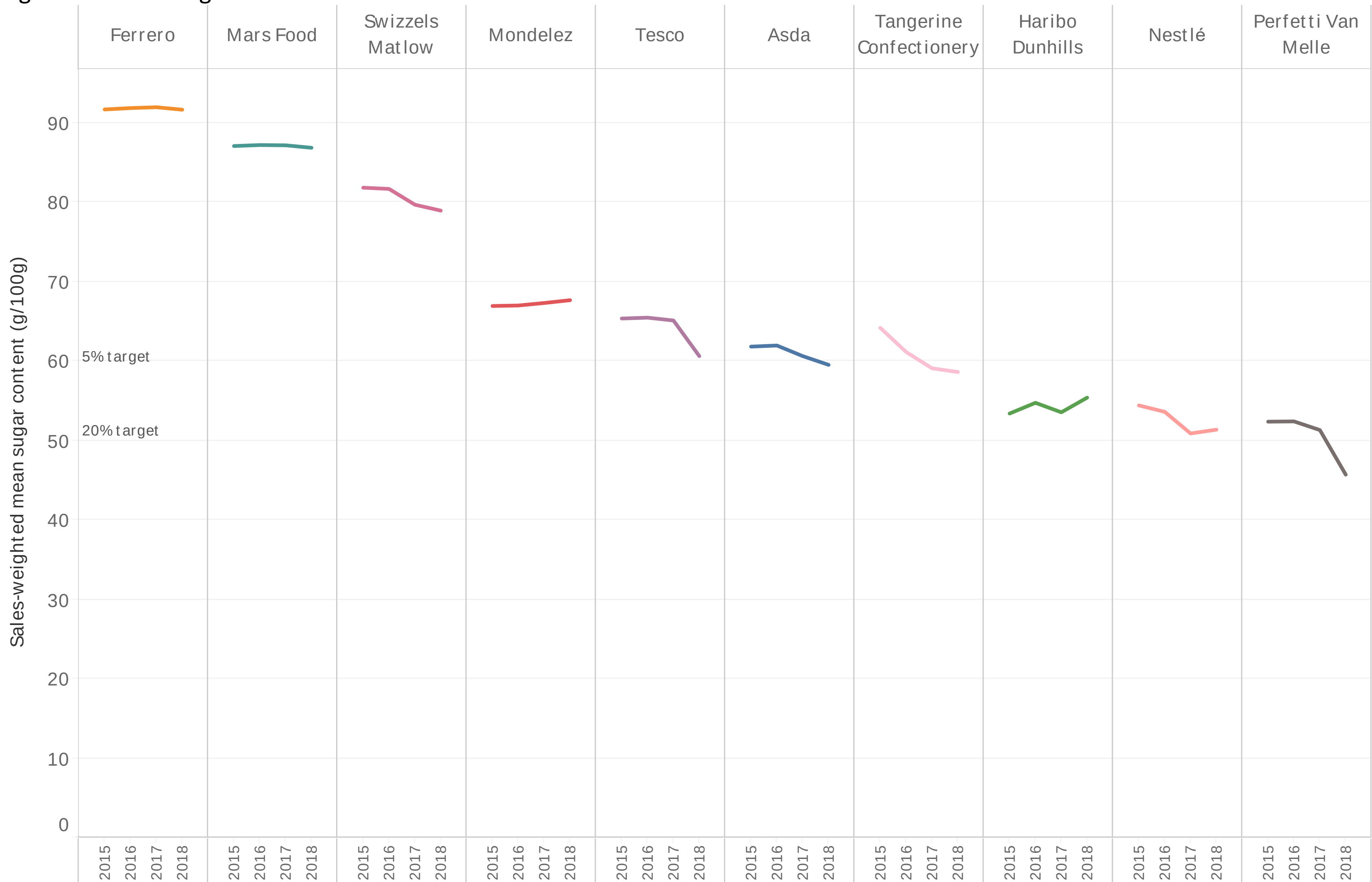
In 2018, 127,000 tonnes of sugar from sugar confectionery was sold, equivalent to 5.3g sugar per capita per day on a population level. The top five companies – Mondelez, Haribo, Nestle, Mars and Swizzles – represented two-thirds of the total volume of sugar sold. Both Haribo and Swizzles saw increases in the total volume of sugars sold, as did Perfetti and Tangerine Confectionery (**Figure 34**).

Figure 34: Total volume of sugar sold from sugar confectionery by company in 2015 and 2018



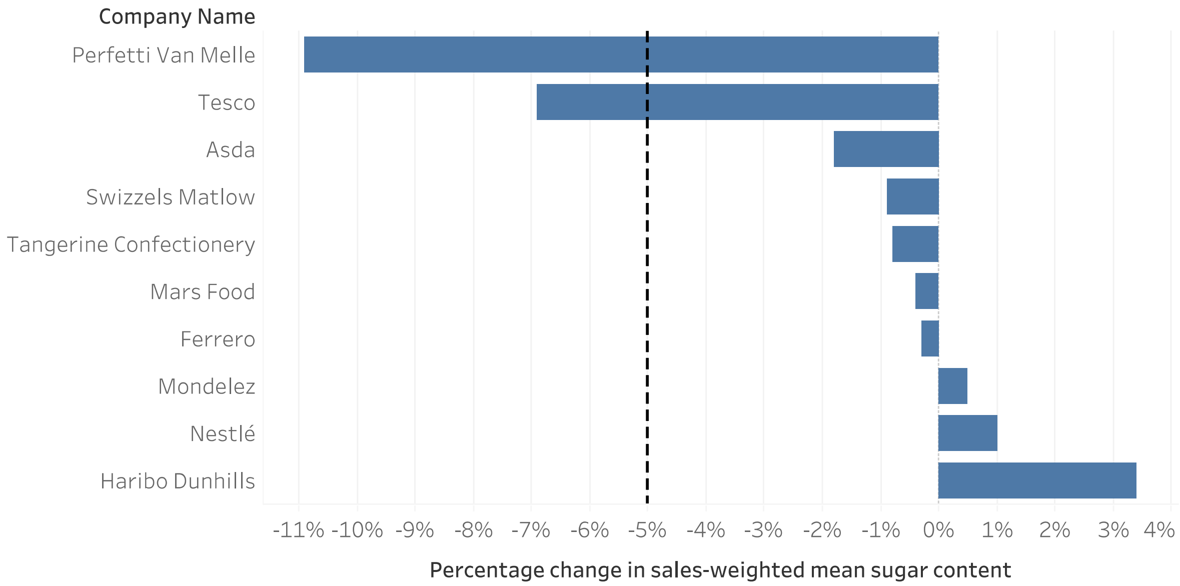
Ferrero had the highest sales-weighted mean sugar content at 91.6g/100g in 2018, followed by Mars (86.2g/100g) and Swizzels (78.9g/100g) (**Figure 35**). Three of the top ten companies met the 5% sugar reduction target of 59.1g: Tangerine Confectionery, Haribo and Nestle. In 2018, the sales-weighted mean sugar content of Perfetti's products was 45.7g/100g, below the 20% reduction target of 49.7/100g.

Figure 35: Sales-weighted mean sugar content of sugar confectionery by company 2015-2018, in relation to the 5% and 20% sugar reduction targets



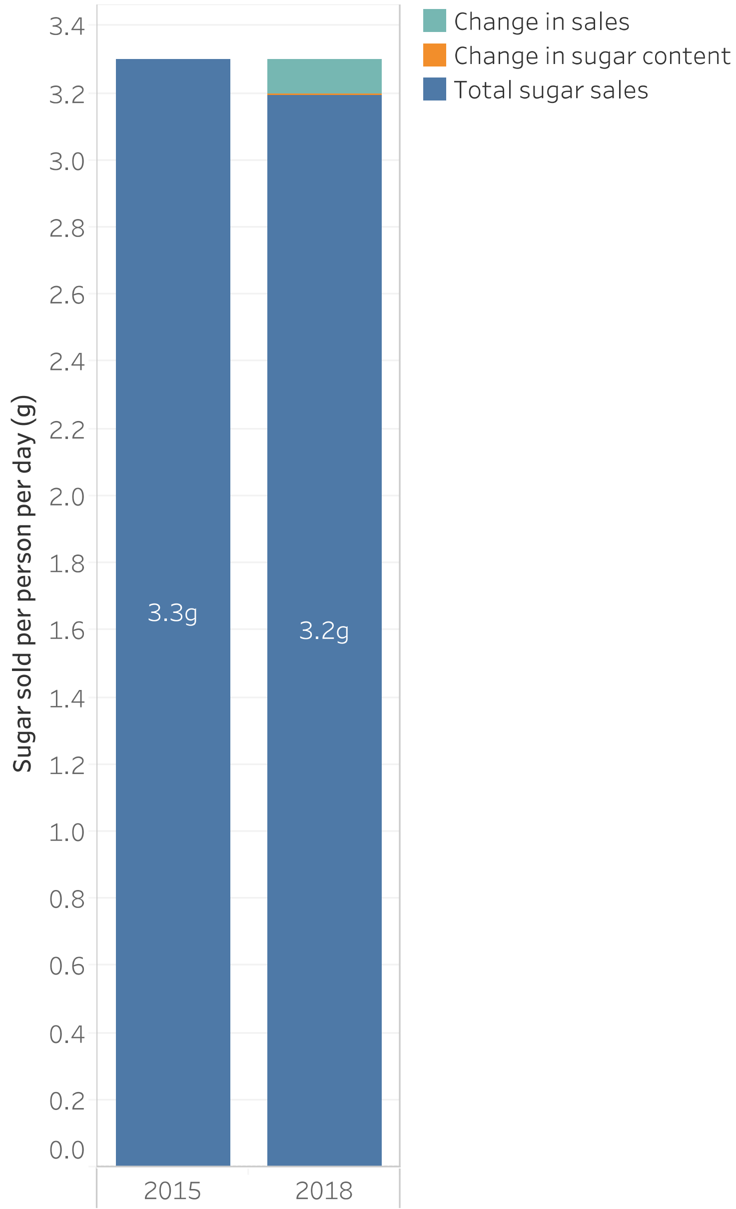
None of the top ten sugar confectionery companies have achieved a 20% change in the sales-weighted mean sugar content of their products between 2015 and 2018 (**Figure 36**). Perfetti and Tesco saw reductions greater than 5%, at -11% and -7% respectively. The three largest sugar confectionery companies, all saw small increases in the sales-weighted mean sugar content of their products.

Figure 36: Percentage change in sales-weighted mean sugar content of sugar confectionery by company, 2015-2018



Sales of sugars from breakfast cereals fell by 0.5g from 2015 to 2018, with 40% due to a change in product sales and 60% due to a change in the mean sugar content of products (**Figure 37**).

Figure 37: Proportion of change in sugar sales from sugar confectionery due to change in mean sugar content compared to change in volume sales, 2015 vs 2018



Yoghurts

There were 546 yoghurt products being sold under 53 brand names included in this dataset in 2018, which were manufactured by 16 companies (**Table 30**). This was a slight increase compared to the 538 products seen in 2015.

Table 30: Data points in nutrient composition and sales data sets

	2015	**2016**	**2017**	**2018**
Number of individual products in nutrient composition dataset	538	565	581	546
Number of brands in sales dataset	47	48	54	53
Number of companies	17	17	16	16

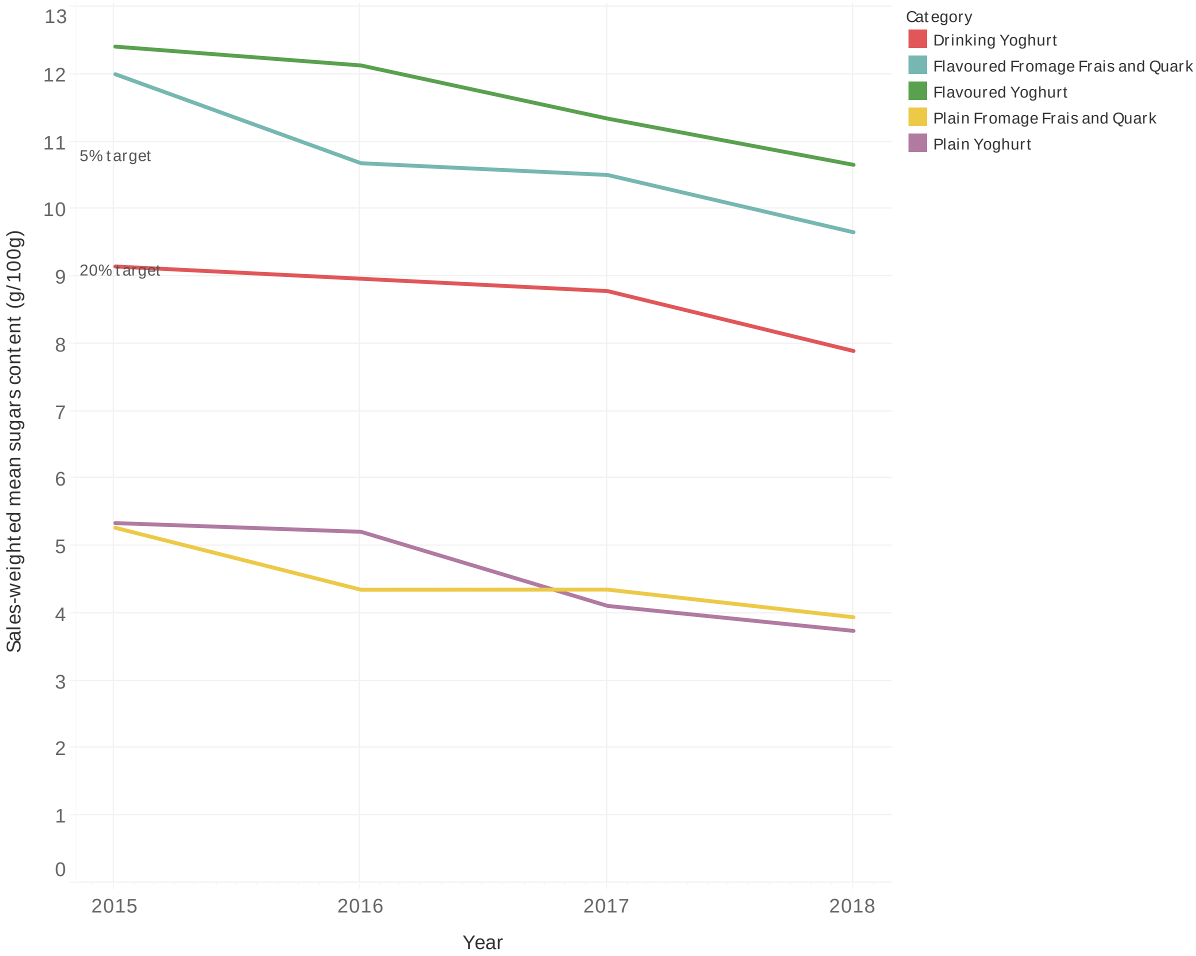
The sales-weighted mean sugar content of yoghurts fell from 11.2g/100g in 2015 to 9.3g/100g in 2018, a decline of 17% (**Table 31**). This, combined with a fall in the total volume of yoghurt sold, meant that there was an 18% decline in the total volume of sugars sold between 2015-2018, equating to 0.5g of sugar per person per day at the population level.

Table 31: Total volumes and mean sugars content of yoghurts 2015-2018

	2015	2016	2017	2018	% change 2015-18
Sales volume (tonnes)	511,600	514,900	513,600	503,200	-2%
Total sugars volume (tonnes)	57,200	55,300	51,500	46,800	-18%
Total sugars per capita per day (grams)	2.4	2.3	2.1	1.9	-20%
Sales weighted mean sugar content (g/100g)	11.2 (10.9-11.5)	10.7 (10.4-11.2)	10.0 (9.8-10.4)	9.3 (9.1-9.6)	-17%
Absolute mean sugar content (g/100g)	11.4 (11.0-11.7)	10.9 (10.6-11.2)	10.3 (10.0-10.6)	9.8 (9.5-10.2)	-14%

Flavoured yoghurt was the sweetest type of yoghurt in 2018 (9.7g/100g), containing more than twice as much sugar as plain yoghurt (3.7g/100g) and plain fromage frais (3.9g/100g) (**Figure 38**). Both flavoured yoghurt and flavoured fromage frais had not met the 20% sugar reduction target of 8.9g/100g in 2018.

Figure 38: Sales-weighted mean sugar content of yoghurt by category



The largest five yoghurt companies – Muller, Danone, Yoplait, Yeo Valley and Lactalis – represented 71% of the total volume of sugars sold from yoghurts in 2018. Four of these companies saw a decline in the total volume of sugars sold from 2015-2018 (**Figure 39**) while Yeo Valley increased the total volume of sugar sold by 3%. None of these top five companies had met the 20% reduction target of 8.9g/100g in 2018 (**Figure 40**), although all except for Lactalis had met the 5% reduction target of 10.6g/100g.

Figure 39: Total volume of sugars sold by company, 2015 and 2018

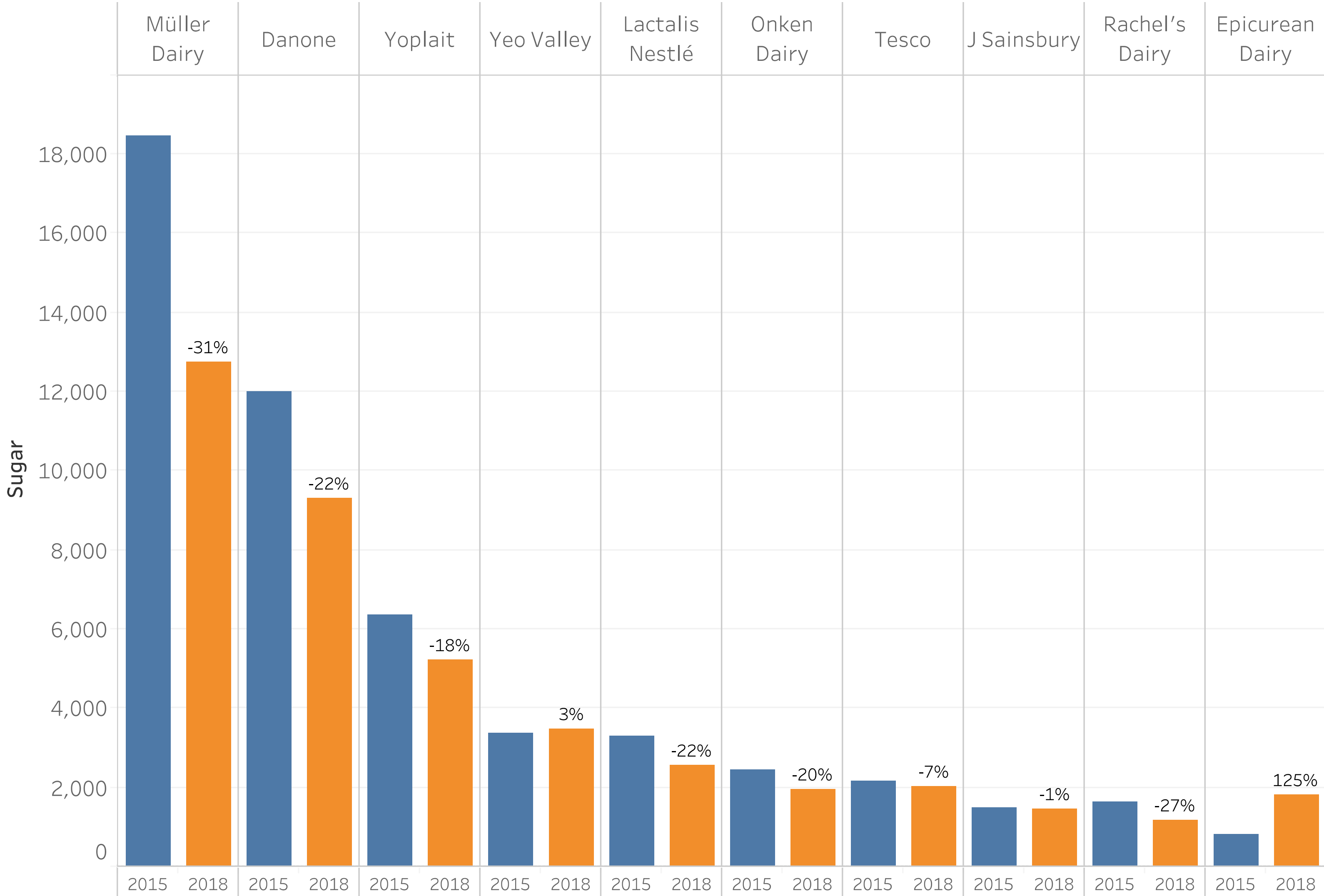
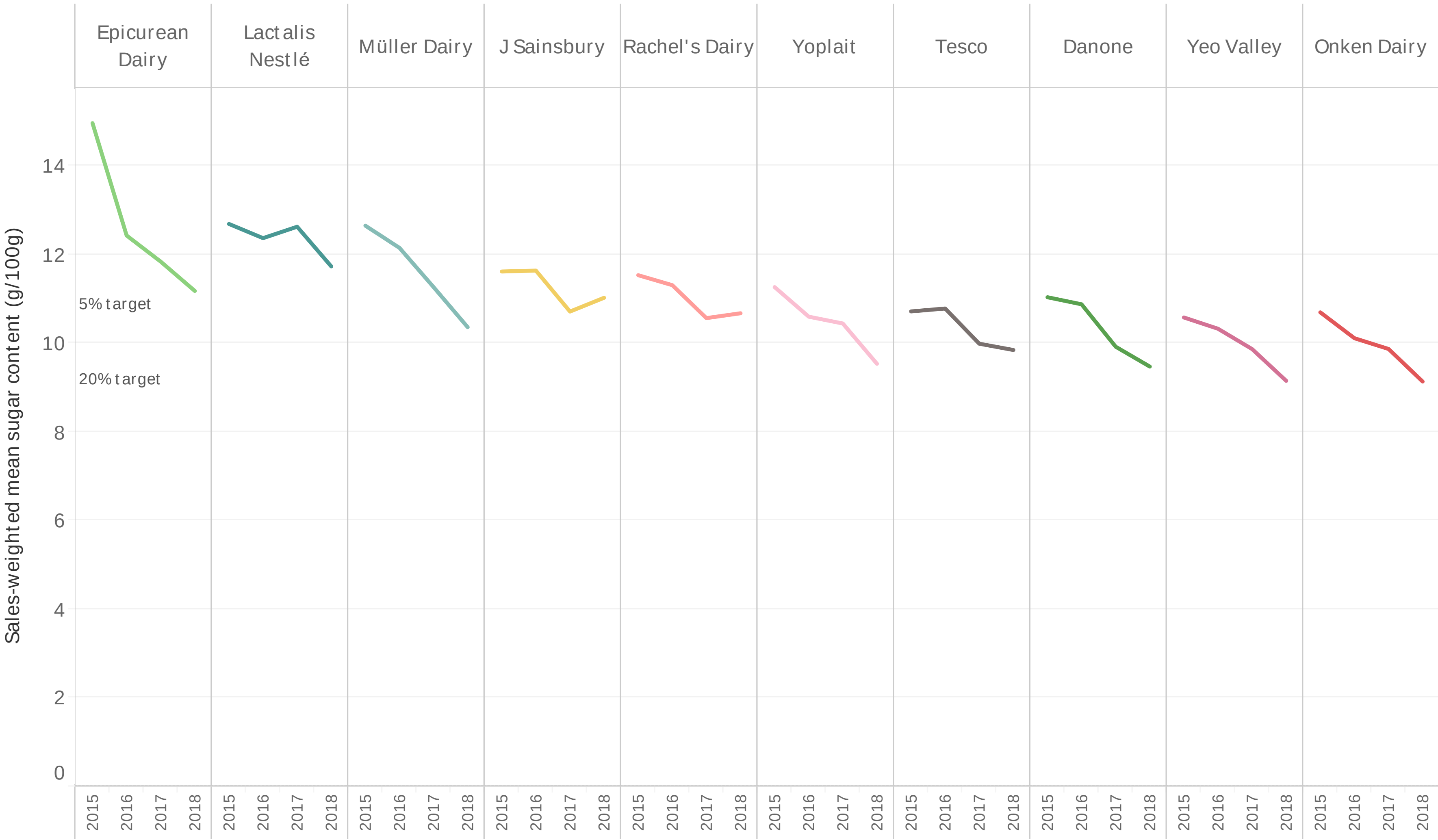
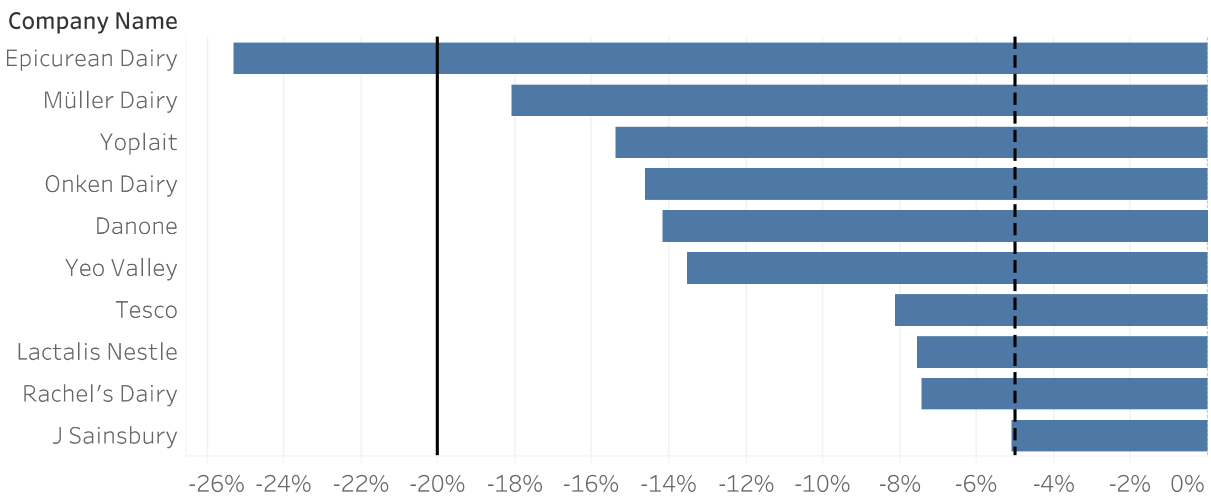


Figure 40: Sales weighted mean sugars content of yoghurt by company, in relation to 5% and 20% sugar reduction targets, 2015-2018



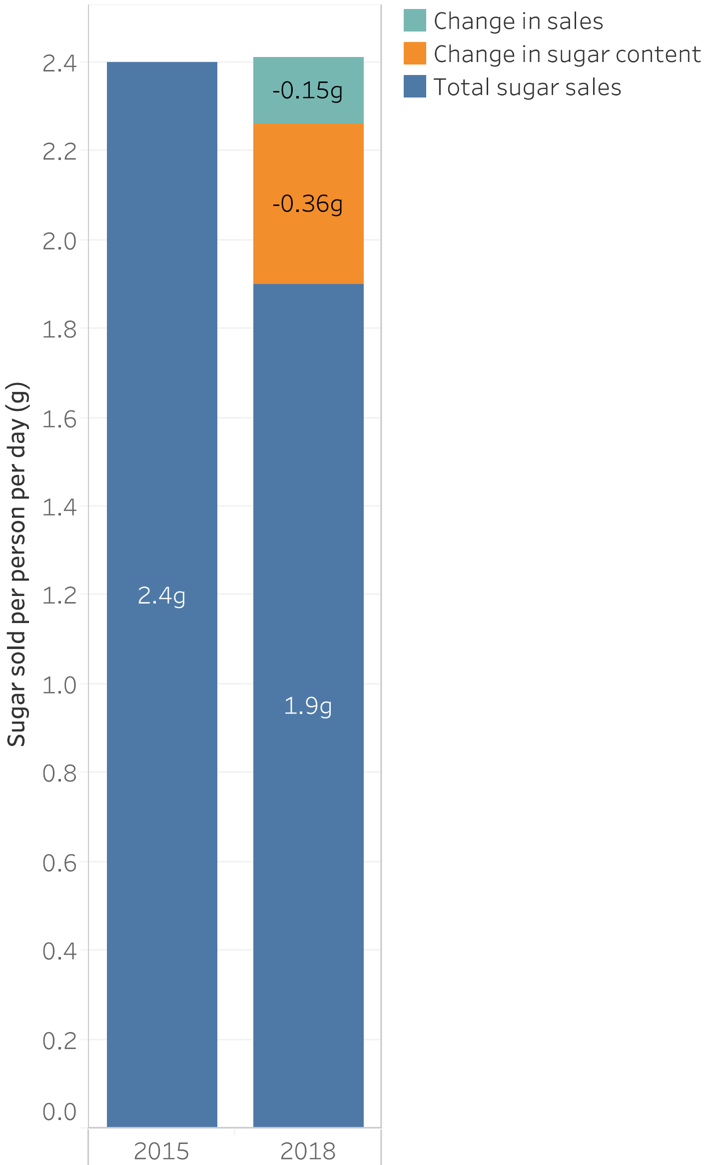
All 16 of the yoghurt companies included in 2018 saw an overall decline in the mean sugar content of their products compared to 2015 (**Figure 41**). Of the top ten companies that contribute to total volume sales of sugars, all declined by at least 5% over the time period. Epicurean Dairy, owner of premium brand Collective Dairy, saw a 25% drop in its sales-weighted mean sugar content. Large players Müller and Yoplait saw declines of 18% and 15% respectively, with smaller declines for retailers Tesco (-8%) and Sainsbury's (-5%).

Figure 41: Percentage change in the sales-weighted mean sugar content of yoghurts by company, 2015-2018



The volume sales of sugar from yoghurts fell by 0.5g per capita per day from 2015 to 2018. Of this, 30% was due to a change in product sales, and 70% was due to a change in the sugar content of products (**Figure 42)**.

Figure 42: Proportion of change in sugar sales from yoghurts due to change in mean sugar content compared to change in volume sales



Discussion

Between 2015 and 2018, the total volume of sugar consumed from biscuits, breakfast cereals, confectionery, soft drinks and yoghurts fell by 6.3g per capita per day, from 36.8g to 30.5g, a reduction of 17%. Three-quarters of this reduction was attributable to changes in soft drinks alone. The change in the food categories was more modest, at 1.7g, a reduction of 8%. The total sales-weighted mean sugar content of these foods fell by 5% between 2015 and 2018, from 28.7 to 27.3/100g. The sales-weighted mean sugar content of soft drinks declined by 34% throughout the period, from 4.4g/100ml to 2.9g/100ml. There was marked variation in the change in sugar content between individual categories. Yoghurts saw their overall sales weighted mean sugar content fall by 17% from 11.2g/100g in 2015 to 9.3g/100g in 2018. Breakfast cereals fell by 14%, from 18.8g to 16.3g/100g. In comparison, the mean sugar content of biscuits and cereal bars decreased by only 6%, and there was only a 1-2% reduction for both sugar and chocolate confectionery.

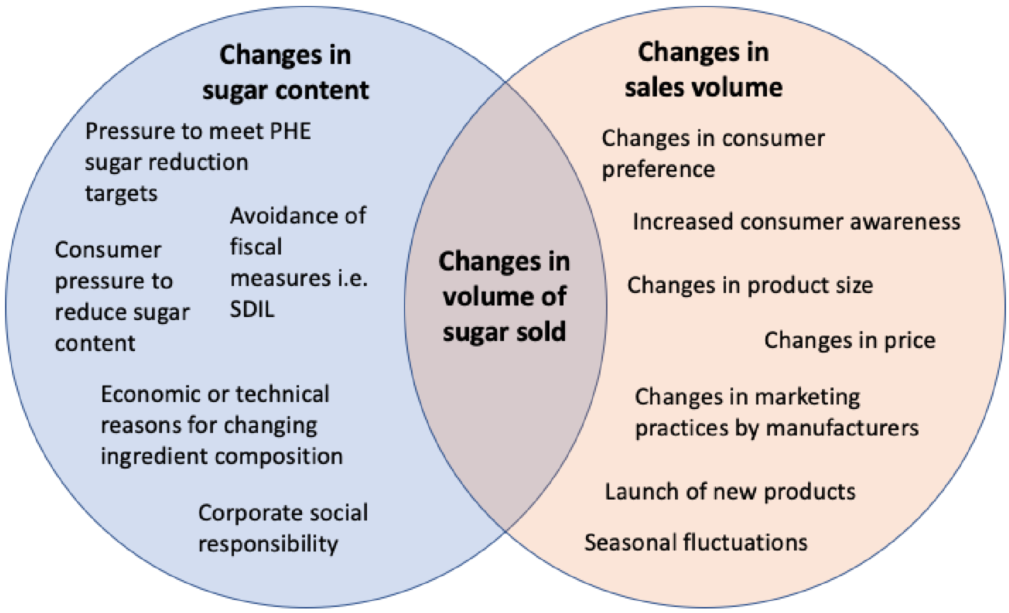
A reduction in the total volume sales of sugar is fundamentally down to two factors: a change in the mean sugar content of products, and/or a change in their sales volume. In this case, the majority (85%) of the change in soft drinks was due to a reduction in the mean sugar content of products: i.e. companies removing sugar from their products between 2015 and 2018. The remaining proportion (15%) was due to a change in sales volumes. For foods, the total split between reformulation and sales was 57% and 43%. For breakfast cereals and yoghurts - the only two food categories that saw significant reductions in total sugar sales – the majority of the change was due to reformulation, at 60% and 70% respectively. For the other categories (i.e. biscuits and confectionery), any change that was seen appeared to be due to changes in sales only.

There was great heterogeneity in how companies responded to the sugar reduction targets, but of the 63 companies presented in the analysis above, only 9% (n=5) met one 20% reduction target for sales-weighted mean sugar content and only 26% (n=15) met one 5% target. Kellogg's was the only company to meet two 20% targets for breakfast cereals and biscuits and Sainsbury's and Tesco met the 5% targets for 2 and 3 categories respectively. Overall, the company level changes seen within the voluntary reformulation targets seem small compared to the company level changes in soft drinks, where seven out of the top 10 companies reduced their sales-weighted mean sugar content by 20% or more.

Policy actions to reduce sugar

Changes in the mean sugar content of products are down to manufacturers changing the formulation of products, whereas a change in the sales volume can be due to both consumer and manufacturer behaviour. The factors influencing the change in total sugar sales are illustrated below (**Figure 43**).

Figure 43: Factors influencing the change in the total volume of sugar sold



While there are multiple reasons why the rate of the change in total volume of sugar sold is different between soft drinks and foods, which cannot necessarily be distinguished here, the difference may reflect the relative success of the two policy approaches taken with sugar reduction: a mandatory tax with soft drinks, and voluntary reduction targets for foods.

This analysis is not a specific evaluation of the SDIL. The annual time points are not granular enough for anything to be inferred about how the sales or sugar content of products changed in the lead up to and time after the announcement (March 2016) and implementation (April 2018) of the SDIL, which would be needed for, and indeed is part of, the formal SDIL evaluation (235). However, there are two main results presented in this analysis that suggest that the SDIL may been effective. Firstly, the greatest rate of change in the sales-weighted mean sugar content of soft drinks was in 2017-18, the year the SDIL was implemented (-13% in 2017-18 compared to -7% and -10% for 2015-16 and 2016-17 respectively). Secondly, the volume sales of tax-eligible soft drinks fell by 51%, from 9.8ml per capita per day to 4.8ml per capita per day, while the volume sales of all soft drinks increased by 5% over the same time period. The results of this analysis also suggest that the SDIL was more effective at prompting reformulation than the voluntary 20% sugar reduction targets. The sales-weighted mean sugar content of soft drinks fell by 34%, compared to 5% for the included food categories. The total volume sales of sugar for soft drinks fell by 30% over the same time period, equivalent to 4.6g sugar per capita per day, compared to 8% or 1.7g for the included food categories.

The relative success of sugar reduction in soft drinks compared to foods may also be accounted for by technical challenges of reformulating. Reformulation for soft drinks is relatively straightforward – the sweetness delivered by sugar and other caloric sweeteners can be replaced with high intensity sweeteners and water (236). Other foods containing starches and/or fats combined with sugars, are harder to reformulate (236). In food categories such as breakfast cereals, chocolate confectionery and baked goods, sugar does not only deliver sweetness but has other technical properties, including water retention, browning, texture modification and structure (236). In these cases, sugar often has to be replaced with other ingredients, which does not always result in a reduction in the energy content of the product (237). The consumer acceptability of reduced-sugar foods has been shown to be lower than their regular counterparts meaning that food manufacturers may be reluctant to reformulate to reduce the sugar content of their products than with soft drinks (237)(238). It may be that the small reductions seen in the sugar content of foods may be accounted for by the above.

Comparison of UK sugar reduction programme with initiatives in other countries

There are multiple frameworks that can be used to map food policies, including the NOURISHING framework by the World Cancer Research Fund (239) and the 'Four Ps of marketing' (product, price, place and promotion), established in the 1960s as a means of translating market planning into practice (15). The NOURISHING framework did not seem suitable for the purpose of comparing sugar reduction programmes across countries in the context of this chapter, as it only includes one point on the food supply. The 'Four Ps of Marketing' is business-centric and excludes people-centred policy elements such as health awareness and labelling. Instead, the WCRF's 'Four As' framework was used, which sets out the four policy areas that can be used to reduce sugar consumption (240). These four areas are:

1) Reducing the **availability** of high-sugar products
2) Reducing their **affordability** by increasing prices with the aim of reducing consumption
3) Increasing the **acceptability** of healthier and low sugar alternatives
4) Improving the **awareness** of the benefits of reducing sugar consumption

The UK claims to be the first country in the world to have implemented a sugar reduction programme (241). While specific sugar reduction targets may not have been introduced in other countries, we already know that reducing the availability and affordability of high-sugar products, in combination with improving awareness, works. In Mexico for example, an SSB and non-essential energy-dense (NEED) food tax on products >275kcal/100g was implemented in 2013, alongside a nationwide public awareness campaign. The purchases of NEED foods fell by 5% after the implementation of the tax (94) and consumption of SSBs fell by 7.6% from 2012-2014 (88), with adults who were aware of the tax reporting a significantly lower volume of SSBs compared to those who were not (89).

In France, the National Nutrition and Health Programme (PNNS) is currently in its fourth iteration and aims to reduce the consumption of sugars in the context of improving the total diet (242)(243). It includes a tax on soda (reducing affordability), a mass media campaign to reduce the consumption of foods high in sugar, fat and/or salt (improving awareness), the establishment of a Food Quality Observatory (Oqali) to assess the nutritional composition of foods and the implementation of Nutriscore, a front of pack nutrition label (242)(243). An evaluation of the soda tax (which includes all sweetened drinks, not just those containing sugar) showed it reduced consumption of taxed drinks by 10ml per capita per week (90). Results from Oqali show that the sugar content of breakfast cereals fell by 10% from 2001-2008 and that an estimated 11,700-13,000 tonnes of sugar were removed from the food supply between 2008-2010 (240).

In 2011, Hungary introduced a tax on a range of processed foods according to their sugar or salt content, including soft drinks, confectionery and snacks (reducing affordability). An initial evaluation of this policy showed that prices of tax-eligible products increased by 29%, while consumption fell by 3.4% (91).

According to the ‘four As’ framework, the sugar reduction programme currently implemented in the UK is relatively comprehensive. Greater reductions in the mean sugar content of breakfast cereals were seen in the UK compared to France (17% between 2014-2018 vs 10% in France from 2001-2008). The volume sales of tax eligible beverages fell by 56 ml per capita per day in this study, compared to 12ml/day in Mexico and 10ml/week in France, although this chapter is not a specific evaluation of the SDIL and so these results are not directly comparable. The sugar reduction programme in the UK appears to be successfully reducing the availability and affordability of high-sugar food and drinks, relative to other countries. As well as the SDIL and sugar reduction targets, some of this effect may be due to improved awareness resulting from other programmes, including the promotion of traffic light labelling, the Eatwell Guide, reformed school meal standards and the Change4Life programme. That said, in one study that modelled the impact avoiding red foods had on individual nutrient intakes, there was some evidence that traffic light labels could reduce intakes of energy, saturated fat and sodium, but not sugar (51). In 2015, it was estimated that two-thirds of the packaged food and drink had adopted the traffic light label (244). Change4Life is a health awareness and education campaign launched in 2009 which promotes the benefits of reducing the consumption of high-sugar foods and promotes low-sugar alternatives through its 'Smart Swaps' programme. An evaluation of the Smart Swaps programme, which began in 2014, found that may push people towards healthier choices, although there is no evidence this is effective at reducing sugar intakes in the long run (50). It therefore seems unlikely that the traffic light labelling scheme, Change4Life programme and other Government policies designed to improve diets would have made a major contribution to the sugar reductions seen in this study between 2015 and 2018.

Despite the success of the UK sugar reduction targets in certain categories, the total volume sales of sugar still far surpass dietary guidelines. Both the WHO and SACN recommend that daily sugar intake does not exceed 19g for children aged 4-6 years, 24g for children aged 7-10 years and 30g for those aged 11 and above (245)(124). This analysis shows that in 2018, the volume sales of sugar in the included categories was 30.5g in per capita per day terms. Public Health England estimate that the categories covered by the sugar reduction targets represent between 40-60% of sugar intake, depending on age range. Using this to extrapolate the results presented in this study, total sugar intake would therefore be between 50.8-76.1g in 2018. The numbers presented here are only a mean for the total population, obscuring differences in age and heterogeneity in consumption between individuals. Therefore, the current consumption levels are likely to far exceed the recommended intake of 30g for those aged 11 years and above. While the reductions observed in this study are a step in the right direction, further and more drastic action is needed.

Alternative policy options

In order to significantly reduce levels of diet-related disease in the UK, bolder interventions are needed. Much of the current sugar reduction programme (e.g. the sugar reduction targets and Change4Life) falls low down on the Nuffield Ladder of Intervention (see Chapter 1). Implementing policies that guide choice through disincentives and restrict and eliminate choice are needed. Ultimately, policies need to reduce the affordability, awareness and accessibility of high-sugar products and improve the acceptability of low sugar alternatives, five of which have been included below.

1. Lowering the SDIL threshold to below 5g

The results of this study show that there was a marked increase in the proportion of drinks in the market classified as low sugar. However, the volume of sugar sold from products classified as 'low sugar' has increased by 24% from 2015-2018 and the sugar content of many of these products is close to the threshold for the levy. Reducing the thresholds of the SDIL may prompt further reductions in sugar content – although it may also risk antagonising the industry, as previously they had two years between the announcement and introduction of the levy. Lowering the threshold may punish companies that have already acted in good faith (e.g. Lucozade Ribena Suntory), while stimulating no further change in companies that have decided not to reformulate (e.g. Red Bull). Lowering the SDIL would reduce the affordability of high-sugar soft drinks, reduce their availability and ultimately, with big shifts in the market and lower sugar products (<4g/100ml) becoming the norm, make low-sugar products more acceptable.

2. Extending the SDIL to products that are currently exempt

The proportion of sugar sold from tax-exempt products (e.g. 100% juices) increased from 21% to 28% between 2015 and 2018, although the total volume of sugar from tax exempt soft drinks has declined from 3.3g per capita per day to 3.0g. Both adults and children perceive fruit juices to be healthier than carbonated drinks, when in reality they are often just as sweet (246). Milk-based flavoured drinks are also excluded from the SDIL and also contain high levels of sugar. Including currently exempt products in the SDIL is likely to encourage reductions in their sugar content and would signal clearly to consumers that these are high sugar products and consumption should be limited. Extending the SDIL would reduce the affordability of these high-sugar products, reduce their availability if it stimulated reformulation, and help to make low-sugar products more acceptable.

3. Introducing a confectionery industry levy

If voluntary sugar reduction targets for foods are not working, then fiscal measures, such as taxes, should be considered, especially given the relative success of sugar reduction in soft drinks. Part of the rational for taxing soft drinks was that they contribute significantly to sugar intakes but provide only empty calories. The same can be said for chocolate and sugar confectionery, which contribute to 34% of the total volume of sugars sold from the included food categories in this analysis, and where changes in mean sugar content in the past 4 years have been minimal, despite the 20% sugar reduction targets. Introducing a tax on these products - based either on volume and/or their sugar content - may lower consumption and trigger manufacturers to reformulate. Like the SDIL, a confectionery tax would reduce the affordability of high-sugar products. Part of the reason that no change was seen in the mean sugar content of confectionery may be due to technical difficulties in reformulating such foods. However, a confectionery industry levy may instigate technical innovation, reduce sugar content and make high-sugar products less available, and low-sugar products more acceptable.

4. Making traffic light labelling compulsory

It is estimated that two-thirds of the packaged food and drink market has adopted traffic light labels (244). Making traffic light labelling compulsory for all packaged food and drinks and fast food menus will improve consumer awareness on the nutritional quality of foods and could lead to healthier choices and improved nutritional intake (51)(247)(248), although there is currently little evidence that traffic light labels reduce sugar intakes specifically (51).

5. Tightening the restrictions on the advertisement of unhealthy foods

There is strong evidence that the marketing of foods high in sugar, fat and salt (HFSS) contributes to their overconsumption and obesity in children (249)(250)(251). The World Health Organisation recommends restrictions on the advertisement of HFSS foods to children, including in digital media (252). TV advertisement restrictions were introduced in the UK in 2006 by Ofcom, but these only apply for programmes where the audience is predominantly made up of children (253). This means that family programmes are currently not covered by the restrictions. Banning the advertisement of HFSS foods completely, as Transport for London have done (254), would improve the healthiness of the food environment.

Overall strengths and limitations of this study

The sales and nutrient composition data of five food categories and soft drinks was analysed. By pairing composition data with sales data, it has been possible to capture not just what is available, but what is sold, and the net impact on total sugar sales and per capita consumption. This provides novel insights into how both consumers and individual companies have responded to sugar reduction policies and the broader debate about sugar in the UK. Reporting by company provides transparent information for policy makers, NGOs and other organisations interested in assessing how companies are progressing towards public health targets.

The aim of this study was to demonstrate that nutrition composition data and sales data can be used in combination to monitor company level changes in the food supply. While this aim was met, there are limitations in the study design. As has been previously discussed (see figure 31), there are a range of complex factors that can influence the change in the total volume of sugars sold. While these data show what proportion of the change was due to reformulation compared to a change in sales, they cannot distinguish between how and what individual factors influenced sales and reformulation.

This analysis does not cover the entire food and drinks market, nor does it cover every category included in PHE's sugar reduction targets. Desserts, morning goods, cakes and ice cream were excluded. Morning goods and cakes were excluded due to a lack of granularity in the sales data. Unpackaged cakes (43% of total cake sales) and pastries (50% of total sales) did not have any brand information and were simply labelled 'artisan', therefore could not readily be paired with composition data.

Within this analysis, there were relatively few companies that manufactured products in multiple categories. This meant that results could not reasonably be aggregated by company, and were presented by category instead. Further analysis is needed to demonstrate how nutrition composition and food sales data can be used to monitor companies specifically. A study with such an aim is presented in Chapter 5 of this thesis.

Strengths and weaknesses of the sales data used

There are two main advantages to using sales data, as opposed to dietary survey data. Firstly, it avoids the reliance on individual recall of consumption, and secondly, current data sets include greater detail about individual brands. Euromonitor data has a wide coverage, including hypermarkets, supermarkets, convenience stores, vending machines and fast food outlets. This means that it is particularly suited to studying changes at a company and brand level. However, as with other possible data sources (219), there are limitations. Users of the data have no control over the data collection process and there is limited transparency in the methods of data collection or the reliability of the sources (219). Euromonitor also classifies small and local brands under the umbrella term 'others'. These brands represented 15% of total volume sales in 2018 and had to be excluded from this study because they were unable to be linked with composition data. Within the Euromonitor dataset, the granularity by brand differed from company to company. For example, sales figures were given for Diet Coca-Cola and regular Coca-Cola separately, but for Sprite both diet and regular versions were combined.

When multiple products were available under a single sales figure, an average sugar level from all identified products in the Brand View datasets was used. To test what impact this had on the results, the sales and composition data of a subset of the database – soft drinks - was taken. This category was selected as it is common for soft drink brands to have full sugar and zero sugar variants, which may be grouped under a single brand. For brands that did have a volume stratified between diet and regular versions (n=16), these volumes were taken and the mean sugar levels were calculated in the same way as for products where stratified sales data were not available. For these 16 brands, the mean sugar content was 30% lower overall when compared to the sales-weighted mean sugar content, with much heterogeneity by individual brand. This may have introduced bias into the results, with the mean sugar content for brands that have multiple product variants being less accurate than those with a single variant.

Strengths and limitations of the nutrient composition data used

The Brand View nutrient composition data were collected from three supermarket websites (Asda, Sainsbury's and Tesco) at single time point in the four years included in the analysis (13th December 2015-2018). The number of unique products included in this study is likely to be an underestimate of the total number of products on the market for two reasons. First, products that are only available for purchase outside of the three included supermarkets have not been included. Second, taking data from single time points means that the churn of products over the year has not been captured (e.g. products leaving the marketplace and being replaced by new ones).

In order to investigate this further, a comparison of a subset of products – soft drinks – was conducted against other datasets used in the NIHR-funded SDIL Evaluation project (235), to give a better idea as to how this may have affected the results. Across the four snapshots, a total of 10773 soft drink products were included in the Brand View dataset. 2134 products were removed as duplicates matching on barcode and year (i.e. the same product sold in the same year in different supermarkets). A further 1222 products were removed as their brand name and manufacturer could not be matched with the Euromonitor sales data. This left 7377 unique products observed over the four years.

The number of soft drink products in the Brand View dataset were checked against two sources of data from the SDIL Evaluation Project. The first is a dataset of drinks called foodDB. This is collected in a similar way to the Brand View data used here, by scraping the websites of six UK supermarkets (Tesco, Sainsbury's Asda – as are included here – and Morrisons, Waitrose and Ocado). These six supermarkets account for 70% of UK grocery sales (255). According to foodDB, an average of 4780 soft drinks are available on the UK marketplace in any given week. However, this figure includes all observations of the same drink sold in different volumes and the same drinks sold in different supermarkets, as barcode is not collected. It therefore contains duplicates, unlike the Brand View dataset where duplicates were removed. It does, however, provide an upper estimate for the number of soft drinks available in UK supermarkets at any single time point, which is of the same magnitude as the estimates given here (on average 1844 products per year, vs 4780 per week from foodDB, including duplicates).

Based on barcodes, only 58% of the soft drink products in the 2018 Brand View snapshot were found in the 2015 snapshot, suggesting a high level of churn in the marketplace. The number of products included in this study was compared with the number in the Kantar Worldpanel dataset used by the SDIL Evaluation Team. Kantar Worldpanel has information on the products purchased by 38467 households between 2015 and 2018. In any one 4-week period, the Kantar dataset contains 2716 unique products collected from 13202 households. Over the course of three years, this amounts to a total of 6844 products, including multiple sizes with the same formulation, but with duplicate barcodes removed. This does not accurately reflect the true churn in the marketplace, as any timepoint in the Kantar dataset includes only drinks that are purchased by panel members are identified, rather than being representative of all drinks available on the whole marketplace.

The Brand View (1735 products in 2018) and Kantar data (2716 for any given 4-week period) seem reasonably aligned, but are not directly comparable. This is because the Kantar data include all products purchased over 4 weeks, compared to Brand View, which looks at the availability on one single date annually. The Brand View snapshot was also collected in December and will not account for seasonal fluctuations.

The nutrition information for brands that are not sold in the three supermarkets represented in the Brand View database (n=20) had to be collected manually from the brand website in 2019. This means that no historical change could be measured for these brands, other than changes in sales levels. These products make a small contribution to overall sales (<1% in 2018) and re-running the analysis to exclude these 20 brands made no substantive difference to the main results.

The aim of this paper was to show how nutrient composition and food sales data can be used to estimate the total volume of sugars sold from selected food and drink categories over time. The number of products included in the database, combined with the sales data, give a sufficient sample size for this study. For example, according to the Euromonitor data, the top ten UK soft drink companies alone represent 70% of volume sales, and the companies we have included in this analysis here represent an estimated 80%.

Comparisons with other studies

This is the first study to report on the changes made towards reducing sugar in the UK by individual companies. The findings we report here are similar to the few other studies that have looked at the sugar content of foods and soft drinks in the UK in recent years, though only one other has reported on the change in sales.

A study of the sugar content in a sample of energy drinks in 2017 compared to 2015 (excluding zero-sugar products) reported a 10% decline (10.6g/100ml in 2015 vs 9.5g/100ml) (232). Once adjusted to exclude zero-sugar products, the absolute mean content of energy drinks fell by 30% over the same time period, while the sales weighted mean fell by 49% (9.6g/100ml in 2015 to 5.9g/100ml in 2017). This may be due to different data collection methods (in-store checks in supermarkets vs online data collection) and a difference in the number of products included (e.g. 49 energy drinks included in 2017 in the Hashem et al study vs 128 in this analysis).

Another comparable study is the evaluation of the sugar reduction programme by Public Health England (PHE) from 2015-2018 (256). Overall, findings between the two studies are similar, with the greatest reductions seen in soft drinks, yoghurts and breakfast cereals (**Table 32**). The total volume of sugar sold from soft drinks was also similar, with a 22% reduction reported by PHE, compared to 29% presented here.

Table 32: Results of percentage change in sales-weighted mean sugar content of different food and drink categories between 2015 and 2018 compared to Public Health England findings (256)

Category	Public Health England % change in sales weighted mean sugar content	Study findings % change in sales weighted mean sugar content
Biscuits and cereal bars	-1%	-6%
Breakfast cereals	-9%	-14%
Chocolate confectionery	0%	-1%
Soft drinks	-29%	-34%
Sugar confectionery	-1%	-2%
Yoghurts	-10%	-17%

There were some discrepancies in the total volume of soft drink purchases between the two studies (8.9 vs 3.9 billion litres for PHE in 2018). The comparatively low volumes reported by PHE could be due to the underreporting of purchases by Kantar panel participants (257) or to overestimates of sales in Euromonitor data due to their indirect approach to estimation (see Chapter 3 for full research methods). Nonetheless, the percentage change findings are remarkably consistent between the two studies.

Conclusion

This novel method of combining food sales and nutrient composition data has assessed progress that individual companies have made towards the sugar reduction targets set by Public Health England. It shows clear differences between categories, with soft drinks seeing the greatest reductions in sales-weighted mean sugar content and total volume of sugars sold, modest changes for breakfast cereals and yoghurts and very little change in biscuits and confectionery. This chapter has demonstrated that nutrition composition and food sales data can be used to monitor and evaluate companies' progress towards meeting public health targets and can be a useful tool for policy makers and NGOs.

Chapter 5: Nutrient profiling of the products made available and sold by the top 10 food and drink companies in the UK

Chapter summary

This chapter applies the FSA/Ofcom nutrient profiling model to the top 10 companies' product portfolios to monitor how the nutritional quality of companies' products has changed over time (2015-2018). This gives a more holistic view into how the food industry has responded to calls to improve the nutritional quality of their products than looking only at sugar reduction, as was done in Chapter 4. The results show that there has been no significant change in the mean nutrient profiling score of the top 10 food and drink companies' products in the UK, and that no company portfolio had a score of 70 or more to be classified as 'healthy'. A reduction in the sugar content of soft drinks, and the increased sales of bottled water, juices and low/no calorie drinks, increased the proportion of volume sales classified as healthy from 38% in 2015 to 46% in 2018. The benchmarking tool outlined in this chapter has the potential to be used by investors to indicate which companies, based on their product portfolios, are exposed to financial risk in the long term. Ethical health investment may be used as a potential driver of improvement in the nutritional quality of products available and sold to the public.

Introduction

In the previous chapter, the sugar content of companies' products was measured over time. While these analyses are useful for monitoring how companies have responded to specific policies in certain categories, one limitation is that they only looked at a single nutrient, sugar, meaning the results do not reveal anything about how companies are responding more holistically to improve the overall nutritional quality of their products.

Nutrient profiling is "the science of classifying and ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health" (258). Nutrient profiling generally involves the application of a model that classifies or ranks foods based on their overall nutrition composition, rather than looking at individual nutrients in isolation. It has multiple applications, including supporting healthy labelling schemes and restricting the marketing of foods to children (259).

The current UK nutrient profiling model was developed by the Food Standards Agency (FSA) to provide the Office for Communications (Ofcom) with a tool to differentiate between foods that can and cannot be advertised to children on television, based on their nutrition composition (260). It uses a scoring system whereby points are allocated based on the nutrient composition per 100g of food or drink. "A-points" are awarded for energy, saturated fat, total sugar and sodium, and "C-points" are awarded for fruit, vegetable and nut, fibre and protein content. The final nutrient profiling score is calculated by subtracting C-points from the A-points. Foods that score 4 or more points and drinks that 1 or more points are subject to Ofcom's restrictions on advertising on children's TV (260).

The UK FSA/Ofcom nutrient profiling model is currently being revised (261) but the final version of the new model has not been published. In this chapter, 'FSA/Ofcom model' refers to the original model developed by the FSA in 2005-06 (260).

In the UK, it is mandatory for nutrition information to be declared on pre-packaged foods. The nutrient that must be declared are: energy, fat, saturated fat, carbohydrates, sugars, protein and salt (223). Fibre is not subject to mandatory labelling. Pre-packaged foods must also declare a full ingredients list and if a product name refers to ingredients (e.g. carrot and coriander soup), then the proportion of those ingredients mentioned must be declared in the list (224).

During the systematic review (Chapter 2), one peer-reviewed paper – funded by the Access to Nutrition Initiative - was identified that used food sales data, nutrition composition data and the Health Star Rating (HSR) nutrient profiling model to analyse the nutritional quality of 11 food manufacturers' product portfolios in India. The Access to Nutrition Initiative (ATNI) has published a report that does something similar for 18 manufacturers in the UK, but only provides a single snapshot for 2016, i.e. it does not track changes over time. Assessing the nutritional quality of companies' product portfolios has the potential to be used to rank companies against each other, to be used as an advocacy tool to instigate policy change and as a tool for investors to help inform them of a company's risk to exposure of public health measures, such as health-related taxes.

The aim of this chapter is to apply the FSA/Ofcom nutrient profiling model to monitor how the nutritional quality of companies' products has changed over time by scoring the full range of a food company's products and weighting by sales. This will allow for overall brand, company and category scores to be calculated and ranked.

The research questions of this study are outlined below, with a focus on how variables have changed over time:

- What are the sales-weighted nutrient profiling scores of the food products manufactured by the top 10 food companies in the UK?
- What proportion of each company's sales are classified as healthy (≥70)?
- How do sales-weighted nutrient profiling scores vary by category?
- How do companies' scores vary by brand?

Methods

The top 10 UK food and soft drink manufacturers in value terms were identified using Euromonitor sales data for 2018 (see chapter 3 for further details on the Euromonitor data). A company is defined here by Euromonitor as: 'the legal entity that produces or distributes an individual or group of brands globally'. All of the brands manufactured by these 10 companies between 2015 and 2018 were identified. A brand is defined by Euromonitor as a set of products that have the same name and are manufactured by one company. One brand may have multiple variants. For example, the company Mondelez manufactures multiple brands, including Cadbury Dairy Milk, Belvita and Philadelphia. Within a single brand there may be a number of different products, for example Cadbury Dairy Milk with whole nuts, and Cadbury Dairy Milk with fruit and nuts. Further information about the Euromonitor data, including data types and coverage, can be found in chapter 3.

Matching the sales data and composition data

These composition data used here were provided by Brand View, a private analytics company that collects product information, including nutrient composition data, by scraping from the websites of three leading UK retailers: Asda, Sainsbury's and Tesco. These data were scraped from these three websites on the same data (13th December) for four consecutive years (2015, 2016, 2017 and 2018).

The sales data from Euromonitor and nutrition composition data from Brand View were matched with the help of data scientist Sven Hollowell. He used an algorithm in Python 3 that paired the datasets based on brand name (sales data), product name (nutrition composition data), year and category (both). No corresponding nutrition composition data could be found for 64 brands in the sales dataset. 41 of these brands were not manufactured in the given time period (2015-2018) and were removed by from the dataset. For the remaining 23 brands, the nutrition composition database was searched manually in Excel based on product name and category. The barcodes for these products were identified in the composition dataset and manually merged with the main dataset in Excel.

Applying the FSA/Ofcom nutrient profiling model

The FSA/Ofcom nutrient profiling model was applied to the individual product composition data by project supervisor Richie Harrington, using Python 3. The appropriate points were awarded based on each product's energy, saturated fat, total sugar, sodium ("A-points") and fibre, protein and fruit, nut and vegetable content ("C-points") per 100g. A brief description of how these points are awarded is described below (**Table 33)** (260).

Table 33: Summary of the points awarded for each nutrient in the FSA/Ofcom nutrient profiling model (260)

Nutrient per 100g	**Point type**	**Range of points awarded**	**Nutrient content range**
Energy (kJ)	A	1-10	335-3350
Saturated fat (g)	A	1-10	1.0-10.0
Total sugar (g)	A	1-10	4.5-45
Sodium (mg)	A	1-10	90-900
AOAC fibre (g)	C	1-5	0.9-4.7
Protein (g)	C	1-5	1.6-8.0
Fruit, nut and vegetable content (g)	C	1,2, 5	40-100

The sum of A-points is subtracted from the sum of C-points. If a food scores 11 or more A-points and less than 5 for FNV, then the points awarded from protein are excluded from the calculation. A food is classified as 'less healthy' if a product scores four points or more. A drink is classified as 'less healthy' if it scores 1 point or more. For the purpose of direct comparison between foods and drinks, the nutrient profile score was converted to a 1-100 scale using the formula: NEW SCORE = (-2)*OLD SCORE + 70 (260), where the direction of the scale has been reversed (so that higher scores for food and drinks indicate healthier products) and where 70 points is the threshold for restrictions on advertising.

If the nutrient content for a product was missing, then data was imputed by calculating a brand and category average, and if this was not possible, a category average. Fruit, nut and vegetable content was estimated using an algorithm coded in python 3 with the help of supervisor Richard Harrington. This algorithm used the ingredients list to categorise ingredients into 'fruit', 'nut', 'vegetable' and 'other'. The percentage composition of ingredients was identified if this information was provided in the ingredients list. For the ingredients where percentage composition was not given, values were imputed based on a brand and category average, or if this was not possible, a category average.

A total of 13,371 products were included in this dataset. The proportion of imputed values for each nutrient, and the total number of products that had one or more imputed value, is given below in **Table 34**.

Table 34: Proportion of imputed data by each nutrient needed to calculate a product's nutrient profiling score

Nutrient needed to calculate nutrient profile score	Number of missing values (%)
Energy	0 (0%)
Saturated fat	911 (7%)
Total sugars	410 (3%)
Sodium	486 (4%)
Fibre	4186 (31%)
Protein	424 (3%)
FNV	8896 (67%)
Total number of products with one or more missing value	10391 (78%)

Variables calculated

The total value (£mn per year) and volume of food and soft drinks (tonnes per year) and the sales-weighted mean nutrient profiling score were calculated for each brand, company and category. When one brand had multiple product variants, the mean nutrient profiling score was calculated and paired with the sales data. These analyses were conducted in R Studio.

While all brands were included in the analysis, only the top five for each company (n=50) were presented for the brand-level analysis, for clarity of presentation of results. These 50 brands represented 76% of total value sales in 2018.

Where relevant, to adjust for population changes and to put the results in a public health context, per capita results were calculated using annual population estimates from the Office for National statistics (ONS) (234) and per day results were calculated by dividing by 365, to give per capita per day figures.

Baby food (including purées, ready-prepared meals, dried cereal products and snacks) were included in the analysis, as although they are designed for toddlers, these products are often eaten by children over the age of five. Infant formula (i.e. breast-milk substitutes) were excluded.

Statistical analysis

Chi-squared tests were performed to test if there were any significant changes in the number of products and brands each company manufactured over time (2015-2018). ANOVA tests were used to test for differences in the mean nutrient profiling scores over time for each company and each category. 95% confidence intervals were calculated using the sales-weighted standard deviations and means.

Results

The top 10 UK food and soft drink companies

In 2018, the top 10 food and soft drink companies had total value sales of £17.1 billion (**Table 35)**. This equates to a daily spend of £0.70 per capita on products manufactured by these 10 companies. The top 10 companies by value were also the largest 10 in terms of volume sales, although there is variation in the ranking between these two measures. Food company Mondelez is the largest in value terms, while Coca Cola is the largest company in volume terms. This is because Coca Cola sells only soft drinks, which have a larger pack size and lower price per 100ml compared to foods.

Table 35: Number of products, brands and total volume sales by company, 2018

Company Name	Value sales (£mn)	Value sales (£ per capita per day)	Total volume sales (‘000 tonnes)	Total volume sales (grams per capita per day)
Mondelez	2903	0.12	286	12
PepsiCo	2541	0.10	1073	44
Mars	2228	0.09	155	6
Coca-Cola	2167	0.09	1948	80
Nestlé	1531	0.06	92	4
Danone	1418	0.06	108	5
Premier Foods	1346	0.06	74	3
Unilever	1160	0.05	185	8
Kraft Heinz	930	0.04	61	3
Kellogg	858	0.04	144	6
Total	**17,081**	**0.70**	**4,126**	**170**

In 2018, there were 3278 individual products produced by these companies and included in the dataset under 222 different brands (**Table 36**). Premier Foods had the largest product portfolio in 2018, with 613 individual products. Kellogg had the smallest, with 91 individual products. There was a significant change in the total number of products that were manufactured by the top 10 companies over the period of analysis, from 3475 in 2015 to 3278 in 2018, a reduction of 6% ($p < 0.05$). Seven out of ten of the companies reduced the number of products they manufacture. Significant changes were seen by Danone ($p < 0.01$) and Kellogg ($p < 0.01$), suggesting they have consolidated their portfolios.

Table 36: Number of brands and individual products by company included in the dataset, 2015-2018

Company name	Number of brands					Number of individual products				
	2015	**2016**	**2017**	**2018**	**p-value**	**2015**	**2016**	**2017**	**2018**	**p-value**
Coca-Cola	17	17	16	17	1	258	238	251	285	0.25
Danone	8	8	8	9	0.81	346	318	312	283	<0.01
Kellogg	19	16	16	16	0.61	141	128	106	91	<0.01
Kraft Heinz	8	9	9	10	0.64	379	371	375	345	0.21
Mars	24	24	23	23	0.88	390	405	356	361	0.29
Mondelez	42	43	42	42	1	399	412	395	374	0.37
Nestlé	32	33	32	35	0.71	254	261	229	273	0.41
PepsiCo	19	19	18	19	1	388	391	374	358	0.27
Premier Foods	23	23	22	24	0.88	610	606	573	613	0.93
Unilever	27	27	26	27	1	310	310	305	295	0.54
Total	**219**	**219**	**212**	**222**	**0.89**	**3475**	**3440**	**3276**	**3278**	**<0.05**

Overall nutrient profiling score for all foods

The overall sales-weighted mean nutrient profiling score of all the brands manufactured by the top 10 food and drink companies in the UK was 65 in 2018, below the threshold of 70 (the threshold to be considered healthy enough to advertise to children). The unweighted mean was lower, at 55. This is because the unweighted mean does not consider the large sales volume of high scoring soft drink products.

There was no change in the unweighted mean over time (p = 0.28), and the sales-weighted mean increased by 2% between 2015 and 2018, from 64 to 65. In 2018, 32% of the 3278 products included in this analysis were healthy by the FSA/Ofcom nutrient profiling model, up from 31% in 2015. Nearly half (46%) of volume sales were of products that scored 70 or more in 2018, up from 38% in 2015.

Nutrient profiling score by company

The company with the highest sales-weighted nutrient profiling score for all four years was Coca-Cola, followed closely by Pepsi Co (**Figure 45**). The large volume sales of no/low sugar drinks, bottled water and juice products in these two companies' portfolios contribute to their relatively high scores compared to other companies. Danone, which produces mainly dairy and pre-prepared baby foods, also scored highly. Mondelez and Nestlé, whose sales are dominated by confectionery and snacks, scored the lowest. The only company that change significantly over time was Kellogg, which increased from 53 in 2015 to 56 in 2018 ($p < 0.05$).

Figure 44: Total sales-weighted nutrient profiling score by company and year

Company Name	2015	2016	2017	2018
Coca-Cola	68	68	69	69
PepsiCo	69	68	69	69
Danone	66	67	67	66
Kraft Heinz	62	62	63	62
Kellogg*	53	53	54	56
Premier Foods	52	52	54	54
Mars	39	39	39	39
Unilever	37	38	39	38
Nestlé	36	36	35	37
Mondelez	31	30	30	31

Nutrient profiling score
16 78

* *p<0.05*

Nutrient profiling score by category

Baby food was the highest scoring category in 2018, at 72 (**Figure 46**). Soft drinks also scored highly (70), with the volume sales of juices, diet drinks and bottled water boosting the score. Spreads, confectionery and ice cream and desserts were the lowest scoring categories. The only category that saw any significant change over time was staples (pasta, rice and noodles), which increased from 60 to 63 (p <0.01).

Figure 45: Total sales-weighted nutrient profiling score by category and year

Category	2015	2016	2017	2018
Baby food	73	73	73	72
Soft drinks	70	70	69	70
Ready meals	65	65	66	66
Staples*	60	61	61	63
Sauces, soups and gravies	63	61	62	62
Baked goods	58	58	59	60
Breakfast cereals	55	54	56	56
Savoury snacks	49	48	50	49
Dairy	42	47	47	45
Ice cream and desserts	42	41	43	43
Confectionery	33	32	34	33
Spreads	30	31	31	30

Nutrient profiling score

16 78

**p<0.05*

Nutrient profiling score by company and category

The top 10 companies combined manufactured a wide range of products, in 12 different categories (**Figure 47**). Baked goods and sauces, dressings, soups and gravies were the two categories that had the highest number of companies - six - manufacturing one or more brands. Coca-Cola was the least diverse company producing only soft drinks. Mondelez and Nestlé were the most diverse, with their portfolios containing products from six categories. There was variation in the scores of companies within categories. For example, the company scores within the baked goods category ranged from 22 (Nestlé) and 69 (Premier Foods). In contrast, there was little variation within soft drinks (68-71) and confectionery (26-42).

Figure 46: Sales-weighted nutrient profile score by company and category, 2018

Category	Coca-Cola	Kellogg	Mars	Danone	Kraft Heinz	PepsiCo	Premier Foods	Unilever	Mondelez	Nestlé
Staples					51		60	67		
Spreads								30	24	
Soft drinks	69			68		71				68
Savoury snacks		52			42	49				39
Sauces, dressings, soups and gravies			70		48	55	65	44		45
Ready meals					67		48		41	
Ice cream and desserts				71				41	35	
Dairy				68			65	47	29	46
Confectionery			35						42	26
Breakfast cereals		56				77				
Baked goods		50	35			48	69		53	22
Baby food				72	50					

Nutrient profiling score: 16 – 78

Nutrient profiling score by brand

Three of the top five of Coca Cola and Pepsi Co's brands by volume sales scored 70 or more (**Figure 48**). Danone and Premier Foods had one brand with a score of 70 or more, while Kellogg Co, Kraft Heinz, Mars, Mondelez, Nestlé and Unilever had no healthy brands in their top five. Of the 50 top brands, only six saw an increase in the nutrient profile score of 3 points or more over time. Kellogg's Coco Pops increased from 48 to 61 (+27%) and Special K increased from 58 to 62 (+7%). Premier Food's Angel Delight increased from 54 to 61 (+13%) and Philadelphia from 43 to 46 (+7%). Confectionery brands Cadbury Dairy Milk and Maltesers increased from 20 to 26 (+30%) and 19 to 23 (+21%) respectively, although their scores still remain very low.

Figure 47: Sales-weighted nutrient profile score for top 5 brands by company 2015-2018

Company Name	Brand Name	2015	2016	2017	2018
Coca-Cola	Innocent	72.8	73.3	72.7	72.2
	Coca-Cola Zero Sugar	70.0	70.0	70.0	70.0
	Diet Coke	70.0	70.0	70.0	70.0
	Fanta*	68.1	68.6	68.8	69.2
	Coca-Cola	66.0	66.0	66.0	66.0
PepsiCo	Tropicana	74.5	73.4	74.0	72.9
	Diet Pepsi	70.0	70.0	70.0	70.0
	Pepsi Max	70.0	70.0	70.0	70.0
	7-Up	68.1	68.6	69.2	69.3
	Pepsi	66.0	66.0	66.0	66.0
Danone	Volvic*	68.5	68.8	69.0	69.9
	Actimel	68.6	69.0	69.2	69.2
	Danio	70.3	70.3	67.0	68.0
	Activia	66.2	67.0	67.6	67.7
	Oykos	54.0	54.7	55.1	54.8
Kellogg	Kellogg's Corn Flakes	66.0	66.0	66.0	66.0
	Kellogg's Special K	58.4	60.0	62.2	61.8
	Pringles	54.0	52.7	53.0	52.4
	Kellogg's Coco Pops*	48.0	48.0	54.8	61.2
	Kellogg's Crunchy Nut Cornflakes	48.2	47.6	48.9	48.5
Premier Foods	Mothers Pride	74.0	74.0	74.0	74.0
	Angel Delight*	54.0	59.8	60.0	61.4
	Batchelors Super Noodles	58.0	57.8	58.8	59.8
	Bisto	48.3	47.4	44.6	44.4
	Mr Kipling Angel Slices	28.0	30.0	30.0	28.0
Kraft Heinz	Heinz	65.9	66.1	66.7	66.7
	HP	48.3	51.0	50.0	51.1
	Daddies	46.0	49.3	49.3	48.0
	HP Brown Sauce	48.0	48.0	48.0	48.0
	Lea & Perrins	44.0	44.0	44.0	44.0
Mars	Dolmio	69.0	68.5	68.4	69.7
	Extra	68.0	67.9	67.9	68.0
	Mars	27.7	27.1	27.2	26.8
	Galaxy	21.7	22.6	23.2	22.1
	Maltesers*	19.0	18.5	19.0	23.0
Mondelez	Belvita	54.7	54.8	54.9	54.8
	Philadelphia	42.5	43.4	45.3	46.0
	Cadbury	41.0	41.4	41.2	40.2
	Cadbury Dairy Milk	20.1	23.9	24.0	25.9
	Cadbury Mini Rolls	22.8	23.5	23.7	23.0
Unilever	Carte d'Or	45.5	46.5	46.5	45.1
	Hellmann's	43.2	44.2	45.1	44.4
	Flora	31.7	32.9	32.7	31.1
	Bertolli	29.2	29.2	28.3	29.7
	I Can't Believe It's So Good	27.3	27.3	27.3	27.6
Nestlé	S Pellegrino*	66.2	67.1	67.1	68.0
	Rowntree's Fruit Pastilles	42.4	42.5	47.1	45.1
	Milkybar	23.2	22.2	25.6	24.2
	Kit Kat	24.2	23.7	23.1	22.5
	Rolo*	21.3	20.8	18.4	18.4

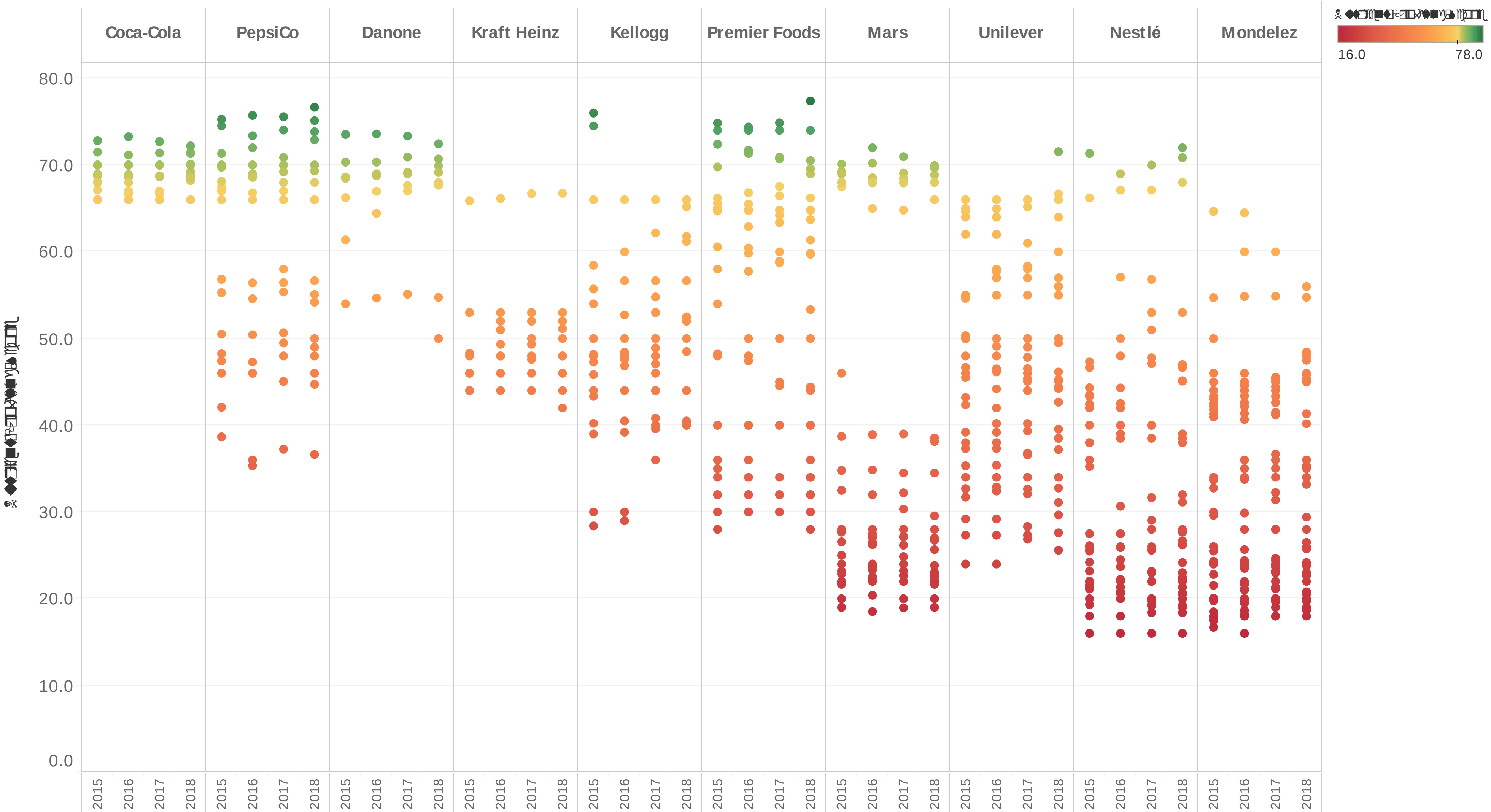
Brand Score

16.0 78.0

*p<0.05

Figure 49 gives an overall summary of the distribution of the nutrient profiling scores for all of the brands included in the top 10 companies. There is a difference in the range of nutrient profiling scores within and between companies. For example, Coca Cola manufactured 17 brands in 2018, with a range of scores between 66 and 72. In contrast, Nestlé manufactured 30 different brands in 2018, with a score range of 16 to 72. Figure 5 also shows how brands within a company's product portfolio cluster based on their nutrient profiling score. For example, Mars's cooking sauce brands (e.g. Uncle Ben's, Dolmio) score highly and cluster at the top end of the nutrient profiling score scale, whereas its confectionery brands score low. PepsiCo's soft drink and breakfast cereal brands cluster with a high score, while its snack brands have a lower nutrient profiling score.

Figure 48: Nutrient profile score of individual brands by company 2015-2018



Discussion

There has been no significant change over time in the overall nutrient profiling score for the top 10 food and drink companies in the UK. In 2018, the mean score was 65, below the score of 70 which is considered 'healthy'. No individual company had a score above 70. There was little change in the number of individual products classified as healthy, from 31% in 2015 to 32% in 2018. However, the proportion of 'healthy' volume sales was higher, at 46% in 2018, up from 38% in 2015. This rise has been driven by an increase in the volume sales of bottled water, low/no calorie carbonates and juices, a trend which was also identified in the previous chapter (chapter 4). Once soft drinks are removed from analysis, the proportion of volume sales of healthy products was only 2%. Baby food, soft drinks and ready meals were the three categories with the highest nutrient profiling score, although only one category, staples, saw any significant improvement over time, from 60 to 63 (+5%) ($p<0.05$).

Kellogg's was the only company that saw a significant improvement in its nutrient profiling score over time, from 53 in 2015 to 56 (+6%) in 2018. This was the result of reducing energy density, sugar and sodium content in a number of their key brands with large volume sales, including Coco Pops and Special K. But this was an exception and otherwise, there was very little change in the healthiness of products sold by the top 10 manufacturers over time. Soft drink brands Fanta, Volvic and San Pellegrino saw their scores improve over time, as a result of sugar reduction, as did Angel Delight, which saw a six-point increase in its score. However, these brand-level changes were not enough to see any changes at the company level.

By pairing composition data with sales data and applying a nutrient profiling model, both the healthiness of the individual food and drinks available and the healthiness of what is sold have been assessed, as has how this has changed over time. Compared to the previous chapter, it gives a better idea of how companies are responding to public health calls to improve the healthiness of their products overall, not just in relation to the content of a single nutrient.

Strengths and weaknesses

The strengths and weaknesses of this analysis relate to the value of the sales and composition datasets used, as discussed in chapter 4. However, some additional limitations specific to this analysis should also be noted.

Missing and imputed data

The values for seven nutrients (energy, saturated fat, total sugars, sodium, fibre, protein and FNV content) are needed to calculate the FSA/Ofcom nutrient profiling score of a product. As shown in **table 1**, 32% of the 13,371 products included in this study had missing values for fibre, and 67% of products did not have ingredients information, or had insufficient composition detail in the ingredient information, to be able to calculate %FNV, so values were imputed with either a category and brand average, or if that was not available, a category average.

Finding a higher proportion of missing/imputed fibre and FNV compared to other nutrients is to be expected as the labelling of fibre on foods is not mandatory (unlike other macronutrients) (223). Percentages for individual ingredients only have to be stated when the product title includes an ingredient name, or when a claim about the amount of an ingredient in the product has been made on the label (224). The need to impute these values was therefore not unexpected.

To test what impact the imputed fibre data may have had on the results, a sensitivity analysis was conducted. 31% (4186) of all products in the original dataset had imputed fibre values, and these were evenly distributed across the four years. The fibre content for these products was adjusted to 0.0g/100g and as a result the Ofcom points awarded for fibre also fell to zero, the lowest score possible. After this adjustment, 52% (n=2170) of the 4186 products saw a change in their final Ofcom score. The number of products that were classified as healthy (>70) fell from 32% to 31% and there were negligible changes in the total nutrient profiling score for 2018, which fell from 65.8 to 65.5. (-0.5%). A small change in the nutrient profiling score of PepsiCo from 68.5 to 68.9 meant that it overtook Coca Cola, whose score remained at 68.8, to move into first place in the company rankings. This suggests that while the inconsistencies in the fibre values is a weakness in the dataset, it has little effect on the overall results.

For fruit, nut and vegetable content, 8896 (67%) of included products had imputed values, although three-quarters of these (n=6624) fell into categories that did not contain fruit, nut or vegetables: baked goods, confectionery, dairy, ice cream, savoury snacks, soft drinks, spreads and staples. To test what impact the imputed FNV data may have had on the results, the remaining 2272 products (that fell under the baby food, breakfast cereals, ready meals and sauces, dressing, soups and gravies categories) had their %FNV adjusted to 0%. After this adjustment, 25% (n=564) of the 2272 products saw a change in their final Ofcom score. The number of products that were classified as healthy (>70) fell from 32% to 31%, and there were negligible changes in the total nutrient profiling score for 2018, which fell from 65.8 to 65.5 (-0.5%). A small change in the nutrient profiling score of PepsiCo from 68.5 to 68.9 meant that it overtook Coca Cola, whose score remained at 68.8, to move into first place in the company rankings. These findings were similar to findings of the fibre sensitivity analysis set out above and it may be that a similar group of products were changed in the FNV analysis. Overall, it suggests that while the inconsistencies in the FNV values is a weakness in the dataset, in reality it affected a smaller group of products than initially suggested, and the results have not been affected by this limitation.

Coverage and interpretation of nutrient profiling model

The overall aim of this chapter is to demonstrate how food sales and nutrition composition data can be used to develop a method to monitor the nutritional quality of the food supply, and this chapter is therefore a proof of concept. Only 10 companies were included in the analysis, which represented 24% of total value sales in in the UK in 2018. These top 10 companies were selected based on their value sales, although they are also the top 10 companies in terms of volume sales too. Including more, or all, companies in this analysis would give a better picture of the overall healthiness of the UK packaged food market, and how this has changed over time. In the future, including more, or all companies, including retailers, would give a more in-depth view of how food companies in the UK are changing their products to meet public health targets. Data restrictions meant the time period covered changes made between 2015-2018. Previous reformulation efforts made before 2015, for example as part of the salt reduction programme which began in 2006, will be excluded. Using a wider historic time period may show that companies have made more significant changes previously, although that is of limited use for monitoring and evaluating current policies.

The FSA/Ofcom nutrient profiling model was applied to the nutrition composition data, with a score of 70 or more being classified as healthy. This model was selected because it is designed for and used in the UK market. It is also the model that has been most widely validated in terms of its use and the impact on dietary choices and human health measures (262). However, its original purpose was for the assessment of whether or not a product is should be advertised to children. In the future, applying multiple nutrient profiling models in the same way and comparing the results would be desirable. One potential nutrient profiling model that could be used is the Australian Government Health Star Rating (HSR), which is a front of pack labelling system that rates a packaged food product's nutritional composition from 0.5 to five, and is designed to allow consumers to compare the healthiness of products and choices (263). Another is the algorithm for the Nutri Score front-of-pack nutrition label that consists of five letters (A-E) and corresponding colours (green-red) assigned on the basis of the nutrient content of products, allowing consumers to identify which products are recommended (264).

Because of the way that points are allocated by the FSA/Ofcom nutrient profiling model, soft drink products score highly because they only receive points for total sugar and energy and have a low energy and high water content per 100g compared to other foods. Bottle water, included in this analysis, scores 70 as it has no added ingredients, and pure fruit juice scores highly due to its 100% fruit content. As a result, the soft drinks category scores more healthily compared to confectionery and snacks for example, despite the fact that they contribute to 22-33% of sugar intakes for children and adults (12). If soft drinks are removed from the analysis, then the overall nutrient profiling score for total foods is 56 in 2018, down from 65. Coca-Cola is excluded entirely from the analysis, given that it only manufactures soft drinks, and large drops are seen for Pepsi Co and Nestlé, while the exclusion of drinks improves Danone's score by 1.4 points (**Table 37**).

Table 37: Sales-weighted nutrient profiling scores for 2018 including and excluding soft drink products

Company name	Rank	Original sales-weighted nutrient profiling score 2018 including soft drinks	Rank	Sales-weighted nutrient profiling score 2018 excluding soft drinks
Coca-Cola	1	69	-	NA
Pepsi Co	2	69	5	49
Danone	3	66	1	67
Kraft Heinz	4	62	2	62
Kellogg	5	56	3	56
Premier Foods	6	54	4	54
Mars	7	39	6	39
Unilever	8	38	7	38
Nestlé	9	37	8	27
Mondelez	10	31	9	31

Comparisons with other studies

Only one peer-reviewed study, identified in the systematic review (chapter 2), has a similar aim and method to this chapter. The study, conducted in India by Jones et al. 2017, used Euromonitor sales data and Food Switch nutrition composition data for 943 products, collected from either the packet or company website. It applied the HSR to analyse the nutritional quality of the largest 11 packaged food manufacturers in India. The study found that the overall healthiness of products was low and that only 17% of products were considered healthy (190). This is lower than the 32% of products classified as healthy in this study. These differences are to be expected as the Indian study excluded products like staples (bread, pasta, rice), but also because a different nutrient profiling model was used (HSR). While there is likely to be some overlap with the companies included in the UK, the company names are anonymised in the India study and they therefore cannot be compared.

In 2019, the Access to Nutrition Initiative (ATNI) published its UK Product Profile (265). It analysed the nutritional quality of 3069 products from the top 5 food categories from the world's top 18 manufacturers in 2016. Like the Jones et al paper, they also applied the HSR nutrient profiling model. Nine of the 10 companies (excluding Premier Foods, a UK only company) included here were also included in the ATNI index. ATNI found similar results presented in this chapter, with 31% of products being classified as healthy in 2016, compared to 30% here. ATNI classified 22% of sales as healthy in 2016, compared to 34% here. The rankings of the companies in the ATNI study and the present study were compared using a Spearman's rank correlation test. There was little correlation between the two ($\rho = 0.51$, $p = 0.14$). How the companies ranked in the two studies is given below (**table 38**).

Table 38: The ranking of UK food and soft drink companies in this study, compared to that from the ATNI UK product profile (265)

ATNI study	ATNI Ranking	Ranking for the current study
Campbell	1	-
Friesland Campina	2	-
Grupo Bimbo	3	-
Kraft Heinz	4	4
Danone	5	3
Arla	6	-
Lactalis	7	-
General Mills	8	-
Kellogg	9	5
Pepsi Co	10	2
Ajinimoto	11	-
Unilever	12	8
Coca Cola	13	1
Suntory	14	-
Nestlé	15	10
Mars	16	7
Mondelez	17	9
Fererro	18	-

Both Danone and Kraft Heinz appeared in the top five of both indexes and Nestle, Mars and Unilever were towards the bottom. However, the top three ATNI companies were not included in this study, as they are not in the top 10 UK companies, and Pepsi Co and Coca Cola were lower in ranking in the ATNI index compared to this study.

There are several differences in the methods used by ATNI and this study which are likely to account for the differences between the results. Firstly, not all company products were included in ATNI, only products from the top five categories, meaning coverage was lower (this study included 3440 products for 10 companies in 2016, compared to 3069 products for 18 companies for ATNI). ATNI also applied a different nutrient profiling model - HSR - compared to the FSA/Ofcom model used here. HSR scores soft drinks more strictly than FSA/Ofcom, and given that soft drinks account for a large proportion (72%) of the volume sales of total packaged food and soft drinks, this is likely to account for differences in the scores for companies that manufacture soft drinks in particular, and is likely why the highest scoring companies in this study (Coca-Cola and PepsiCo) are lower down in ATNI.

The main advantage of this study over ATNI is that it includes four years' worth of data and therefore examines trends over time, whereas ATNI is just a snapshot of one year.

ATNI have also produced a Global Index for the world's top 18 food and beverage companies. In this index, the nutritional quality of companies' products only represents 25% of the score given to companies. Other elements include company governance (corporate strategy, 20%), accessibility (delivering affordable products, 20%), marketing (having healthy advertising policies, 20%), lifestyles (supporting health lifestyles, 2.5%), labelling (informative labelling and nutrition claims, 15%) and engagement (engagement with policy makers and stakeholders, 5%). The details of how each element is scored is not made clear and much of the data used to score these elements is self-reported by companies, making it less objective. The ranking of companies is very different when based just on their products, compared to the company-wide scoring. Nestlé and Mondelez, which drop down the list when based only on its product portfolio, are both included in the top five companies of the overall index. This means that the nutritional quality of the companies' products doesn't contribute very much to the overall index.

The International Network for Food and Obesity/NCD Research, Monitoring and Action Support (INFORMAS) have developed a Business Impact Assessment (BIA) on Obesity and Population-level nutrition tool (266), based on the ATNI Global Index methods. They group companies into food and beverage manufacturers, supermarkets and chain restaurants, and so cover a greater proportion of the food market than ATNI and this study. Their methods include searching organisation's publicly available data regarding product information (nutrition composition, pack size, serving size etc), marketing practices (especially regarding to children), labelling practices, affordability and availability (266). They also look at companies' responses to public consultations, extent of political lobbying and donations and funding of research. To date, INFORMAS have completed benchmarking exercises in Australia, New Zealand, Canada and Thailand. These reports focussed on company's self-reported commitments to reformulation, rather than including any independent analysis of nutrition composition data. The New Zealand, Australia and Canada reports each showed, like the ATNI index, that Nestlé is the best performing company when it comes to meeting its criteria, despite the low nutritional quality of its products.

Implications of this research: How benchmarking companies based on the nutritional quality of their product portfolios could be used

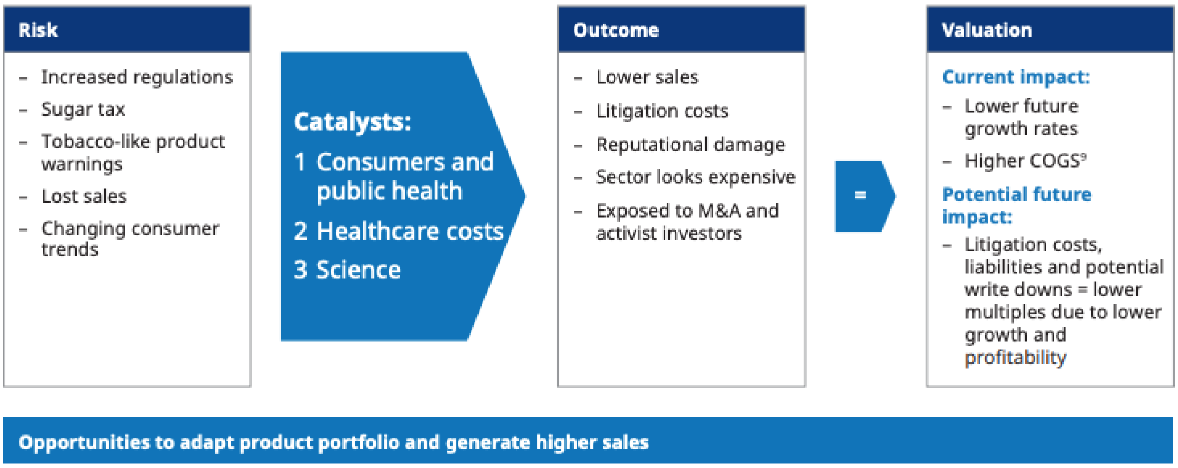
How benchmarking is currently used

Benchmarking has traditionally been used by businesses to improve company performance and inform strategy. The process usually involves comparing products and operations with competitors to better understand markets (267). More recently, benchmarking has been used as the basis for tools and reports that compare companies based on various environmental factors. Examples of these include Oxfam's "Behind the Brand" company scorecard on environmental and social issues (268), palm oil company scorecards and plastic use league tables from Greenpeace (269)(270), a carbon footprint investment risk index from a global investment bank (271) and Green Awards from the European Commission (272). The aim of all these initiatives is to increase the awareness, encourage the adoption, and improve the implementation of sustainable business practices, with the ultimate aim of reducing environmental impacts.

Benchmarking food companies as a tool for 'healthier' investment

Increasingly, investors and other organisations are interested in what impact food and beverage companies are having on public health and how responsible their business practices are. In particular, investment bankers, as financial intermediaries, advise on and conduct financial transactions in public and private companies, including food and beverage manufacturers. For them, deteriorating consumer health and the impact of regulation on the food industry could become a material risk (273). Food companies at risk also have the opportunity to protect or increase their market share and revenues by responding and adjusting to the demand for healthier foods. The catalysts and potential investment impacts are summarised below (**figure 6**).

Figure 49: A summary of the risks, catalysts and outcomes of financial investment in food and beverage companies (273)



Investment banks, including Schroders and Rathbone Greenbank, are calling for greater transparency from companies around how they are dealing with this material risk (273). While they are currently focussed on governance, company strategy, policy implementation and public position and lobbying, they are also interested in companies demonstrating measurable progress, and have made a call for specific metrics that can be used to monitor companies exposure to risk (273).

The methods set out here could be used as a tool for investors to:

1) Monitor how companies' products and sales are changing over time.

2) Influence investment decisions based on how successful companies are in improving their products, driving research and development and assessing how at-risk companies are to stricter regulation such as taxes. This would hopefully:

3) Add a financial incentive for companies to improve the nutritional quality of their products and company policy.

Benchmarking companies as a means of increasing public awareness about company performance

Including the benchmarking of companies, as presented in the results section, as part of a public awareness campaign run by a civil society NGO or health organisation, may increase the pressure on companies to make meaningful change to their products. There is evidence that pressure from the social environment is a factor for corporate behaviour (274). There are several well documented case studies that show public discontent can have an impact on a company's image and sales. For example, exposure of Nestlé's marketing practices of breast-milk substitutes in developing countries in the 1970s and 80s led to an international boycott (275), and more recently, large corporations faced public scrutiny after their tax-avoidance policies were disclosed (276). That said, there is little evidence that 'naming and shaming' has any substantial and lasting impact on company policy and practice.

Benchmarking companies as a policy monitoring and evaluation tool

The ongoing monitoring and evaluation of a policy is essential for identifying if it has met its aims and objectives and how it can be improved (129). Using this method, policy makers will be able to tell which companies are responding to their policies to improve the nutritional quality of food products over time. The headline results here show that there has been little change in the nutritional quality of companies' products over the past four years. However, there is great heterogeneity between companies, categories, and more specifically, individual brands. For example, Kellogg Coco Pops and Special K saw significant improvements in the score of their products over time, due to reformulation. Whether this has been driven because these products are easier to reformulate, or if because of the company’s willingness to change compared to others, is hard to distinguish. However, these results demonstrate that lessons could be learnt from other companies and that brand-specific reformulation targets, rather than category baselines, as are currently used by PHE, may instigate more significant reformulation by companies.

Conclusion

This method of combining food sales and nutrient composition data has been demonstrated that it is possible to assess the progress individual companies have made towards improving the nutritional quality of the products that they make available and sell in the UK. It shows that companies have made very little progress and that despite a few individual brand success stories, very little change has been made by the top 10 companies. This chapter demonstrates that these datasets can be used to monitor and evaluate adherence to public health policy, but could also be used by investors to indicate which companies, based on their product portfolios, are exposed to financial risk in the long term. Ethical health investment may be used as a potential driver of improvement in the nutritional quality of products available and sold to the public.

Chapter 6: Discussion

Chapter summary

This chapter summarises the main findings of this thesis, discusses the strengths and weaknesses of the methods that have been developed, and considers the implications of this research for policy and practice.

Introduction

The main aim of this thesis was to develop a method that allows an individual company's contribution to the food supply to be quantified and monitored over time by combining food sales data and nutrition composition data. A systematic review identified potential data sources and reviewed how these data have already been used in public health nutrition research (Chapter 2). After assessing possible data sources and conducting a cross-comparison study, food sales data from Euromonitor were selected for this method and paired with nutrition composition data from Brand View (Chapter 3). This method was then applied to monitor sugar reduction in food and soft drinks by company and category in the UK between 2015 and 2018 (Chapter 4). Finally, a more integrated assessment of individual companies was conducted, by ranking the top 10 food and beverages in the UK in terms of the healthiness of their entire product portfolios and considering the change over recent years (Chapter 5). The main findings of these chapters are summarised below.

Main findings of this thesis

The results of the systematic review (Chapter 2) identified that academic researchers have previously used sales or purchase data from four main companies: Euromonitor, GfK, Kantar and Nielsen. The review showed that sales and purchase data have been used to evaluate population health interventions, including the impact of the saturated fat tax in Denmark, the soft drink and junk food taxes in Mexico and supplemental nutrition programmes in the USA. They have also been used to identify trends in the nutrient composition of foods over time and patterns in food purchasing, including sociodemographic variations in purchasing.

These four possible data sources were then narrowed down in Chapter 3. Quality assessment analyses were conducted and showed that only Euromonitor and Kantar provided appropriately granular data on both value and volume sales for soft drink products in the UK, had transparent and robust data collection methods, and provided access to their data within the resource limits of this project.

A novel cross-validation study using soft drinks data from Kantar and Euromonitor was conducted to assess whether the choice of data was likely to have a meaningful effect on the results presented in this thesis. The results showed that there were large differences between Kantar and Euromonitor in terms of the volume sales of soft drinks, and of sugar sold from soft drinks, at the total and company level. However, differences between the sales-weighted mean sugar content and nutrient profiling scores for companies were not statistically different when tested using a Bland-Altman plot. I decided to use Euromonitor data rather than Kantar for my research for two reasons: 1) the data seemed more accurate as it better represented the total market, with a larger proportion of outlets (e.g. corner shops, vending machines, street markets) and volumes were much closer to those reported by the British Soft Drinks Associated (BDSA); 2) Euromonitor allowed for independent research as it did not impose any restriction on the reporting of results. Kantar insisted that any results stated either in this thesis or an associated peer-reviewed paper would have to be approved by them before publication and they were reluctant to allow the publication of company names.

Once the sources of data had been identified, the composition and sales data were paired together, and the sugar content of selected food and drink categories were analysed. Results showed that the sales-weighted mean sugar content of soft drinks fell by 34% between 2015 and 2018, from 4.4g/100ml (0.0-9.2g/100ml) to 2.9g/100ml (0.0-4.3g/100ml). The total volume of sugars sold from soft drinks decreased by 30%, from 15.5g per capita per day to 10.8g per capita per day, a reduction of 4.7g. The total volume sales of soft drinks that are subject to the Soft Drinks Industry Levy (SDIL) (i.e. contain more than 5g/100ml of sugar) fell by 50%, while volume sales of low and zero sugar (<5g/100ml) drinks rose by 40%. In comparison, food products that are subject to PHE's 20% voluntary sugar reduction targets did not see such large falls in mean sugar content or sugar sales. The total volume sales of sugar from the give included categories fell by 8%, equating to 1.7g per capita per day. The majority of this change (1.0g or 59% of the total reduction) was due to reduction in two categories: breakfast cereals and yoghurts. The remaining categories (biscuits, chocolate and sugar confectionery) saw very little change in their sugar content or sales over time. Only five companies out of 63 met at least one category-specific 20% reduction target for sales-weighted mean sugar content. Kellogg was the only company that met more than one target across different categories (breakfast cereals and biscuits).

A reduction in the total volume of sales of sugar could be due to two different factors: a change in the mean sugar content of products, and/or a change in their sales volume. The majority (85%) of the change in soft drinks was due to a reduction in the mean sugar content of products (i.e. companies reformulating). The remaining proportion (15%) was due to a change in sales volumes. For the five food categories, 57% and 43% of the reduction was attributable to reformulation and reductions in sales respectively.

There are several possible drivers of change in the sales volumes such as public health campaigns, media stories and changes in marketing and advertising. However, in the case of both soft drinks and foods the results presented in this thesis suggest that pressure on companies to reformulate their products – whether through fiscal measures or voluntary targets – has led to larger changes in industry behaviour compared to changes in consumer behaviour when purchasing these products.

Chapter 4 was concerned with one nutrient, sugar, but chapter 5 aimed to provide a more holistic analysis of how companies are changing the overall nutritional quality of their products. The main finding of this chapter was that there has been no significant change between 2015 and 2018 in the nutrient profiling score for the top 10 food and drink companies in the UK. In 2018, the sales-weighted mean score of all food and drinks was 65, below the score of 70 which can be considered 'healthy'. No individual company had an overall score of above 70. There was little change in the number of individual products classified as healthy, although the proportion of products classified as healthy increased from 38% to 46% of total volume sales, driven by an increase in the sales of bottled water and low/no calorie soft drinks. This analysis revealed that in spite of industry and media reports of ‘success’ stories, often for individual products, the overall rate of change is almost imperceptible.

The trends identified in Chapter 5 were similar to those identified in Chapter 4, although there were some nuanced differences. Both Chapter 4 and 5 observed greater changes for soft drinks than for foods, with the reduction in sugar content of drinks and increased sales of bottled water and juices observed in Chapter 4 also leading to the increased proportion of healthy sales in chapter 5. Kellogg was the only company that met multiple 20% sugar reduction targets in Chapter 4, and it was also the only company in Chapter 5 that saw a significant improvement in its nutrient profiling score over time.

Strengths and limitations of this thesis

Food purchasing is a strong antecedent of consumption at a population level and by pairing composition data with sales data, this analysis gives a good indication of what the UK population has consumed over this time period. It has allowed novel insights to be drawn on how both consumers and individual companies have responded to public health policies in the UK, and provides a novel method to monitor and evaluate industry action and the impact of public health policies. However, some important limitations should be noted.

Strengths and limitations of Euromonitor sales data

Euromonitor sales data was selected because it covers a large proportion of the market, including sales from supermarkets, convenience stores, discounters, markets and vending machines. Euromonitor data also allowed for analysis at various levels, including category, company and brand. The data was also fully accessible through the Oxford University Library system and the company imposed no restriction on how the data are used, or how the results can be published.

There are two main consequences of using Euromonitor sales data for this thesis. The first is that the sales data are a proxy for consumption, rather than consumption itself. A lot happens between a food being sold and it being consumed, including food preparation, distribution amongst household members and waste. The lack of demographic information means that the per capita results presented in this thesis are based on the total population and will include non-consumers. The second is that data are only available on an annual basis, prohibiting analysis using interrupted time series that could better investigate how specific interventions have changed consumption patterns.

The National Dietary and Nutrition Survey (NDNS) is currently considered the gold standard for measuring dietary intake at the population level in the UK because it measures individuals' dietary intakes. The Health Survey for England and the Scottish Health Survey collect data on individual's fruit and vegetable intake and the Living Cost and Food (LCF) survey uses household expenditure statistics on food to estimate nutrient intakes. These national surveys have small sample sizes (e.g. approximately 1,000 individuals for NDNS and 10,000 households for LCF) and are very resource intensive to conduct. Misreporting in dietary surveys is common and well documented (132). Underreporting may occur as a result of participants omitting – both accidentally and intentionally – to record food and drink consumed, particularly out of the home, underestimating quantities, or from changing dietary behaviours as a direct result of participating in a health-related survey. Underreporting is particularly common in overweight individuals (133)(134), thus exacerbating the paradox of reported energy intakes being below dietary guidelines, while obesity prevalence continues to rise. While the sales data used in this thesis report on what is being sold, rather than what is being consumed by individuals, the reporting of sales data may be more objective that data collected using dietary surveys. Survey results are also published annually, offering no greater granularity for time series analysis than the sales data collected by Euromonitor. More importantly for this thesis, sales data provides information on company and brand sales, which are not collected/reported in dietary surveys.

Euromonitor sales data was selected because it covers a large proportion of the market, including sales from supermarkets, convenience stores, discounters, markets and vending machines. Euromonitor data also allowed for analysis at various levels, including category, company and brand. The data was also fully accessible through the Oxford University Library system and the company imposed no restrictions on how the data are used, or how results can be published.

However, there are three main limitations to the Euromonitor data, which have been explored in previous chapters but which are summarised here. The first is transparency. Euromonitor does not carry out any primary data collection, but rather a team of analysts collate data from secondary sources including national statistics, data from trade associations and the trade press, company reports, and data received directly from companies. These data are validated by conducting trade interviews, whereby the industry provides feedback on their results, and store checks. However, the exact methods, sources and references used for the data are not available, meaning there is limited transparency for researchers and academics using these datasets.

While Euromonitor provides granular detail on sales by brand and company, there was a proportion of sales where brand and manufacturer are not given and are simply attributed to “others”. The proportion of sales falling under “others” varied by category, averaging at around 20% for the categories included in this thesis. This means that the results of total volume sales are likely to be an underestimate. The sales included under “others” were excluded from this thesis as they could not be paired with corresponding nutrition composition data. However, an alternative approach would have been to assume that the composition of the sales of products included under “others” would be the same as the rest of the market, and the final results adjusted accordingly.

The other main limitation of the Euromonitor data is that sales are given by brand (e.g. Cadbury Dairy Milk), rather than by individual product (Cadbury Dairy Milk Fruit and Nut, 200g). This means that when pairing the sales data with the nutrition composition data, averages of multiple, individual products under the same brand had to be calculated. This limitation is discussed further in the pairing method section below.

Strengths and limitations of Brand View nutrition composition data

The nutrition composition data for this thesis was sourced from the commercial company Brand View. The data, including nutrient composition per 100g, was scraped for every grocery product on three supermarket websites – Tesco, Sainsbury’s and Asda – on the same date (13th December) in four consecutive years (2015-2018). Ingredients information was also provided, and this data was used to calculate the fruit, nut and vegetable content of foods, which was needed for the nutrient profiling of products. The data collection method was the same every year, ensuring continuity and comparability, and fell within the budget of this DPhil project.

The main limitation of Brand View data is that the data is not validated, beyond the company's reputation as one of the leading data providers to the industry and other organisations. It is assumed that information on all products from supermarket websites was collected, although the exact proportion is unknown – as with Euromonitor, transparency around data collection methods is limited. Some of products used in the analysis for this thesis had missing nutrient values, although this varied depending on the nutrient, with no products having missing energy values to 31% having a missing fibre value (for further information see table 39, Chapter 5). It is not known what proportion of missing values are as a result of errors in data collection and what proportion of values are missing because they were not declared on the website or by the manufacturer. An unpublished study conducted by the Centre on Population Approaches for NCD Prevention has shown that of 295 products available in 10 different supermarkets in Oxford, 85% were available to purchase online (277). The study also found that the nutrition information on the back of the pack in store was virtually identical to the nutrition information given online (277). These findings support the view that Brand View data is a good reflection of what is available for purchase online and in store in the UK. However, Brand View data only included data from three supermarkets, meaning products sold exclusively in discounters, convenience stores, vending machines etc were excluded. The Brand View dataset is also only a single snapshot of what is being sold in supermarkets on one given day. That said, only 2% of total volume sales did not have corresponding nutrition composition data, and a sensitivity analysis carried out in Chapter 4 showed that these missing data had no real impact on the results.

Brand View also provided ingredients information of products. The fruit, nut and vegetable (FNV) content of products was estimated with the help of supervisor Richard Harrington using Python 3. This algorithm used the ingredients list to categorise ingredients into 'fruit', 'nut', 'vegetable' and 'other'. The percentage composition of ingredients was identified if this information was provided in the ingredients list. For the ingredients where percentage composition was not given, values were imputed based on a brand and category average, or if this was not possible, a category average. Only one-third of products in the Brand View database contained ingredients information that was detailed enough to estimate %FNV, although the majority of the remaining products fell into categories you would not expect to contain FNV. A sensitivity analysis conducted in Chapter 5 showed that the inconsistencies in the FNV data did not appear to affect the results of this

Strengths and limitations of pairing methods

A large part of this thesis centred around the pairing of two different datasets. This pairing was conducted in two different ways for Chapters 4 and 5. The categories and companies between the Euromonitor and Brand View databases were relatively well aligned, although brand and company names did not match exactly. The pairing for Chapter 4 was done manually in Excel using the search and filter functions – individual products in the nutrition composition data were given the same code as the corresponding brand sales data, based on the product's name, category, manufacturer and year. While very time consuming, this method also meant that any variations in product name or category were easily identified.

Due to the increased number of brands and products included in Chapter 5, an alternative to manual pairing was sought. An algorithm that automatically paired products in a similar way to the manual process described above was used, based on product name, category and year, which cut down the pairing time from an estimated eight weeks to a few hours. The dataset was checked manually for pairing errors by identifying outliers in the mean nutrition composition and sales volumes of each included brand. These errors were caused by limitations in the algorithm – individual products that belonged to a brand that was present in one or more category (e.g. chocolate confectionery and desserts both branded Dairy Milk) were all automatically paired with the sales data only from the first category and brand in the list. Big brands that had products in multiple categories therefore had to be paired manually, as all products under that brand were automatically paired with sales data from a single category. Brands that had common words in their name (e.g. 'Extra' or 'Duo') were automatically paired with individual products with names containing the same word, despite the fact that they were manufactured by different companies. These products had to be checked and reclassified manually.

Limitations in measuring uncertainty

There are two features of the datasets that were used in this thesis that complicate the interpretation of confidence intervals to measure the uncertainty of results: 1) Population-level data; and 2) Identifying an appropriate 'unit of analysis'. The implications of these two factors are discussed below.

Population-level data

The process of calculating confidence intervals assumes that the data are a representative sample being used to estimate a property of the population from which the sample has been taken. The uncertainty is due to random variation in the selected sample (hence as the sample size increases, the sample better represents the whole population and the confidence interval narrows). In this thesis, the data represent all of the population (e.g. sales data for soft drinks in Chapter 4 represent the sales of *all* soft drinks in the years 2015 to 2018). These data are measured with some degree of inaccuracy (which have been outlined in the limitations above). However, the confidence intervals are not based on these inaccuracies, as they would produce systematic biases in the dataset which cannot be incorporated into confidence intervals using standard statistical techniques. Instead, the confidence intervals represent the uncertainty due to the estimates being a sample of data in time drawn from a population of all possible datasets, using different time points. As an example, the sales data used in this thesis all capture total sales in a calendar year. Slightly different results would be given if the data captured total sales in say a financial year (or any other period of 365 days). The confidence intervals demonstrate this variance in results.

Identifying a unit of analysis

Working with datasets of food and drink products introduces additional challenges compared to datasets of people. The main issue is identifying an appropriate ‘unit of analysis’. Since food and drink products are unique, it is not always clear how they should be grouped in analytical datasets. For analysis of sugar levels in soft drinks, it may be appropriate to group all drinks that are labelled the same and have the same formulation (e.g. Pepsi Max sold in any product size). For analysis of price, it would not be appropriate to group together products sold in different size ranges. For calculating uncertainty ranges, it is appropriate to use the unit of analysis where all of the variance is introduced into the dataset. For this thesis, focussing on formulation and sales, there are two choices: unique products (which captures all the variance in nutrients) or unique sales (which captures all of the variance in purchasing decisions). Unfortunately, the sales data are not provided on a basis that allows for the identification of the number of individual purchases (e.g. number of units sold), but only total value and volume. Therefore, variance was captured using the individual products presented in the composition dataset.

Comparison with other studies

Overall, this thesis presents a novel method using food sales data and nutrition composition data to provide new insight into how the food industry has responded to public health nutrition policy in the UK. How the analyses presented in this thesis compares with other studies has been discussed in detail in each chapter. The systematic review on how food sales data has been previously been used by public health nutrition researchers is novel, and will hopefully be useful to other academic researchers who are considering using food sales data in their studies. The analysis comparing Euromonitor and Kantar data is also novel – of the 68 studies included in the systematic review, none compared the the use of different data sources as presented in Chapter 3.

Chapter 4, the analysis of sugar content of selected products, is similar to that conducted by Public Health England. The trends in the two studies were very similar, with both finding significant reductions in the sugar content of soft drinks (22% for PHE vs 29% presented here) and both studies found that yoghurts and breakfast cereals were the only two food categories that saw any significant reduction in sugar content. The results presented in this thesis are also published by company, and allow policy makers to better evaluate how widely their policies are being adhered to by the food industry.

There has been a similar benchmarking exercise carried by the Access to Nutrition Initiative (ATNI) in the UK as that presented in Chapter 5. The main advantage of this thesis over ATNI is that it includes four years' worth of data and therefore examines trends over time, whereas ATNI is just a snapshot of one year, and only covers the top five categories of each companies' product portfolios.

Future method development and research direction

Each chapter in this thesis has addressed an important research question, either in regard to how food sales data can be used for public health nutrition research, or how the food industry is responding to public health goals. The systematic review (Chapter 2) highlighted the need for a review of studies that have used food purchase data directly from supermarkets, including loyalty card data. A stronger understanding of the advantages of these specific data is needed so they can be better utilised by academics researching shopping-related consumer behaviours.

One of the main research questions arising from the analysis on sugar reduction (Chapter 4) is what impact the changes in sugar content seen in food and drinks has had on calorie content. Future work should look at sugar and calories concurrently, to give a better idea what impact the changes seen have had on energy intakes. Doing similar analysis on the saturated fat and salt content of the top manufacturers' foods would give a more holistic picture of the nutritional quality of food and drink, as would expanding the analysis to the fast food sector, rather than food just sold through retail.

The analysis in Chapter 5 could be expanded to include not just the top 10 food and soft drink companies in the UK, but the top 30, or even all food companies included in the dataset. This would give a much better picture of the actions that the food industry is taking to improve the nutritional quality of their products. Cross-comparison studies using different nutrient profiling models, and repeating the analysis for other countries, would allow for the best metric to assess overall company change to be identified.

These analyses could all be carried out using FoodDB. This data platform contains product information collected from 10 UK retailers dating back to 2017. It also has data from Australia, France, Ireland, New Zealand, Norway and the United States, and there are plans to start collecting data in the Czech Republic, Estonia and Portugal. Food sales data from Euromonitor are also available in these countries through the Oxford University Library. Systematically pairing FoodDB data with food sales data using an improved algorithm than that used for the analyses presented in Chapter 5. Potentially incorporating the use of barcode information would allow for analysis, not just of a select few companies and categories, but for a more comprehensive examination of the response of the food industry, including the fast food and retail sectors, in responding to public health goals.

Policy implications

At the UN General Assembly High Level Meeting on the Prevention and Control of Non-communicable Diseases in 2011, Heads of State and Government were asked to call upon the private sector to consider promoting and producing foods that are more consistent with a healthy diet, including through reformulation (14). This thesis has developed a novel method using food sales data and nutrition composition data that allows for company-level changes in the nutritional quality of the food supply to be monitored over time.

It has two main implications for policy. The first is that the methods described here can be used by policy makers to aid them in monitoring and evaluating how the food industry is responding to its policies, as demonstrated with the sugar reduction analysis in Chapter 4. The specific results in this chapter also provided some useful insights for future policy development. Firstly, with respect to soft drinks, the increased reduction seen in 2017-18 and the drop in the sales volume of high sugar (>8g/100ml) products, suggests that the Soft Drinks Industry Levy (SDIL) has been successful in reducing the sugar content of, and volume of sugar sold from, soft drinks. It has also shown that further progress is needed in the sugar reduction of foods, which have seen little change over time. The overall reduction in sugar sales of 6.3g per capita per day means that sugar intakes still exceed recommended levels, and further and more drastic action is needed. Therefore, the Government should consider developing its policies further by:

1. Lowering the SDIL threshold to below 5g/100ml, and/or extending it to milk drinks and juices to trigger further sugar reduction in soft drinks
2. Evaluating alternative options to the current policy of voluntary sugar reduction targets. These may include:
    a. Setting brand specific targets, putting more pressure on manufacturers of the top-selling products which contribute the most to sugar intakes

b. Considering making the sugar reduction targets mandatory and by introducing fines for manufacturers who do not meet them
c. Replacinge the sugar reduction targets with a levy system similar to the SDIL, taxing companies based on the sugar content of their products
d. Introducing tougher marketing restrictions on products that contain high levels of sugar, or for companies that have shown no reductions

The second main implication of this thesis is related to the use of a nutrient profiling model to score and benchmark companies' product portfolios. Such a benchmarking tool has the potential to be used in several ways:

1. As a tool to aid 'healthy' investment by financial investors. As discussed in detail in Chapter 5, there have been calls by investment banks (273) for a set of key performance indicators to be developed that will allow for the risk and exposure of food companies to Government legislation (such as taxes) to be measured and monitored. Applying financial pressure in such a way may in stimulate positive changes by manufacturers.
2. By working with health organisations and civil society NGOs, this benchmarking tool could also be used to increase public pressure on manufacturers and influence their corporate social responsibility policies, triggering a change in the nutritional composition of their products.

Conclusion

This thesis has developed a novel method using food sales data and nutrition composition data to provide new insight into how the food industry has responded to public health nutrition policy in the UK. It has allowed company-level changes in the food supply to be monitored over time, something that is particularly important given that there are a number of current UK Government policies – the SDIL and 20% sugar reduction targets – that depend on the industry making changes for them to be successful in terms of their public health impact. This thesis shows that there have been significant reductions in both the mean sugar content and volume of sugar sold from soft drinks, although reductions in food have been much smaller and the top 10 UK companies have made little progress in improving the overall nutritional quality of their product portfolios. Population nutrition intakes remain above the recommended levels and if diet-related disease is to be reduced, then more drastic action is needed on behalf of the Government, industry and consumers. The method that has been developed in this thesis has the potential to be used to continually monitor the nutritional composition of the food supply going forward, and evaluate which companies, if any, are making the biggest efforts to improve public health nutrition.

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Appendix: Systematic review results table

Author-date	Title	Objectives	Geography	Demographic	Study design	Intervention or non-intervention	Measuring patterns in food purchases or nutrient content of foods	Variables measured and outcomes calculated	Source of sales data	Source of composition data	Summary of key findings
Cross-sectional studies											
Alexander et al. 2011 **	Major multinational food and beverage companies and informal sector contributions to global food consumption: implications for nutrition policy	To define the contribution of selected players in the food and beverage industry to the sales of packaged foods and soft drinks sold To describe food and soft drink company pledges relate to health, with a focus on IFBA commitments	Global	Company-level data	Cross-sectional	Non-intervention	Food purchases	Top 10 packaged food company shares (% retail value) by country Top 10 soft drink company shares (% retail value) by country	Euromonitor	N/A	Globally, the top 10 packaged food companies represent 15.2% of sales, with no single company accounting for more than 3.3%. The top 10 soft drink companies represent 52.3% of sales globally. Without participation from small and medium sized businesses, the impacts of health pledges from IFBA will be limited.
Baker and Friel 2016 **	Food systems transformations, ultra-processed food markets and the nutrition transition in Asia	To measure the extent of market transnationalism market concentration by: - describing recent trends in ultra-processed food sales, changes in grocery retail distribution channels and food services sales - Identifying the main transnational food and beverage companies operating in Asia	12 countries, Asia	Company and product level data	Cross-sectional	Non-intervention	Food purchases	Per capita consumption of ready meals, sweet and savoury snacks, confectionery, biscuits, oils & fats and carbonated soft drinks Spend and market share of top 10 food and beverage companies Market concentration in ultra-processed food categories 2004 vs 2013 Distribution share (%) of processed foods through grocery retail channels 1999-2013	Euromonitor	N/A	The sales of ultra-processed foods have grown rapidly in middle-income countries, with supermarkets and hypermarkets becoming the main channel of distribution. These market forces are likely to be strong drivers of the nutrition transition in Asia.
Basu et al. 2013	Relationship of soft drink consumption to global overweight, obesity and	To estimate the relationship between soft drink consumption and obesity and diabetes worldwide	75 countries	Overweight and diabetic population, 1997-2010	Cross-sectional	Non-intervention	Food purchases	Obesity prevalence Diabetes prevalence Per capita consumption of soft drinks	Euromonitor	N/A	A 1% rise in soft drink consumption was associated with an additional 4.8 overweight adults per 100, 2.3 obese

	diabetes: a cross-national analysis of 75 countries										adults and 0.3 adults with diabetes
Binkley and Golub 2007	Comparison of grocery purchase patterns of diet soda buyers to those of regular soda buyers	To compare the grocery purchase patterns of regular and diet soda drinkers	USA	1574 single-purchase households, 1999	Cross-sectional	Non-intervention	Food purchases	Spending by consumers on different soda types Volume consumption of soda by type Demographic characteristics by soda buyer type Mean annual ounces of food groups purchased by regular soda buyer Difference in mean annual ounces of food groups purchased by soda buyers	Nielsen	USDA Nutrition Database	Diet soda consumers spend a smaller proportion of their total annual grocery spend on foods higher in calories, such as fruit juice and dairy, and spend a higher proportion on lower fat version of foods, such as dairy products, frozen entrees and salad dressings
Bonnet et al. 2014	Household food consumption, individual caloric intake and obesity in France	To provide a descriptive analysis of individual food consumptions according to household demographics	France	8,000 households, 2073 products, 2001-2002	Cross-sectional	Non-intervention	Food purchases	Consumption of energy and macronutrients, per capita per day, BMI classification (normal, overweight, obese) Share of energy from each macronutrient Energy and share of energy from macronutrients by age, sex and BMI classification	Kantar	Multiple sources including individual company websites	Results suggest that the consumption of fat and protein is higher than recommended and carbohydrates is lower in those overweight and individuals Overweight and obese individuals consume more calories at all ages and 20% more fat than those individuals with a normal weight
Castetbon et al. 2012	Purchases of ready-to-eat cereals vary across US household sociodemographic categories according to nutritional value and advertising targets	To describe the ready-to-eat (RTE) cereal purchases according to marketing strategy, nutritional quality and household demographics	USA	57,171 households that purchased RTE cereals in 2008	Cross-sectional	Non-intervention	Food purchases	Total spend on 249 individual products, the total number of households that purchased each product and their frequency of purchase The nutrition composition of each product The targeted advertising exposure (“child-targeted”, “adult-targeted” or “family-targeted”)	Nielsen	Cereal FACTS (Food Advertising to Children and Teens Score) report, Rudd Centre for Food Policy and Obesity, 2009	African-American and Asian households, those earning less than US$30,000 per annum and those with one or more children purchased the most RTE cereal The nutritional quality of cereal purchases was lower in African-American and Hispanic households

Combris et al. 2011	Improvement of the nutritional quality of foods as a public health tool	To assess the potential contribution of improving the nutritional quality of breakfast cereals, bread-based products and biscuits/pastries on individual nutrition intake To discuss the means to encourage food manufacturers to implement reformulation	France	20,000 households, 2006	Cross-sectional	Non-intervention	Nutrition composition	Nutrient content of products (sugars, fat, fibre and sodium g/100g) Total quantity of sugars, fat, fibre and sodium delivered to the market	Kantar	Oqali database (FULL REF)	Improvement in the sugar, fat, fibre and salt content in the products with the lowest nutritional quality would lead to significant variation in an individual's nutrient consumption Encouraging reformulation is a worthy target for policy makers
De Roos et al. 2016	Differences in expenditure and amounts of fresh foods, fruits and vegetables, and fish purchased in urban and rural Scotland	To quantify expenditure on all fresh foods, fruits, vegetables and fish across urban and rural households in Scotland	Urban and rural Scotland, UK	2567 urban and rural households	Cross-sectional	Non-intervention	Food purchases	Mean weekly expenditure (£/adult equivalent) on fresh food, F&V and fish Mean weekly amount (kg/adult equivalent) Average prices per kg by urban and rural areas	Kantar	N/A	Rural households had the highest level of spending on fresh foods and F&V and also bought the most volume (kg) of these items. Prices paid for products was higher in urban compared to rural areas. These data suggest that the higher expenditure in rural areas is due to factors other than pricing and availability of products.
Eyles et al. 2016	Estimating population food and nutrient exposure: a comparison of store survey data with household panel food purchases	Compare estimates of nutrient exposure from a packaged food store survey with those from a household panel	New Zealand	16,812 products from 1229 households, compared to 8440 products, 2012	Cross-sectional	Non-intervention	Nutrition composition	Mean content of saturated fat, sodium, sugar and energy content of packaged food products Mean difference between nutrient content of household panel products and survey products	Nielsen	Nutritrack database	Products recorded from the store survey had a higher sodium and sugar content compared to those from the household panel
Author-date	**Title**	**Objective**	**Geography**	**Demographic**	**Study design**	**Intervention or non-intervention**	**Measuring patterns in food purchases or nutrient content of foods**	**Variables measured and outcomes calculated**	**Source of sales data**	**Source of composition data**	**Summary of key findings**
Jones et al. 2017 **	An evaluation of the healthiness of the Indian packaged food	To use nutrient profiling to examine the healthiness of packaged food	India	Company-level data	Cross-sectional	Non-intervention	Food purchases	Sales-weighted health star rating (HSR) of food and beverage products	Euromonitor	FoodSwitch Data direct from manufacturer	Healthiness of Indian packaged food was low, with an overall mean HSR 1.8 out of 5 and only 17%

	and beverage supply	products from India's top manufacturers						% sales of products with HSR >3.5 ("healthy") by company Mean HSR by company and product category			of products classified as 'healthy'. There was significant variation between companies (0.5-3.0) based on the types of product and the nutritional composition of individual products
Juhl and Jensen 2014	Relative price changes as a tool to stimulate more healthy food choices – A Danish household panel study	To examine the effects of discounting on the purchasing of low-fat and full-fat yoghurt	Denmark	2000 households that purchased yoghurt, 2010-2011	Cross-sectional	Non-intervention	Food purchases	Number of full-fat and low-fat products purchased Listed prices Levels of discount applied Household income Number of children present in household	GfK Mintel	N/A	Discounting has an asymmetric effect on full-fat and low-fat yoghurts, with discounting
Mhurchu et al. 2011	Sodium content of processed foods in the United Kingdom: analysis of 44,000 foods purchased by 21,000 households	To determine if household panel data can be used to assess the sodium content of processed foods To estimate the mean sodium content of processed foods	Great Britain	44,372 foods purchased in 21,108 households, 2008-2009	Cross-sectional	Non-intervention	Nutrition composition	Product description product weight, number of annual purchases Sodium content (mg/100g) Unweighted and sales-weighted mean sodium values calculated	Kantar	Kantar	Table salt, processed meat and bakery products were the largest contributors to sodium purchases. For some products, including bread, cereals and processed meats, sales-weighted sodium means were higher than unweighted means, suggesting that market-leading products contain more salt. Targeting a small number of product categories for reformulation could have a significant public health benefit.
Nakumura et al. 2015	Price promotions on healthier compared with less healthy foods: a hierarchical regression analysis of the impact on sales and social patterning of responses to	To establish if less-healthy foods are more likely to be promoted than healthier food To find out if consumers are more responsive on less-healthy products To establish if there are socioeconomic differences in food	UK	11,323 products in 26,986 households, 2010	Cross-sectional	Non-intervention	Nutrition composition	Household demographics, including age, sex, income, educational attainment and self-reported BMI Total number of units of each product sold in each household per week Price and promotional status of each purchase used to calculate total	Kantar	Kantar	60% of products analysed were healthy, 40% were less healthy. A one-point increase in the category mean nutrient profile score was associated with a 7.7% increase in sales (the higher the NP score, the less the product). The uplift in sales of promotional items was higher in low SES households compared to

	promotions in Great Britain.	purchases in response to price promotions						number of promotional purchases per week Nutrient profile score of each product			high SES households, although there was no significant SES gap in the purchase of less-healthy foods on promotion.
Pechey and Monsivais 2015	Supermarket Choice, Shopping Behavior, Socioeconomic Status, and Food Purchases.	To assess the contributions of supermarket choice and shopping behaviours to the healthfulness of purchases and social patterning in purchases	UK	24,879 households stratified by social class, 2010	Cross-sectional	Non-intervention	Food purchases	Household demographics, including occupation, income, age Households classified by social class Number of trips to different types of supermarkets per month Proportion of 'small trips' to supermarkets (10 items or fewer) Mean number of different chains visited per month Whether households used a primary chain Proportion of energy from less-healthy foods and soft drinks Proportion of energy consumed from fruits and vegetables	Kantar	Kantar	Households using low-price supermarket chains to shop purchased significantly less energy from fruits and vegetables and a higher percentage from less-healthy foods and beverages. More frequent trips and fewer small trips were associated with healthier purchasing choices. Although supermarket choice and shopping behaviour are both associated with the healthfulness of purchases, neither appears to contribute to socioeconomic differences
Pechey and Monsivais 2016	Socioeconomic inequalities in the healthiness of food choices: Exploring the contributions of food expenditures	To explore the extent to which food expenditure mediates socioeconomic inequalities in the healthiness of household food choices	UK	24,879 households stratified by social class, 2010	Cross-sectional	Non-intervention	Food purchases	Head of household occupation as indicator of socioeconomic status Total household spend on take-home food and beverages over 52-week period of 2010 Energy adjusted food expenditure (£ per 200 kcal) Supermarket choice Healthiness of food and beverage choices	Kantar	Kantar	Higher social class was associated with higher expenditure on food and healthier purchases, suggesting that lower expenditure on food leads to less-healthy food choices for low socioeconomic groups.
Slining et al. 2015	An approach to monitor food and nutrition from factory to fork	To develop an approach that links purchase and consumption data of food and beverage products	USA	38,311 uniquely formulated foods, 2007-2008	Cross-sectional	Non-intervention	Nutrition composition	Mean daily intakes of energy, total sugars, saturated fat and sodium	Nielsen	USDA National Nutrient Database Mintel Datamonitor	Depending on the source of the nutrition information, differences in the daily calories, sugars and sodium was observed. By combining commercial food and beverage purchases with national

Author-date	Title	Objective	Geography	Demographic	Study design	Intervention or non-intervention	Measuring patterns in food purchases or nutrient content of foods	Variables measured and outcomes calculated	Source of sales data	Source of composition data	Summary of key findings
											nutrition databases, changes in the US food supply can be captured
Stern et al. 2016 (2)	Where people shop is not associated with the nutrient quality of packaged foods for any racial-ethnic group in the United States.	To examine whether the mix of food stores people shop at is associated with the nutrient profile of packaged food purchases	USA	368,934 household-year observations, 2007-2012	Cross-sectional	Non-intervention	Nutrition composition	Household demographics, including ethnicity, age, educational attainment and income Name and store type of every purchase Nutrition composition of foods Categorisation of households into three groups: primarily grocery cluster, primary mass-merchandiser cluster and combination cluster	Nielsen	Gladson Nutrition Database	Shopping primarily at grocery stores was not associated with a better nutrient profile of household PFPs compared to the mass-merchandisers or combination clusters. These results were consistent across ethnic groups. Policies that promote access to different types of stores may be ineffective as a public health intervention.
Stewart et al. 2011	Can low-income Americans afford to satisfy MyPyramid fruit and vegetable guidelines?	To estimate the cost of meeting the My Pyramid fruit and vegetable guideline	USA	64,440 households, 2008	Cross-sectional	Non-intervention	Food purchases	Total expenditure on foods and volumes purchased Calculated price per ounce/pint Estimated cost-per-cup equivalent	Nielsen	N/A	In 2008, a wide variety of fruits and vegetables cost US$0.40-0.50 per cup equivalent. If households spend 40-50% of their food budget on fruits and vegetables, they should be able to satisfy the MyPyramid guideline
Author-date	**Title**	**Objective**	**Geography**	**Demographic**	**Study design**	**Intervention or non-intervention**	**Measuring patterns in food purchases or nutrient content of foods**	**Variables measured and outcomes calculated**	**Source of sales data**	**Source of composition data**	**Summary of key findings**
Thunstrom 2010	Preference Heterogeneity and Habit Persistence: The Case of Breakfast Cereal Consumption	To examine the strength and heterogeneity in the habit persistence of breakfast cereals	Denmark	181 breakfast cereals purchased by 926 households, 2003, mixed multinomial logit model	Cross-sectional	Non-intervention	Food purchases	Household demographics, including income, educational attainment and family size Price of products (SEK per 100g) Grams of fat, saturated fat, fibre, sugar and salt per 100g of product Presence of Keyhole label	GfK	Swedish National Food Association (SLV)	Breakfast cereal purchase is highly habitual, with the degree of habit persistence varying across households, with it being significantly weaker for households with several adults or children compared to one-adult households

Whybrow et al. 2017	Dietary patterns of households in Scotland: Differences by level of deprivation and associations with dietary goals.	To evaluate dietary patterns from food and drink purchase data from Scotland and to identify dietary patterns that were associated with adherence to the Revised Scottish Dietary Goals (RSDG)	Scotland, UK	720 households, 2010	Cross-sectional	Non-intervention	Food purchases	Household size and composition Scottish Index of Multiple Deprivation Weights of food and beverage products purchased Weights adjusted for avoidable and unavoidable food waste Nutrition composition of products Energy density (kcal/100g) of foods Dietary Quality Index of each food	Kantar	Kantar	The mean DQI score for all food products was 38 (out of 100), indicating few dietary goals were being met. Six dietary patterns were identified, accounting for 35% of total variance in food intake. Three dietary patterns were associated with significantly lower DQI score (less healthy diet) and one significantly higher (more healthy diet).
Whybrow et al. 2017a	Social deprivation is associated with poorer adherence to healthy eating dietary goals: analysis of household food purchases	To estimate dietary intake relevant to the SDGs based on levels of household deprivation	Scotland, UK	2586 households, 2012	Cross-sectional	Non-intervention	Food purchases	Household size, composition and income Total weight of products purchased Nutrition composition of products Equalised per person intakes of fruits and vegetables, red and processed meat, oily fish, fibre Percentage energy from fat, saturated fat and non-milk extrinsic sugars Energy density of foods (kcal/100g)	Kantar	Kantar	As deprivation increased, households were further away from achieving the SDGs. Intakes of oily fish and F&V decreased ,and intakes of red and processed meat increased as deprivation increased.
Yan et al. 2016	Asymmetric demand patterns for products with added nutritional benefits and products without nutritional benefits	To investigate consumer demand patterns for products with and without nutritional benefits across processed healthy and unhealthy foods	UK	6218 households, 800,000 transactions	Cross-sectional	Non-intervention	Food purchases	Descriptive statistics of households, including age, ethnicity, education and income Healthiness of each food transaction Nutritional benefits of product purchased, taken from label (e.g. reduced fat, low salt) Price of products purchased and price changes	Kantar	N/A	Consumers are more sensitive to price decreases and less sensitive to price increases for both healthy and unhealthy food These sensitivities are greater for products with no nutritional benefit, supporting the hypothesis that products with nutritional benefits have a higher brand equity than those without
Longitudinal studies											

Anders and Moser 2010	Consumer choice and health: The importance of health attributes for retail meat demands in Canada	To estimate health behaviour and purchase patterns for fat-reduced ground meats that are believed to be "good-for-you" compared to regular products	Canada	9,000 households, 220,000 individual purchases	Longitudinal	Non-intervention	Food purchases	Mean number of purchases and mean expenditure of each purchase, by meat type Retail prices ($/kg) and quantity (tonnes) by generic and branded products Price elasticities by product type	Nielsen	N/A	When it comes to meat purchased at retail, preferences for health triumph over those for taste. "Extra-lean" ground meats have become a staple of the Canadian diet. These results are a starting point for a more in-depth understanding of health behaviours
Author-date	**Title**	**Objective**	**Geography**	**Demographic**	**Study design**	**Intervention or non-intervention**	**Measuring patterns in food purchases or nutrient content of foods**	**Variables measured and outcomes calculated**	**Source of sales data**	**Source of composition data**	**Summary of key findings**
Andersen and Smed 2013	What is it consumers really want, and how can their preferences be influenced	To investigate whether price changes or information would be the best policy instrument to reduce the consumption of fat from milk	Denmark	1700 households over 1997-2004	Longitudinal	Non-intervention	Food purchases	Volume sales of milk by fat content type and demographic factors Price of product by region, store type, mode of production (organic vs conventional) Preferred fat share (g/L) by household demographics Reaction to information campaign based on changes in optimum fat share Estimated price elasticity for fat	GfK	N/A	Consumer who purchase low fat milk purchase a higher volume than those who buy milk with a higher fat content Consumers who prefer high fat milk do not react to information about its health effects but do react to prices Consumers who prefer low fat milk are influenced by information but are not as price sensitive
Batis et al. 2016	First-Year Evaluation of Mexico's Tax on Nonessential Energy-Dense Foods: An Observational Study	To examine changes in volume of taxed and untaxed packaged food purchases in response to Mexico's tax on energy-dense foods, by socioeconomic status and for the entire sample	Urban Mexico	6248 households, 2012-2014	Longitudinal	Intervention	Food purchases	Socioeconomic status (SES) score Consumption of food categories in grams per capita per month	Nielsen	N/A	The mean volume of purchases of taxed food products declined. Low SES households purchased 10.2% less taxed foods than expected, medium SES households 5.8% and no change in high SES households.
Berning 2014	The effects of breakfast cereal coupons on the nutritional quality of	To examine what effect coupon use has on the nutritional quality of consumer	New York City, USA	1442 households that made breakfast cereal	Longitudinal	Intervention	Food purchases	Nutritional composition of breakfast cereals purchased with coupons and without.	Nielsen	USDA National Nutrition Database	Breakfast cereals purchased using a manufacturer or retailer coupon contain more sugar and salt than those

	household purchases	purchases of breakfast cereals		purchases in 2006, 2007, 2008				Purchases by household demographics and coupon use. % change in fat, fibre, protein, sodium and sugar content per serving between coupon types		Nutribase 9 software Health Canada	purchased without a coupon.
Caillavet et al. 2018	Is nutritional quality of food-at-home purchases improving? 1969-2010: 40 years of household consumption surveys in France.	To observe changes in food-at-home purchases by French households and their impacts in their nutritional quality over 1969-2010	France	5,000-20,000 households depending on year	Longitudinal	Non-intervention	Food purchases	Energy content of food purchases (kcal per capita per day) by year Purchases of meat and dairy products, fat, fruits and vegetables, cereal-based products and sugar-based products (g/200kcal) by year Energy contributions of macronutrients (%)	Kantar	CIQUAL food composition table	Overall, there was an increased trend towards processed foods compared to raw products in 2010 vs 1989 The purchase of calories increased by 6.7% and the energy density of products improved However, in the last decade, while nutrient density has ceased to increase, the overall purchase of has increased.
Cho et al. 2011	An analysis of the Olympic sponsorship effect on consumer brand choice in the carbonated Soft drink market using household Scanner data	To investigate the effects of Coca-Cola's sponsorship on consumers soft drink choices during the 2006 Winter and 2008 Summer Olympic Games	USA	11,887 households	Longitudinal	Intervention	Food purchases	Consumer expenditure ($) and market share (%) of top cola brands (Coca-Cola and Pepsi) Quantities purchased and advertising expenditures of Coca-Cola and Pepsi	Nielsen	N/A	Olympic sponsorship generated significantly greater consumer choices for Coca Cola over Pepsi during the Games Results of the model show that advertising effects aside, sponsorship effect on purchasing behaviour exists, although it has short term results
Cleeren et al. 2016	Regular or low-fat? An investigation of the long-run impact of the first low-fat purchase on subsequent purchase volumes and calories	To examine the effectiveness of the first low-fat purchase of chips/crisps on subsequent purchased volume and calories	Netherlands	311 households that purchased chips/crisps, 2004-2007	Longitudinal	Non-intervention	Food purchases	Total volume sales of crisps/chips per year Total number of calories purchased per year Total number of low-fat products available Price of products Advertising Spending in other food categories	GfK	GfK	The purchase of a low-fat chip/crisp product can lead to the over-purchase of products in the long- and short-term.

Author-date	Title	Objective	Geography	Demographic	Study design	Intervention or non-intervention	Measuring patterns in food purchases or nutrient content of foods	Variables measured and outcomes calculated	Source of sales data	Source of composition data	Summary of key findings
Colchero et al. 2016	Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study	To find out what effect the excise tax on sugar sweetened beverages has had on the purchase of beverages from stores in Mexico	Urban Mexico	6253 households	Longitudinal	Intervention	Food purchases	Descriptive statistics of the households Absolute and relative differences in expected volume purchased and post-tax volumes purchased Monthly predicted purchases of taxed beverages by socioeconomic status	Nielsen	N/A	Purchases of taxed beverages declined by an average of 6%, or -12mL per capita per day. There was a reduction in all three socioeconomic groups, although the decline was greatest in the low SES group
Edenbrandt and Jansen 2018	A hedonic analysis of nutrition labels across product types and countries	To increase the understanding of whether consumers value the assistance nutrition labels aim to provide	Netherlands and Denmark	2,998,073 individual items purchased	Longitudinal	Intervention	Food purchases	Number of products sold Presence of label/product characteristic: organic, Fulfill choices/Keyhole criteria Store type Price Size	GfK	N/A	Products that fulfil the Choices criteria in the Netherlands are more expensive than those that do not. In Denmark, products that fulfil the Keyhole criteria and display the label have increased more in price than those that meet the criteria but don't display the label
Eyles et al. 2013	Impact of the UK voluntary sodium reduction targets on the sodium content of processed foods from 2006 to 2011: Analysis of household consumer panel data	To determine what impact the FSA voluntary sodium reduction targets had on the sodium content of processed foods between 2006 and 2011	UK	47,339 products purchased by 18,099 households, 2006-2011	Longitudinal	Intervention	Food purchases	Household demographics Crude and sales-weighted sodium content (mg/100g) of processed food products Mean difference in sodium content (2006 vs. 2011) Number and percentage of products meeting 2010 sodium target in 2006 vs. 2011	Kantar	Kantar	Between 2006-2011, there was a mean reduction in sodium content of -26mg/100g, equivalent to a fall of 7%, indicating that the FSA sodium targets have delivered a moderate reduction
Ford et al. 2014	Are food and beverage purchases in households with pre-schoolers changing? A	To describe changes in consumer packaged goods purchases between 2000 and 2011 among households with	USA	42,753 households with one or more child aged 2-5 years, 2000-2011	Longitudinal	Non-intervention	Food purchases	Calories purchased per capita from foods and beverages Calories purchased per capita by race, female head of household	Nielsen	Does not specify	Total calories from purchased packaged food and beverages declined significantly over 2000-2011, with milks, juices, grain-based desserts, savoury snacks and sweet

	longitudinal analysis from 2000-2011	children aged 2-5 years						education and household income			snacks and candy among the major changes. Changes varied significantly between race, female head of household education level and household income.
Griffith et al. 2015	Relative prices, consumer preferences, and demand for food	To understand how large changes in relative food prices affect the nutritional quality of households shopping baskets over 2006-2011	UK	22,000 households, demand model	Longitudinal	Non-intervention	Food purchases	Change in relative prices by food groups Mean calorie and macronutrient purchases across time periods Calories (per person per day) and % of total calorie share by food group	Kantar	Kantar	Changes in the relative prices of foods over time seem to have a negative effect on the composition of foods purchased While relative prices undoubtedly affect food purchases, failure to model other factors, such as consumer preferences, can lead to the misestimation of the impact of price on nutrition
Grummon and Taillie 2017	Nutritional profile of supplemental nutritional assistance program household food and beverage purchases	To describe the usual purchases of SNAP households, income-eligible households and higher-income households across key food, beverage and nutrient groups.	USA	70,447 households split by SNAP participant, income-eligible non-participant and higher income households, 2012-2013	Longitudinal	Intervention	Food purchases	Store purchases of food and beverage groups in nutrient (g/kcal)/person/day split by social demographics Household size, number and age of children, marital status, age of household head, race/ethnicity, maximum educational attainment, income	Nielsen	Doesn't specify source – linked by unique product code (UPC) to nutrition facts panel	SNAP households purchased on average 565 kcal/person/day from SSBs and junk food. Average household purchases did not meet dietary guidelines for fruits, vegetables, saturated fat, fibre or sodium. Compared to non-participants, SNAP households purchased 15-20 kcal more from SSBs, more total calories and more total sodium.
Jensen and Smed 2013	The Danish tax on saturated fat - Short run effects on consumption, substitution patterns and consumer prices of fats	To assess the market effects of the Danish saturated fat tax on butter, butter blends, margarines and oils	Denmark	2000 households, 2008-2012	Longitudinal	Intervention	Food purchases	Descriptive statistics of panel members, including residence, further education levels and family composition Annual consumption of butter, butter blends, margarines and oils in kg/individual Market share of discount stores (% volume of product purchases)	GfK	Dos not specify source of average saturated fat content (g/100g)	The introduction of a saturated fat tax on the considered products reduced consumption by 10-15%. Results also suggest that there was a shift away from purchases in high-end retailers to discounter stores. Data also suggest that some retailers increased the price of products more than the pure tax increase.

								Average saturated fat content (g/100g) Price (DKK/kg)			
Levy and Shrapnel 2014	Quenching Australia's thirst: A trend analysis of water-based beverage sales from 1997-2011	To show trends in sugar sales of sugar-sweetened and non-sugar sweetened water-based beverages in Australia over a 15-year period	Australia	10,000 households, 2007-2011	Longitudinal	Non-intervention	Food purchases	Volume sales, annual grown rate, difference per capita and losses and gains of volume share by beverage category and year Sugar contribution in tonnes and kg per person by year and beverage category Demographic penetration of beverage categories (% persons consuming)	Nielsen	N/A – rounded estimates by beverage category only	Sales of water-based beverages grew by 1.7% per annum, driven mainly by the growth of non-sugar varieties (4.9% per annum) Volume share of non-sugar varieties increased from 30% to 42% over the 15-year period Sugar contributions from water-based beverages fell from 9.2kg to 7.6kg per person Soft drinks, energy drinks and sports drinks were most popular with teenagers and young adults
Lichtman-Sadot 2016	Does banning carbonated beverages in schools decrease student consumption?	Do address what impact banning beverage consumption at schools has on household compensation	USA	7517 households residing in selected school districts, 2004-2009	Longitudinal	Intervention	Food purchases	Demographics of household, including number of children, ethnicity and income Details of local school soda policy (type of soda ban, date implemented) Monthly soda and diet-soda consumption by household	Nielsen	N/A	When high-schools ban the sale of carbonated beverages to students, households with an affected student increase their consumption of non-diet sodas by 3.4 cans per month, offsetting the impact of the high-school ban
Lopez-Olmedo et al. 2018	The Socioeconomic Disparities in Intakes and Purchases of Less-Healthy Foods and Beverages Have Changed over Time in Urban Mexico	To examine the relationship between socioeconomic status (SES) by examining household purchase and individual food intake data	Urban Mexico	5240 households stratified by SES, 2012-2014	Longitudinal	Non-intervention	Food purchases	Demographics of household, including number of occupants, their ages, educational attainment and the number of rooms and cars Per capita daily purchases of healthy and less healthy foods by household SES (g/day)	Nielsen	N/A	Higher SES households purchased more less-healthy foods and more healthy beverages and lower SES households had purchased more less healthy beverages. This group also saw the largest reduction in these purchases from 2012-2014.

Mathias et al. 2015	Monitoring changes in the nutritional content of ready-to-eat grain-based dessert products manufactured and purchased between 2005 and 2012.	To examine the changes in the nutritional content of grain-based ready-to-eat desserts (GBDs)	USA	134,128 households that purchased grain-based desserts from 2005-2012	Longitudinal	Non-intervention	Nutrition composition	Demographics of household, including income, ethnicity, education levels and family composition Number of GBDs that carry a nutrition facts panel Energy, saturated fat and sugar density by year GBD purchases (g/person/day)	Nielsen	Unspecified commercial database of nutrition facts panels	The saturated fat content of GBDs increased the sugar content decreased from 2005 to 2012, resulting in significant reductions in energy density (433 kcal/100g to 422 kcal/100g). Household purchases of GBD fell by 24%. These results highlight the opportunity for manufacturers and public health officials to develop reformulation strategies.
Mendez Lopez et al. 2017 **	Is trade liberalisation a vector for the spread of sugar-sweetened beverages? A cross-national longitudinal analysis of 44 low- and middle-income countries.	To test whether lower tariffs effectively increase exports of sugar sweetened beverages (SSBs)	44 LMICs	Company and product level sales data	Longitudinal	Non-intervention	Food purchases	Sales of SSBs by country in per capita per litre Import value (US$) of SSBs per annum Population size used to calculate imports of SSBs per capita	Euromonitor	N/A	For every 1% increase in tariffs in LMICs, import of SSBs fell by 2.9%. In turn, increased imports of SSBs were associated with an increase in SSB consumption, with a 10% increase in SSB imports resulting in an increased consumption by 0.36L per person.
Mhurchu et al. 2017	Effects of a Voluntary Front-of-Pack Nutrition Labelling System on Packaged Food Reformulation: The Health Star Rating System in New Zealand.	To evaluate the effects of the Health Start Rating (HSR) on food reformulation	New Zealand	35,602 products purchased by 1726 households, 2014-2016	Longitudinal	Intervention	Food purchases	Numbers of products displaying HSR labels Nutritional composition of products Number of units purchased Mean changes in nutrient composition over time	Nielsen	Nutritrack database	In 2016, 5.3% of products carried a HSR label, with the highest rates among cereals and convenience foods. Products displaying an HSR label had higher energy, fibre and sodium densities compared to non-HSR products. Reformulation of HSR products was greater over the same time period compared to non-HSR products, suggesting that the adoption of the HSR system is driving the

											healthier reformulation of some products
Author-date	**Title**	**Objective**	**Geography**	**Demographic**	**Study design**	**Intervention or non-intervention**	**Measuring patterns in food purchases or nutrient content of foods**	**Variables measured and outcomes calculated**	**Source of sales data**	**Source of composition data**	**Summary of key findings**
Ng et al. 2012	Use of caloric and non-caloric sweeteners in US consumer packaged foods, 2005-2009	To examine the extent of caloric sweetener and non-caloric sweetener use in the consumer packaged foods and beverages purchased by US households	USA	85,451 uniquely formulated foods	Longitudinal	Non-intervention	Nutrition composition	Percentage of packaged foods purchased by type of sweetener Most common sweeteners used in packaged foods Percentage of foods containing caloric and non-caloric sweeteners	Nielsen	Gladson Nutrition Database	Of the 85,451 products examined, 75% contain a sweetener (68% caloric sweetener, 1% non-caloric and 6% both). 77% of all calories purchased contained caloric sweeteners and 73% of food volume contains caloric sweeteners. These results highlight the challenge in monitoring sweetener consumption.
Ng et al. 2014	Turning point for US diets? Recessionary effects or behavioural shifts in foods purchased and consumed	To examine if declining energy intakes suggest a shift in dietary patterns that are independent of a turbulent economic period	USA	108, 932 individual households, 2000-2011	Longitudinal	Non-intervention	Food purchases	Average calories purchased per capita per day split by foods, beverages and total by year Average calories purchased per capita per day by ethnicity and employment status	Nielsen	Mintel GNPD	Children were the group that decreased their calorie intake the most After adjusting for economic factors, caloric purchases fell significantly from 2003-2011. The period of the great recession was associated with a small increase in caloric purchases, with a 1% increase in the levels of unemployment associated with a 1.6-4.1 kcal per capita per day increase in the total calories purchased.
Ng et al. 2016	Trends in racial/ethnic and income disparities in foods and beverages consumed and purchased from	To determine if there are disparities in calories obtained from packaged foods between different ethnic and income groups	USA	64,709 households	Longitudinal	Non-intervention	Food purchases	Energy intake by race/ethnicity and income based on the federal poverty line Trends in energy intake over time (200-2012) Proportion of calories from store-bought	Nielsen	Nutrition facts panel, various sources	Store-bought foods represent the largest component of dietary intake Calories purchased from non-store source foods and store sourced

	stores among US households with children, 2000–2013							packaged food and beverages			beverages declined the most over 2000-2013 A slower reduction was seen amongst non-Hispanic black and low income households compared to non-Hispanic white and high income households
Ng et al. 2018	Federal nutrition program revisions impact low-income households' food purchases	To examine changes in household food purchases across the US from 2008-2014 among WIC participating and non-participating households	USA	65,000 households	Longitudinal	Intervention	Food purchases	Product sales volumes and nutrient contents expressed as energy (kcal), total sugars, fats, sodium and fibre (g) purchased per capita per day Classification of food products into "WIC eligible" and "WIC ineligible" categories Classification of food products by degree of industrial food processing and convenience of preparation	Nielsen	Gladson Nutrition Database Mintel Datamonitor	WIC-eligible households saw a significant decreases in the purchase of calories, sodium, fat and sugar, as well as reductions in grains, gran-based desserts, higher-fat milk and SSBs. There were increased purchases of fruit and vegetables with no added sugar/salt. Income eligible non-participating households had similar but smaller reductions WIC packaged revisions seem to have had a positive impact on the nutritional profile of food purchases
Oh et al. 2016	Did Revisions to the WIC Program Affect Household Expenditures on Whole Grains?	To examine the purchases of whole grain products before and after the 2009 changes to the Supplemental Nutrition Program for Women, Infants and Children (WIC)	USA	36,477 households reporting grain purchases, 2008-2010	Longitudinal	Intervention	Food purchases	Household demographics, including income, educational attainment, size and age Monthly wholegrain expenditures (US$) Monthly refined grain expenditures (US$) Monthly whole grain amount (ounces) Monthly refined grain amount (ounces)	Nielsen	N/A	Participation in the WIC program was associated with more wholegrain purchases over 2008-2010. The changes approximately doubled the associated effect of WIC participation on the purchases of wholegrain products. The results confirm the recommendations that changing assistance programs can lead to positive effects on dietary choices.

Piernas et al. 2015	A Dynamic Panel Model of the Associations of Sweetened Beverage Purchases With Dietary Quality and Food-Purchasing Patterns	To examine the independent associations between beverages sweetened with caloric and low-calorie sweeteners (CS and LCs) with dietary quality and food purchasing patterns	USA	34,294 households, 2000-2010, dynamic panel model	Longitudinal	Non-intervention	Food purchases	Household demographics, including age, sex, educational attainment, income and ethnicity Total energy from all purchases Total energy excluding CS and LCS Total energy from foods Total energy from macronutrients Servings per day of LCS and CS beverages (servings/day)	Nielsen	Gladson Nutrition Database	Each 1 serving/day increase in consumption of either CS or LCS beverages resulted in increased purchases of total calories, carbohydrates, total sugars and total fats. Consumers of CS and LCS beverages had a poorer dietary quality overall.
Poti et al. 2015	Is the degree of food processing and convenience linked with the nutritional quality of foods purchased by US households?	To define categories for classifying products by the degree of food processing and convenience To determine the trends in the caloric contribution of processed and convenience foods To compare saturated fat, sugar and sodium content of packaged food purchases across all levels of processing and inconvenience	USA	157,142 households, 2000-2012	Longitudinal	Non-intervention	Nutrition composition	Proportion of total calories purchased by different levels of food processing and convenience Mean nutrient content of foods by levels of processing and convenience Proportions of households whose purchases exceed dietary guidelines on saturated fat, sugar and sodium as defined by degree of processing and convenience	Nielsen	Mintel GNPD	Three quarters of energy in food purchases came from moderately and highly processed foods and beverages in 2012, with no significant change from 2000. When classifying foods by convenience, ready-to-eat and ready-to-heat products formed most of the energy purchased.
Poti et al. 2016	Highly Processed and Ready-to-Eat Packaged Food and Beverage Purchases Differ by Race/Ethnicity among US Households	To examine the association between ethnicity/race with highly processed and ready to eat food purchases	USA	1.2 million individual food products purchased by 157,142 households, 2000-2012, regression model	Longitudinal	Non-intervention	Food purchases	Household demographics, including age, education, income and ethnicity Proportion of saturated fat (% kcal), sugar (%kcal) and energy density (kcal/100g food) of packaged food products	Nielsen	Gladson Nutrition Database	Black households had lower purchases of highly processed foods and RTE convenience foods and higher purchases of basic processed foods such as oils and sugars, when compared to white households. Black households purchased foods that were more energy dense and had higher median sugar content. Highly processed convenience foods are associated with, but cannot fully explain, ethnic

											disparities in the nutritional quality of processed foods
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Poti et al. 2017	Sodium Reduction in US Households' Packaged Food and Beverage Purchases, 2000 to 2014.	To assess the change in the amount of sodium acquired from packaged foods, the sodium content of these products and the proportion of households that purchase products with an optimum sodium density	USA	1.5 million individual food products purchased by 172,042 households, 2000-2012	Longitudinal	Non-intervention	Nutrition composition	The amount of sodium purchased daily per person (mg/person/day) Sodium content of food products (mg/100g) Sodium density of food products (mg/100kcal)	Nielsen	Gladson Nutrition Database	The amount of sodium purchased from packaged foods fell by 396mg/day per capita from 2000 to 2012. The sodium content of products fell by 12%, however in 2012 only 2% of households had packaged food purchases with a sodium density of 1.1mg/kcal or less. Despite signs that sodium purchases have fallen, most households are still buying products with excessive sodium densities.
Slining et al. 2013 **	Food companies' calorie-reduction pledges to improve US diet	To identify the food categories that contributed to total number of calories purchased and relate these to the pledges made by the companies of the Healthy Weight Commitment Foundation (HWCF)	USA	50,000 households over 2000-2015	Longitudinal	Intervention	Food purchases	% food calories from packaged foods manufactured by weight commitment foundation company, no-NWCP company or private label company	Nielsen	Gladson Nutrition Database	HWCF companies accounted for 25% of calories consumed in the US in 2007, and that the calorie reduction pledge of 1.5 trillion calories accounts for 0.8% of total calories sold across all consumer packaged foods and beverages. The effects pledges have on foods supply and individual diets is important to developing new policies to improve nutrition.

Smed et al. 2016	The effect of Danish saturated fat on food and nutrient intake and modelled health outcomes: an econometric and comparative risk assessment evaluation	To evaluate the effect of the Danish fat tax on saturated fat in terms of saturated fat, unsaturated fat, salt, salt, fruit and vegetable consumption and to model the associated changes in mortality	Denmark	2500 households	Longitudinal	Intervention	Food purchases	Sociodemographics of the panel (age, residence, education, family composition) % changes in consumption compared with baseline (taken from national dietary survey) by age and sex Deaths averted and delayed by cause	GfK	Danish Food Composition Databank	The introduction of the saturated fat tax in Denmark had a minor but positive impact on public health. It led to a 4.0% reduction in the consumption of saturated fat. Vegetable and salt consumption increased as a result. A modelled 123 lives were saved annually, equal to 0.4% of all deaths from NCDs in Denmark
Smed et al. 2017	The consequences of unemployment on diet composition and purchase behaviour: a longitudinal study from Denmark	To explore and describe the effect unemployment has on food purchase behaviour and composition of diets	Denmark	3440 households, 2008-2012	Longitudinal	Non-intervention	Food purchases	Nutrient composition per 100g of foods purchased Type of store frequented Monthly purchases of food products Total food expenditure Unemployment status of household, including welfare benefit status, unemployment benefit or supported employment	GfK	Food Composition Databank, National Food Institute, Technical University of Denmark	In the short-run, unemployment led to substitution of discount store products and higher levels of expenditure on products high in fats and protein, mainly due to increased purchasing of animal products. Medium-term, unemployment led to a reduction in total food expenditure, along with a decline in the purchase of animal products, fats and protein, indicating that unemployment has a significant impact on diet composition
Spiteri and Soler 2017	Food reformulation and nutritional quality of food consumption: an analysis based on households panel data in France.	To quantify the contribution of reformulation to changes in the nutritional quality of consumers' food puchases	France	20,000 households, 2008-2011	Longitudinal	Non-intervention	Nutrition composition	Purchase (expenditure and volume) of food products in four groups – breakfast cereals, biscuits and cakes and potato chips and soft drinks Market share of products Key nutrient composition of each product	Kantar	Oqali (French Food Quality Observatory)	Product reformulation programmes have improved the nutritional quality of most food groups examined. Changes were strongest in the saturated fat and sodium content of potato chips and the sodium content of breakfast cereals. These results support the food reformulation as an effective policy compared to promoting behaviour change

Author-date	Title	Objective	Geography	Demographic	Study design	Intervention or non-intervention	Measuring patterns in food purchases or nutrient content of foods	Variables measured and outcomes calculated	Source of sales data	Source of composition data	Summary of key findings
Stern et al. 2015	US Household Food Shopping Patterns: Dynamic Shifts Since 2000 And Socioeconomic Predictors.	To identify where US households are shopping for food, to describe how shopping patterns have changed over time and to establish what SES characteristics are associated with shopping patterns	USA	257,732 households from 2000-2012	Longitudinal	Non-intervention	Nutrition composition	Household demographics, including ethnicity, age, educational attainment and income Name and store type of every purchase Categorisation of households into three groups: primarily grocery cluster, primary mass-merchandiser cluster and combination cluster	Nielsen	N/A	The only trend identified was that low income non-Hispanic black households had a lower probability of belonging to the mass-merchandiser cluster of shopping patterns, otherwise no other association between grocery pattern and ethnicity/income was found.
Author-date	**Title**	**Objective**	**Geography**	**Demographic**	**Study design**	**Intervention or non-intervention**	**Measuring patterns in food purchases or nutrient content of foods**	**Variables measured and outcomes calculated**	**Source of sales data**	**Source of composition data**	**Summary of key findings**
Stern et al. 2016 (1)	The Nutrient Content of U.S. Household Food Purchases by Store Type.	To describe the types of stores US households shop at, to establish if store type changes over time and to establish if the nutrient profile of foods and beverages purchased by US households change by store type	USA	652,023 household-year observations, 2000-2012	Longitudinal	Non-intervention	Nutrition composition	Name and store type for every purchase Energy and nutrient densities (grams of sugar and saturated fat and mg of sodium) per 100g of PFP by store type Grams of PFP per household per day by store type Proportion of calories and volume of food and beverage group by store type Number of calories and volume of food purchased by food type and store type	Nielsen	Gladson Nutrition Database	The number of household purchases of packaged food products increased for mass-merchandisers, convenience stores and warehouse clubs and decreased for grocery chains. The top source of calories from packaged food products was savoury snacks, grain-based desserts and regular soft drinks.
Taillie et al. 2016	Walmart and Other Food Retail Chains: Trends and Disparities in the Nutritional Profile of Packaged Food Purchases.	To better understand the link between food retailer chains, specifically Walmart, and the healthfulness of food purchases	USA	164,315 households, 2000-2013, fixed effects model	Longitudinal	Non-intervention	Nutrition composition	Mean nutrient densities of household PFPs by retailer, including energy (kcal/100g), total sugar (g/100g), saturated fat (g/100g) and sodium (mg/100g) Percentage shifts in volumes of food groups purchased	Nielsen	Gladson Nutrition Database (Slining et al. 2013)	The energy, sugar and sodium density of PFPs from Walmart declined from 2000 to 2013, with other stores having more favourable nutritional profile in 2000 but did not shift as much over time. There were also volume declines in purchases of grain-based desserts,

								Difference in mean nutrient densities of household PFP by retailer and ethnicity and income			savoury snacks and sweets and increases in fruits and vegetables from Walmart.
Whybrow et al. 2016	Buying less and wasting less food. Changes in household food energy purchases, energy intakes and energy density between 2007 and 2012 with and without adjustment for food waste	To test the hypothesis there was no reduction in energy intake once reductions in food waste had been accounted for Compare the effects of area-based deprivation on these changes	Scotland, UK	2657 households, 2007-2012	Longitudinal	Non-intervention	Food purchases	Scottish Index of Multiple Deprivation calculated for each household Household energy purchases (MJ/adult equivalent per day) Energy 'as consumed' (MJ/adult equivalent per day) Energy density (kJ/100g) of purchased foods Energy density (kJ/100g) of foods 'as consumed'	Kantar	Kantar	The amount of food energy purchased per adult equivalent decreased from 8.6 MJ/day in 2007 to 8.2 MJ/day in 2012. However, energy intake was not found to be significantly different after accounting for reductions in food waste.
Allais et al. 2010	The effects of a fat tax on French households' purchases: A nutritional approach	To assess the impact of a fat tax on the nutrients purchased by French households by different income groups	France	5,000 households	Scenario modelling	Intervention	Food purchases	Price elasticities of 22 food categories by income group Quantities of 32 nutrients in 22 food categories Percentage change in total nutrient purchased after 10% fat tax by income group and food group	Kantar	REGAL tables de composition	A fat tax has a small effect on the amount of nutrients purchased by French households and a small impact on bodyweight in the short-term, increasing in the long-term.
Scenario modelling studies											
Allais et al. 2015	Mandatory labels, taxes and market forces: An empirical evaluation of fat policies	To identify the causal impact of fat-content labels on consumer choice in the case of yoghurts	France	13,380 households	Scenario modelling	Intervention	Food purchases	Number of products, mean price and market shares by product type and fat content Variations in average household annual fat purchases (g) by income and mean BMI and between labelled and taxed products	Kantar	Mintel's Global New Product Database and magazine *Linéaires.*	In most cases, voluntary FOP fat labels were only found on low-fat products Results of demand curves suggest that a fat tax has a larger economic impact that mandatory fat FOP-label, but both are equally effective at reducing average fat purchases
Dharmasena and Capps 2011	Intended and unintended consequences of a proposed national tax on sugar-	To use a quadratic almost ideal deamand system (QUAIDS) model to estimate the effects of a proposed 20% tax on sugar	USA	Household size not states; 10 beverage categories used	Scenario modelling	Intervention	Food purchases	Estimated price elasticities by beverage category Direct, indirect and total effects of 20% tax on each beverage type	Nielsen	Composition data not used – calories estimated by adapting results of	Consumption of isotonic drinks, regular soft drinks and fruit drinks is negatively impacted by the proposed tax, while the consumption of tea,

	sweetened beverages to combat the US obesity problem	sweetened beverages (SSBs)						Total calories reduced per capita per month and change in body weight		calorie intake data from National Health and Nutrition Examination Survey (NAHNES)(278)	coffee, low-fat milk and fruit juices is positively affected Reduction in body weight as a result of the tax is estimated to be 1.54 and 2.55 lb per year
Finkelstein et al. 2010	Impact of targeted beverage taxes on higher- and lower-income households	To investigate the impact of a targeted beverage tax on high- and low-income households	USA	Household panel of unspecified size used for a multivariate regression model, 2006	Scenario modelling	Intervention	Food purchases	Mean daily kcal purchased per capita Percentage of households that purchased each type of beverages Average price paid per 1000kcal Household income quartile Daily energy consumed per person by beverage categories and by income quartiles Predicted change in mean energy intake (kcal) by a 20% and 40% tax on both carbonated sugar-sweetened beverages (SSBs) and on all beverages	Nielsen	Gladson Nutriton Database	A 20% and 40% tax on SSBs would reduce calorie intake by 4.2 and 7.8 kcal/d person Resulting weight loss is estimated at 0.32 kg/person a year and 0.59 kg/person, suggesting that large taxes on SSBs would have a positive influence on weight outcomes in a population.
Ford et al. 2015	Targeted beverage taxes influence food and beverage purchases among households with preschool children	To determine how effective targeted beverage taxes of 10%, 15% and 20% are as a means to reduce purchase of beverages	USA	14,784 households with one or more children aged 2-5, 2009-2012	Scenario modelling	Intervention	Food purchases	Socioeconomic characteristics of children aged 2-5 years Food purchases in grams per capita per day Elasticities of demand by beverage categories Change in quantities of beverages purchased based on 10%, 15% and 20% increase in SSBs	Nielsen	Nielsen	Taxes of 10%, 15% and 20% on SSBs were all associated with reduced purchases of juice. Taxes on SSBs plus >1% fat milk and high-sugar milk led to a reduction in calorie purchase from milk, poultry, fish and mixed meats
Ford et al. 2017	SSB taxes and diet quality in US pre-schoolers: estimated changes in the 2010 Healthy Eating Index	To determine how a 20% tax on SSBs might influence the energy intake and diet quality of pre-school children	USA	2009-2012 data from an unspecified number of households	Scenario modelling	Intervention	Food purchases	Socioeconomic characteristics of children aged 2-5 years Average prices of products per 100g/ml Nutrient intakes of children aged 2-5 from the National Health and	Nielsen	N/A	20% increase in price of SSBs was associated with a lower intake of calories (-28kcal/d). Beneficial decreases in empty calories were offset by unfavourable changes in the profiles of saturated

								Nutrition Examination Survey			fatty acids, protein and fruit and vegetables. This suggests a tax may reduce caloric intake but not improve the overall diet quality
Hahn and Davis 2014	Costs of taxing sodium: A lunch meat application	To measure how much a tax on sodium would affect lunch meat demands and to measure how this impacts consumers' economic welfare	USA	25,123 households, 2006	Scenario modelling	Intervention	Food purchases	Category classification and quantity of each category sold by household Average price per pound (lb) of product Mg of sodium per serving Sodium taxes per pound of lunch meat Sodium taxes as a % of the average price of lunch meat	Nielsen	USDA nutrition database	A tax rate that increases the price of the highest-sodium lunch meat by 25% can reduce consumption and lower sodium intake from lunch meat by 20%
Quirmbach et al. 2018	Effect of increasing the price of sugar-sweetened beverages on alcoholic beverage purchases: an economic analysis of sales data.	To provide a direct analysis of the relationship between price increases of SSBs and alcoholic drink purchases, by income group	UK	25,535 households, equating to 6 million beverage purchases	Scenario modelling	Intervention	Food purchases	Mean expenditure on beverages by drink type and household income Change in demand for beverages based on change of price of sugar-sweetened beverages, by income group	Kantar	Kantar	An increase in the price of high-sugar soft drinks leads to an increase in the purchase of lager An increase in the price of medium-sugar drinks reduces the purchases of SSBs An increase in the price of diet soft drinks leads to increased purchases of beer, cider and wine
Author-date	**Title**	**Objective**	**Geography**	**Demographic**	**Study design**	**Intervention or non-intervention**	**Measuring patterns in food purchases or nutrient content of foods**	**Variables measured and outcomes calculated**	**Source of sales data**	**Source of composition data**	**Summary of key findings**
Sharma et al. 2014	The effects of taxing sugar-sweetened beverages across different income groups	To investigate the impact of SSB taxes on consumption, body weight and tax burden for low-, middle- and high-income groups	Australia	1390 households	Scenario modelling	Intervention	Food purchases	Quantities of beverages sold by category (L) and household income Calculated prices (from total expenditure and volume consumed) Household budget share spent by soft drink category	Nielsen	Nutritional Tables for Australia	A volumetric tax would result in a greater per capita weight loss than a valoric tax (0.41kg vs 0.29kg). The tax burden of a volumetric tax is also lower for both low- and high-income households

								Price elasticities of beverage type			compared to the valoric tax. Therefore the tax burden is lower and the weight reduction is higher under a volumetric tax
Tiffin et al. 2014	The effects of a soft drink tax in the UK.	To investigate the effects of a soft drink tax in the UK, and to differentiate the responsiveness of consumers according to soft drink consumption levels	UK	24,495 households, 2010	Scenario modellin g	Intervention	Food purchases	Household demographics, including income, age and number of children Number of portions of soft drinks purchased per week Shares and total expenditure on food and drink Unconditional own-price elasticities for drinks Percentage change in quantity consumed	Kantar	N/A	A tax on soft drinks would have the largest impact on households with high levels of soft drink consumption and that substitution may mitigate effects. The overall impact of a soft drink tax on consumption is likely to be small.